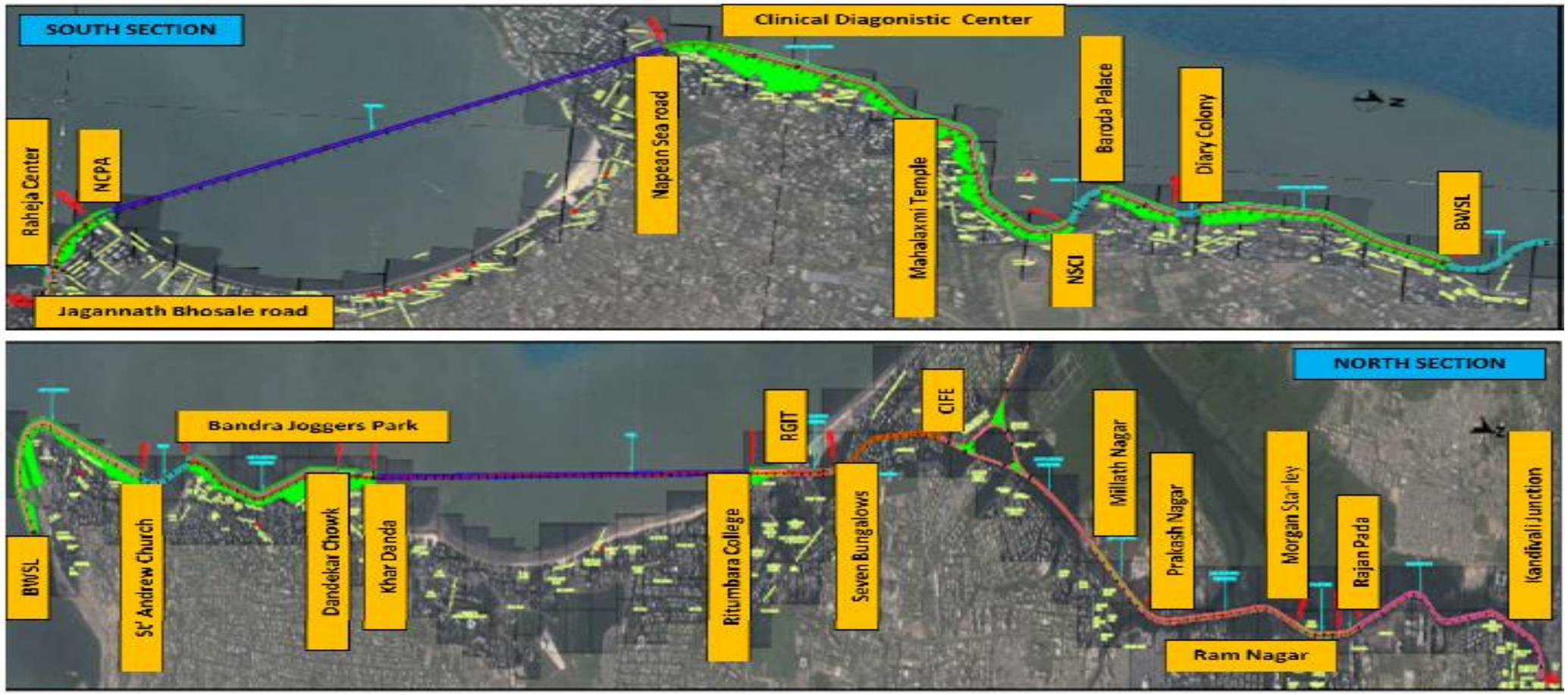
Municipal Corporation of Greater Mumbai

CONSULTANCY SERVICES FOR PREPARATION OF FEASIBILITY REPORT, DPR PREPARATION, REPORT ON ENVIRONMENTAL STUDIES AND OBTAINING MOEF CLEARANCE AND BID PROCESS MANAGMENT FOR MUMBAI COASTAL ROAD PROJECT



DRAFT DETAILED PROJECT REPORT (DPR)

Executive Summary

FEBRUARY 2015

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1. Introduction

1.1 General

Mumbai is reckoned as the financial capital of India. It houses a population of 12.4million besides a large floating population in a small area of 437sqkm. As surrounded by sea and has nowhere to expand. The constraints of the geography and the inability of the city to expand have already made it the densest metropolis of the world. High growth in the number of vehicles in the last 20 years has resulted in extreme traffic congestion. This has lead to long commute times and a serious impact on the productivity in the city as well as defining quality of life of its citizens. The extreme traffic congestion has also resulted in Mumbai witnessing the worst kind of transport related pollution.

Comprehensive Traffic Studies (CTS) were carried out for the island city along with its suburbs to identify transportation requirements to eliminate existing problems and plan for future growth. CTS identified requirement of new arterial road along the Western Coast as part of transportation networks as shown in Figure 1.1. Therefore, Municipal Corporation of Greater Mumbai (MCGM) has proposed to construct a Coastal Road on Western side of the city. The report concentrates on feasibility of the proposed Coastal road.

1.2 History of Reclamation of Mumbai

It took over 150 years to join the original seven islands of Mumbai. These seven islands were lush green thickly wooded, and dotted with 22 hills, with the Arabian Sea washing through them at high tide. The original island of Mumbai was only 24 km long and 4 km wide from Dongri to Malabar Hill (at its broadest point) and the other six were Colaba, Old Woman's island, Mahim, Parel, Worli, Mazgaon as presented in Figure 1.2.

After the British arrival, the demand for land steadily increased, and by 1730; it was becoming impossible to accommodate the entire population of Mumbai inside the Fort. The sea was making inroads at Worli, Mahim and Mahalaxmi, which turned the ground between the islands into a swamp, making travel between Mumbai islands hazardous.

The first major reclamation took place in 1708, to construct the causeway between Mahim and Sion.

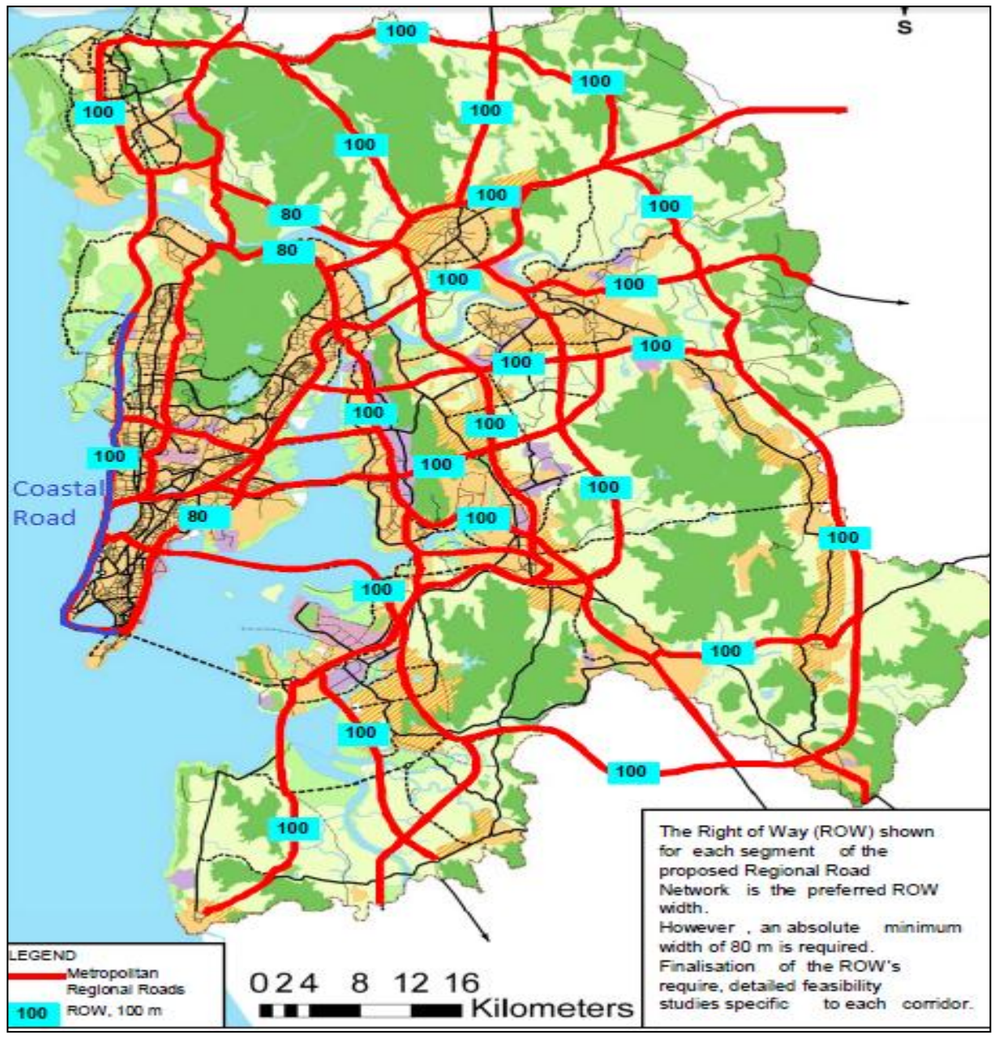


Figure 1.1: Highway Network Proposed by CTS

The second major reclamation took place in 1772, to stop the ingress of water and the consequent flooding of central Mumbai, and to connect Mahalaxmi and Worli. This causeway was named Hornby Vellard, sealing the Great Breach (Breach Candy) between Dongri, Malabar hill and Worli.

At the fortified Dongri hill, an esplanade and parade ground was cleared, from the walls of the Fort to the present day Crawford market. The flat lands from Mahalakshmi to Kamathipura were reclaimed only after the completion of construction at Breach Candy by Hornby in 1784. In 1803, Mumbai was connected to Salsette by a causeway from Sion.

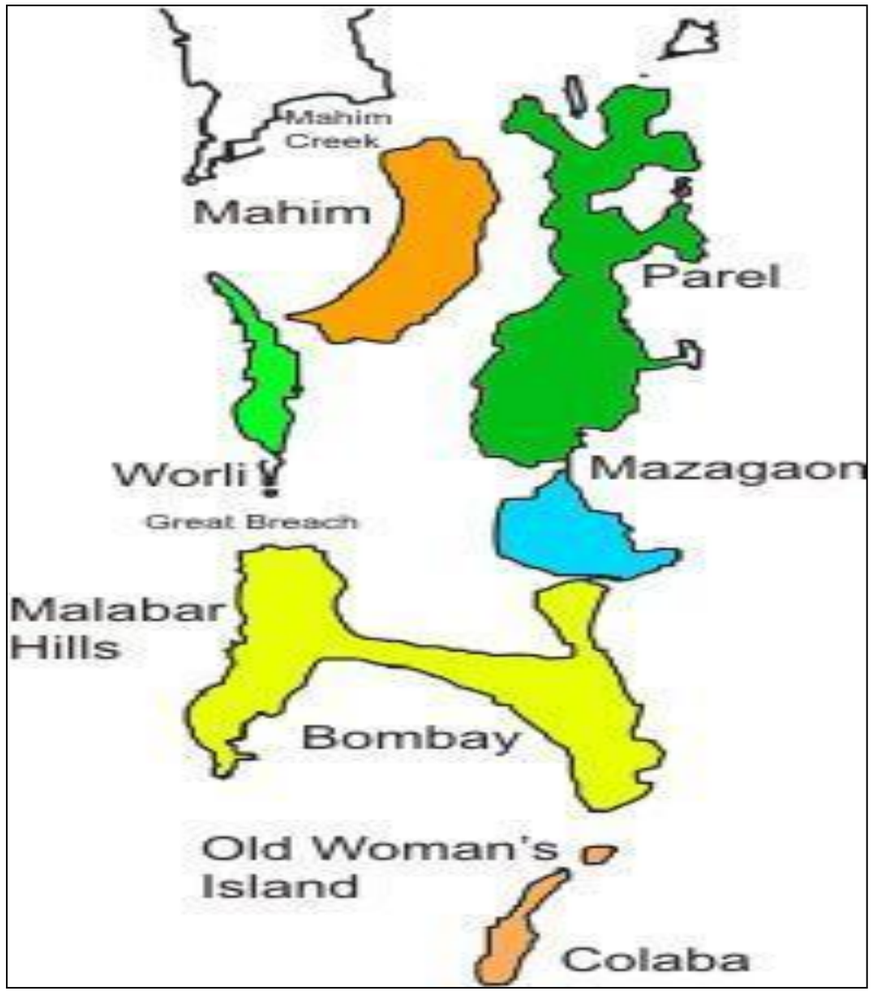


Figure 1.2: Seven Islands of Mumbai

Colaba Causeway

The Thane and Colaba causeway were built during the tenure of Sir Robert Grant, the Governor of Mumbai. He was also responsible for the construction of a number of roads between Mumbai and the hinterland. The Colaba Causeway was completed in 1838 joining Colaba, Old Woman's island and the H-shaped island of Mumbai together. Land prices shot up and Colaba became the centre of commerce. The Causeway was widened and strengthened from 1861 to1863 (Cusrow Baug is built on the causeway).

The horse drawn tramcars revolutionised transport in Colaba. The Prongs Lighthouse was constructed off the island in 1875 and in the same year the Sassoon Docks were built by David Sassoon on reclaimed land. The BB & CI (Bombay and Central India) Railways established a terminus at Colaba. 90,000 sq. yards of land was reclaimed on the western shore of Colaba by the City Improvement Trust, the work was completed in 1905. A seaside promenade (Cuffe Parade) was completed the next year.

The next reclamation came in 1836, when the development of the Mumbai port had already begun. Major quarrying had already begun in 1870. The hills of Chinchpokli and Byculla were quarried and dumped into the sea, to fill the land near the railway line, the swamps and also the port to prevent the accumulation of stagnant water. The first railway line was laid down in 1855 from Bori Bunder to Thane.

By 1862 the town became widespread and the constructions that took place began to give rise to the modern city of Mumbai. This became a regular feature in the succeeding years. The Fort walls were demolished and the tanks up to Parel were filled. From 1870 to 1970, industrial and commercial development prospered, which increased the spate of reclamation that ended with the famous Backbay reclamation.

The first Backbay Reclamation Company (BRC) was formed in the 1860s with the express purpose to reclaim the whole of Backbay. With the end of the American Civil War in 1865, land prices fell. The government took over the narrow strip of land created by the BRC and gave it to the BB & CI Railways (Bombay Baroda and Central India) to construct a new line between Churchgate and Colaba. A proposal was made in 1917 to reclaim 607 hectares of land between Colaba and Backbay. The project was taken over by the Development Directorate who planned to reclaim 463 hectares and would have to relocate the Colaba terminus, which was moved to Bombay Central. The work continued till 1945. Eventually 177 hectares was developed by 1929 of which 94 hectares was sold to the military and 6 hectares was incorporated into the Marine Drive and its sea wall. Figure 1.3 presents the map of Mumbai in 1954.

Independence did not end the reclamation work but a third Backbay Reclamation was put into effect and yielded the acreage on which stand the high rise buildings of Nariman Point and Cuffe Parade. East of the Naval Dockyards some land was reclaimed and work was done to the north too. Coastal Regulation Zone (CRZ) was introduced in 1990 banning reclamation for commercial activities.

1.3 Project Road

Mumbai being island city, surrounded on three sides by Arabian Sea, sea links were planned on the western flank and the trans-harbour link on the east to connect the island city to the main land. One of the prime reason sea links were planned as bridges was the restriction placed by the earlier Coastal

Regulatory Zones (CRZ) regulations preventing reclamation or stilt roads in the CRZ areas. The CRZ notification dated 6 January 2011 issued by the Ministry of Environment and Forests, Govt. of India (MOEF, GOI) now makes it possible to envisage coastal roads on stilts. During the meeting held in Mumbai on 15 April 2011, the proposal of a reclamation based coastal road encircling Mumbai was presented to the Hon'ble Minister MoEF, GoI. Hon'ble Minister suggested the proposal needed a closer examination through a committee. Accordingly, Govt. of Maharashtra constituted a Joint Technical Committee under the Chairmanship of Municipal Commissioner, MCGM on 30 June 2011 to study and make recommendations on the subject of coastal roads in Mumbai. The Committee held various meetings and deliberated on the issues which were presented through its report to Govt. of Maharashtra on 29 December 2011. The Committee recommended about 35.6 km. coastal road comprising a combination of road based on reclamation, bridges, elevated roads and tunnels on western side of Mumbai. The Committee recommended this coastal road with two options of alignments, both with a view to resolve the traffic congestion in Mumbai and to enable creation of the much needed recreational open spaces.

MCGM has appointed consortium of M/S STUP Consultants Pvt. Ltd consultants and M/S Ernst & Young Pvt. Ltd for Preparation of Feasibility Report, DPR Preparation and Bid process management for the proposed Mumbai Coastal Road Project.

1.4 Objectives

This report summarises to studies and findings of detailed project for proposed coastal road.

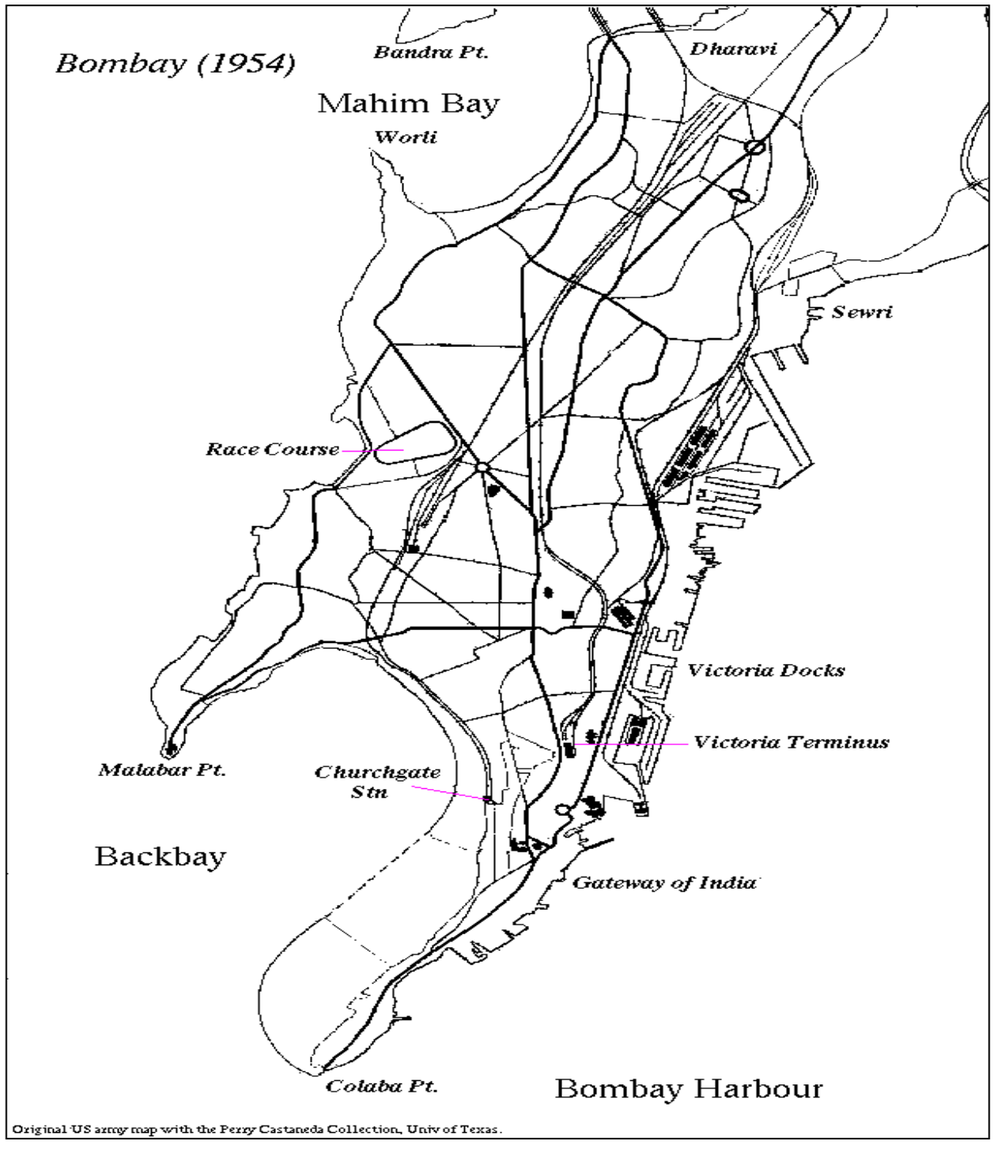


Figure 1.3: Backbay Reclamation

2. Regional/State Socio-economic profile

2.1 General

Mumbai is capital of Maharashtra state. This chapter presents socio-economic profile of the Maharashtra State, as it largely affects growth of Mumbai.

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 to form the Sahyadri Range parallel to the sea-coast and its slopes gently descending towards the East and South-east. Satpuda ranges cover northen part of the State, while Ajanta and Satmala ranges run through central part of the State.

Arabain 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, some 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 crore, 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 sqkm as compared to that of India (382). Mumbai has become the most populated city and world's fifth. In 2011, Mumbai average density was 30,000 persons per sqkm

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.

2.2.4 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
2000 - 2001	252,283	242,615
2001 - 2002	273,188	252,438
2002 - 2003	299,479	269,621
2003 - 2004	340,600	291,197
2004 - 2005	413,826	413,826
2005 - 2006	483,222	473,801
2006 - 2007	581,725	540,750
2007 - 2008	679,004	599,062
2008 - 2009	756,334	619,291
2009 - 2010	901,330	701,550
2010 - 2011	1,029,621	775,020

2.2.4.1 Gross State Domestic Product (GSDP)

Gross State Domestic Product (GSDP), as per the advance estimates, is expected to grow at 10.5 per cent during the year 2010-11 as against 8.7 per cent during the previous year. Increased agricultural production will help 'Agriculture & allied activities' sector to grow by 12.5 per cent as against growth

of 3.1 per cent in the earlier year. Industry sector is expected to grow by 9.1 per cent. Services sector is expected to grow by 10.9 percent during the year.

GSDP at constant (2004-05) prices is 7, 01,550 crore during 2009-10, as against 6, 45,492 crore in 2008-09, showing an increase of 8.7 per cent as per the preliminary estimates. GSDP during 2009-10 at current prices is 9, 01,330 crore, showing an increase of 16.6 per cent over the previous year.

Table2.2: Sector wise GSDP for Maharashtra

Year	Sector Wise GSDP for Maharashtra			
	Primary	Secondary	Tertiary	Total
2000 - 2001	40601	67558	144124	252283
2001 - 2002	44842	70164	159107	274113
2002 - 2003	45719	78382	176375	300476
2003 - 2004	52519	91722	197183	341424
2004 - 2005	52811	105092	229487	387390
2005 - 2006	59654	120861	257543	438058
2006 - 2007	70515	183640	330342	584497
2007 - 2008	84556	217684	382577	684817
2008 - 2009	81001	230921	442048	753970
2009 - 2010	93988	249698	512065	855751
2010 - 2011	132449	290766	611870	1035085
2011 - 2012	153630	331749	714168	1199547

(As per Economy Survey of Maharashtra 20012-2013)

2.2.4.2 State Per Capita Income

The Per Capita Incomes for the state are presented in Table 2.3.

Table2.3: PCI for Maharashtra

Year	Per Capita Income (Rs in Crores)	
	Current Prices	Constant Prices
2000 - 2001	22,777	21,892
2001 - 2002	24,035	22,258
2002 - 2003	26,015	23,447
2003 - 2004	29,139	24,859
2004 - 2005	35,915	35,915
2005 - 2006	41,624	40,947
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

2.2.5 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 liberalisation, 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 33.50lakh hectare. 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 includes Ajanta, Ellora, Elephanta, Kanheri and Karla caves, Mahabaleshwar, Matheran and Panchgani, Jawhar, Maishejghat, 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.

2.2.6 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

(km)

Statutory Development Board	As on 31st March						
	Year	National Highways	State Highways	Major District Roads	Other District Roads	Village Roads	Total
Vidarbha	2011	883	9,879	11,370	12,863	26,023	61,018
	2012	883	9,884	11,405	13,451	26,126	61,749
Marathwada	2011	795	8,073	13,596	8,765	22,239	53,468
	2012	795	8,073	13,775	8,779	22,315	53,737
Rest of Maharashtra	2011	2,698	16,151	24,970	25,269	58,138	1,27,226
	2012	2,698	16,200	25,076	25,299	58,160	1,27,433
Total	**2011**	**4,376**	**34,103**	**49,936**	**46,897**	**1,06,400**	**2,41,712**
	2012	**4,376**	**34,157**	**50,256**	**47,529**	**1,06,601**	**2,42,919**

Source: PWD, GoM

Maharashtra state has seen rapid growth in vehicle population in all categories due to rapid economic growth. Number of vehicles registered in the state are presented in table 2.5 below.

Table 2.5: Category wise Vehicles

Category	As on 1st January					
	Maharashtra			Brihanmumbai		
	2012	2013*	Per cent change	2012	2013*	Per cent change
Two wheelers (Motorcycles, Scooters & Mopeds)	13,513.6	14,928.6	10.5	1,118.1	1,205.3	7.8
Auto rickshaws	661.5	660.9	(-)0.1	113.5	118.5	4.4
LMV (Cars, Jeeps, Station wagons & Taxis)	2,841.0	3,144.1	10.7	691.4	755.4	9.3
Buses (Stage carriages, contract carriages, school buses & PSV)	87.1	96.1	10.3	12.0	12.3	2.5
Goods vehicles {Articulated/Multiaxel vehicles, trucks & lorries, tankers, delivery vans (3 & 4 wheelers), etc}	1,053.6	1,135.8	7.8	62.9	64.9	3.2
Tractors	404.7	449.0	10.9	0.6	0.6	0.0
Trailers	316.7	338.9	7.0	0.2	0.2	0.0
Ambulances	10.5	11.1	5.7	1.4	1.4	0.0
Other vehicles	30.5	35.0	14.8	1.5	1.5	0.0
All	**18,919.2**	**20,799.5**	**9.9**	**2,001.6**	**2,160.2**	**7.9**

Source : Transport Commissioner's Office, GoM * Provisional , LMV–Light Motor Vehicles, PSV – Public Service Vehicles

Railways

Maharashtra has 5,465 km of railway routes of which about 4040 km is broad guage, 510 km meter guage and 915 km is narrow guage. Few projects that are being implemented are presented in table 2.6

Table 2.6: Railway Projects in Maharashtra

(As on 31st December, 2012)

Name of route	Route length (km)	Total estimated cost (₹ crore)	Current status
Amravati-Narkhed (New line)	138	548.95	Completed in July, 2012
Ahmednagar-Beed-Parli- Vaijnath	261	462.67	Work of track linking completed upto 11.7 km remaining work is in progress.
Baramati-Lonand (New line)	54	138.48	Physical progress 95%.
Belapur-Seawood-Uran (New Line)	27	495.44	Physical progress 17%.
Wardha-Nanded (New Line)	285	1,604.94	Physical progress 3.5%.
Panvel-Pen (Doubling)	35	138.48	Physical progress 72%.
Pen-Roha (Doubling)	40	203.00	Physical progress 48%.
Panvel-Roha (Land acquisition for doubling)	75	17.32	Work is in progress and is expected to be completed in near future.

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.

The Airports under the control of the State government are: Amaravati, Baramati, Chandrapur, Dhule, Gondia, Jalgaon, Karad, Kolhapur, Kinwat, Latur, Nanded, Osmanabad, Phaltan, Ratnagiri, Sangli, Solapur, and Yavatmal. At present these airfields have no facilities for the operation of commercial flights.

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

Table 2.7: Airports

(As on 31st March)

Airport	Passengers (lakh)		Cargo (tonnes)	
	2011	2012	2011	2012
Domestic				
Mumbai	199.95	210.44	1, 99,831	1, 90,288
Pune	27.53	32.29	27,828	24,134
Nagpur	12.00	13.77	9,145	4,588
Aurangabad	2.66	4.01	1,841	1,227
Kolhapur	0.06	0.08	0	0
Total	**242.20**	**260.59**	**2, 38,645**	**2, 20,237**
International				
Mumbai	87.48	94.93	4, 70,402	4, 67,182
Nagpur	0.37	0.39	346	388
Pune	0.56	0.64	0	0
Aurangabad@	0.05	0.03	0	0
Total	**88.46**	**95.99**	**4,70,748**	**4,67,570**

Source : Airport Authority of India @ Passenger traffic by chartered plane

Sea Ports

Mumbai Port at Mumbai and Jawaharlal Nehru Port Trust at Navi Mumbai is the major port in Maharashtra. There are 54 minor ports in the state .

Table 2.8: Major Ports In Maharashtra

Item	MbPT		Per cent change	JNPT		Per cent change
	2010-11	2011-12		2010-11	2011-12	
Total cargo capacity (lakh tonnes)	487.00	487.00	0.00	640.00	640.00	0.00
No. of employees	13,391	12,726	(-)4.97	1,730	1,718	(-)0.69
Cargo traffic handled (lakh tonnes)						
A) Import	367.55	388.72	5.76	334.46	332.18	(-)0.68
B) Export	178.30	173.14	(-)2.89	308.71	325.12	5.32
Total	**545.85**	**561.86**	**2.93**	**643.17**	**657.30**	**2.20**
Passenger traffic handled (in '000)	16.01	4.70	(-)70.64	N.A.	N.A.	N.A.
No. of Vessels handled	5,622	5,758	2.42	3,128	2,929	(-)6.36
Operating income (₹ crore)	955.07	1,023.05	7.12	1,122.64	1,167.15	3.96
Operating expenditure (₹ crore)	774.91	821.47	6.01	444.46	499.63	12.41
Operating surplus/profit (₹ crore)	180.16	201.58	11.89	678.18	667.52	(-)1.57

Source : MbPT & JNPT N.A. : Not Applicable

Maharashtra Maritime Board (MMB) has undertaken development of six non major ports. Out of these six Damankhol- Jaigad port has become operational with two cargo berths in first phase and Dighi port is ready for commissioning. The cargo berth is commissioned at Lavagan- Jaigad port in

April, 2012. Pre construction activities are in progress for Vijaydurg port, Rewas-Aware port and Redi port. Cargo handling by non major ports is presented in Table 2.9.

Table 2.9: Cargo Handling by Non Major Ports

Item	2010-11	2011-12	Per cent change
Cargo traffic handled (lakh tonnes)			
A) Import	124.95	163.96	31.22
B) Export	23.79	35.51	49.26
Total	**148.74**	**199.47**	**34.11**
Passenger traffic handled (lakh)			
A) By mechanized vessels	144.53	159.03	10.03
B) By non- mechanized vessels	22.81	20.22	(-)11.35
Total	**167.34**	**179.25**	**7.12**

Source : Maharashtra Maritime Board

2.2.7 Industry

With its key location, linking the northern and southern parts of the country, Maharashtra has firmly established itself as India's most pro-business State. The State has been identified as the country's powerhouse and Industrial sector and occupies a prominent position in the economy of Maharashtra. Cotton textiles, textile products, paper and paper products are the largest and the oldest industry in the state. Important centers of this industry are located at Mumbai, Pune, Aurangabad, Nagpur, Chandrapur, Solapur, Akola, and Amravati; hand loomed goods are produced especially in and around Nagpur and Solapur. Food products, breviaries, tobacco and related products, printing and publishing, rubber, plastic, petroleum, cement and coal products, basic chemicals and chemical products, metal products, and parts, machinery (except electrical machinery), electrical machinery, apparatus and appliances, and transport equipment and parts contribute substantially to the industrial production in the state.

As per the annual survey of industries, the State has more than 1/4th share in the value of output for the country, in respect of the following industries: chemical and chemical products, rubber, plastics petroleum and coal products, metal products and parts, machinery and equipment (except transport equipment), transport equipments and parts, other manufacturing industries, repair of capital goods and the water works.

Table 2.10: Industrial Projects Registered & Implemented in Maharashtra

Years	Projects Registered			Projects Implemented		
	No.	Investment (in Rs. crore)	Targeted Employment (in '000)	No.	Investment (in Rs. crore)	Employment generated (in '000)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
*1991-92	778	20,673	150.53	441	11,8	64.9
1992-93	994	21,172	178.28	542	8,44	67.7
1993-94	1,480	18,092	229.65	850	9,67	80.9
1994-95	979	19,654	160.34	576	10,8	53.7
1995-96	1,077	20,780	210.35	611	10,6	44.6
1996-97	812	16,568	129.82	458	3,41	26.9
1997-98	576	6,947	84.54	347	2,83	24.8
1998-99	1,303	42,468	291.51	430	3,89	39.1
1999-2000	841	37,789	150.46	333	2,44	16.9
2000-01	724	15,114	120.17	273	1,58	15.2
2001-02	703	9,997	100.63	168	540	8.7
2002-03 **	181	5,081	19.14	32	65	0.8
Total	10,448	2,34,335	1,825.41	5,061	670.46	444.7

3. Socio-Economic Profile of the project influence area

3.1 Mumbai Metro City

3.1.1 Introduction

Looking to growth of Mumbai Metro City Govt of Maharashtra in addition to existing authorities like MCGM established Mumbai Metropolitan Region Development Authority (MMRDA) under the MMRDA Act 1974 primarily as planning and development authority for Mumbai Metropolitan Region (MMR) whose boundaries are defined by the said Act and its subsequent amendment. The present boundaries of MMR encompass a total area of 4,355 sq. km. MMR consists of the following revenue units:

- Mumbai City District
- Mumbai Suburban District
- Part of Thane District (comprising Thane, Kalyan, Bhiwandi and Ambernath Tehsils)
- Part of Vasai Tehsil
- Part of Raigad District
- Uran Tehsil; and
- Part of Panvel, Karjat, Khalapur, Pen and Alibaug Tehsils

3.1.2 Climate

The Climate of Mumbai is a tropical wet and dry climate. Mumbai's climate can be best described as moderately hot with high level of humidity. Its coastal nature and tropical location ensures temperatures won't fluctuate much throughout the year.

The mean average is 27.2 °C and average precipitation is 242.2 cm (95.35 inches). The mean maximum average temperatures in about 32 °C (90 °F) in summer and 30 °C (86 °F) in winter, while the average minimums are 25 °C (77 °F) in summer and 20.5 °C (68.9 °F) in winter. Mumbai experiences four distinct seasons: Winter (December–Feb); Summer (March–May); Monsoon (June–Sep); and Post-Monsoon (Oct–Dec).

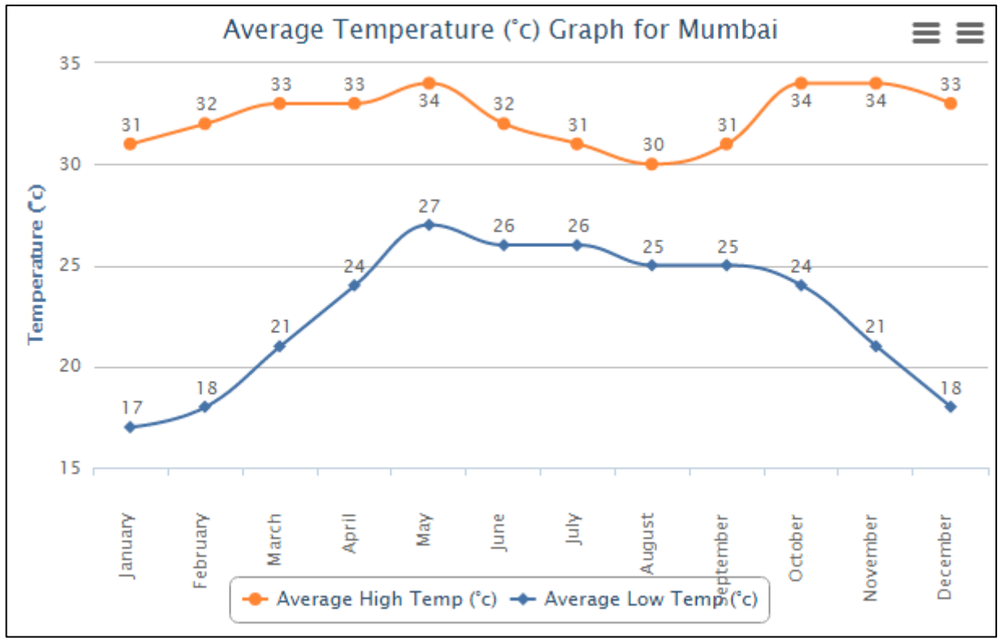


Figure 3.1: Average High/Low Temperature for Mumbai

NOTE: THE DATA FOR CHARTS ABOVE ARE TAKEN FROM YEAR 2000 TO 2012.

3.1.3 Population

Mumbai's 2013 population is estimated at 19 million, but its total metropolitan area is home to more than 20.5 million. As with other metropolitan areas in India, Mumbai's population has grown very rapidly over the past two decades, and much of its population are migrants from other regions in the country who came seeking better employment opportunities.

Mumbai's population has nearly doubled since 1991, when its population was just 12.5 million. This rapid expansion has led to serious health-related issues, and a large percentage of the population lives in slums.

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 Mumbaiker'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 MMR Population as per census of India 2011

Mumbai Metropolitan	Total	Male	Female
Population	18,414,288	9,894,088	8,520,200
Literates	15,132,568	8,423,992	6,708,576
Children (0-6)	1,743,997	917,855	826,142
Average Literacy (%)	90.78	93.85	87.19
Sex Ratio	861		
Child Sex Ratio	900		

3.1.4 Demographics

Mumbai is a real melting pot as people from all over the region move here in search of jobs. Mumbai, like most metropolitan areas of India, has a large polyglot population and 16 major languages of India are spoken here, including Gujarati, Hindi and Marathi, along with a colloquial form of Hindi called Bambaiya.

Mumbai's sex ratio is skewed, and a ward-level analysis of the last Census in 2013 found that 20 of the city's 24 municipal wards had a decline in child sex ratio in the past decade. The Worli-Prabhadevi region had the highest drop in child sex ratio. For every 1,000 boys, there are just 899 girls. This gender imbalance is visible throughout Mumbai and it's blamed on sex-selective abortions.

3.1.5 Average Rainfall in Mumbai

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.

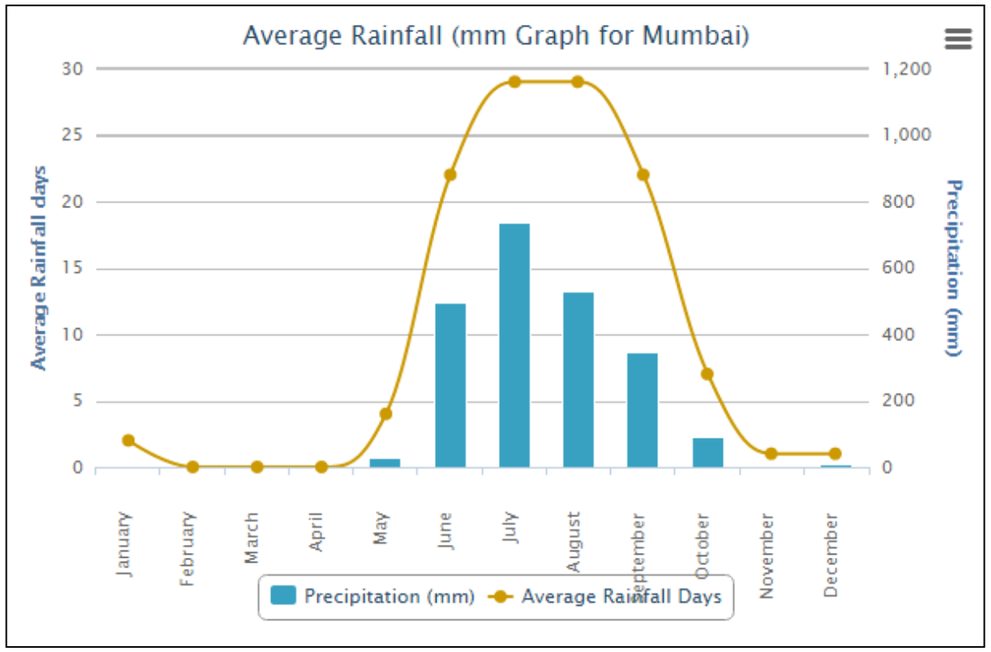


Figure 3.2: Average Rainfall for Mumbai

Note: The data for charts above are taken from year 2000 to 2012.

3.1.6 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.

3.2 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.

Comprehensive Transportation Study for MMR

Comprehensive Transportation Study (CTS) for Mumbai Metropolitan Region (MMR) has proposed extensive transport network for the travel needs of MMR for the horizon period up to 2031. Some of the proposed road corridors are missing links which can provide faster transport connectivity between Greater Mumbai and rest of the region.

As per CTS for MMR, following Highway Network is recommended on the western flank of the island city between Manora (MLA Hostel) area in the south to Malad- Versova in the north:

Table 3.2 Highway Corridor Description

Sr. No	Highway Corridor Description	Length (kms)
H20	Western Sea Link North Extn (Bandra-Dahisar)	26
H21	Western Sea Link North Extn (Dahisar-Virar): EBL Corridor 2016	38
H22	WesternSea Link South Extn (Worli-ColabaSea Link)	13.7

The recommended highway network comprises a significant road length running along the coastline of the city. The road network envisages a road running along the coastline from Nariman Point in the south to connect to Versova on the western flank of the city. Eastern Freeway runs along the eastern coast of the island city between south Mumbai to connect to Chembur and further to link to the eastern express highway at Ghatkopar. The proposed Sewri-Nhava Trans Harbour link (MTHL) will establish connectivity between Sewri on the main land and Nhava on the main land. The MTHL with the connecting road network and the multi modal Virar-Alibag corridor would complete a ring road around Mumbai.

MCGM authorities decided to take the planning and construction of Coastal road. Approximate length of the project corridor is about 35.6 km. The proposed Coastal road approximate length of the project corridor is about 35.6 kms from Nariman Point to Kandivali Junction link road. Figure 3.3 provides alignment of proposed Mumbai Coastal Road Project.

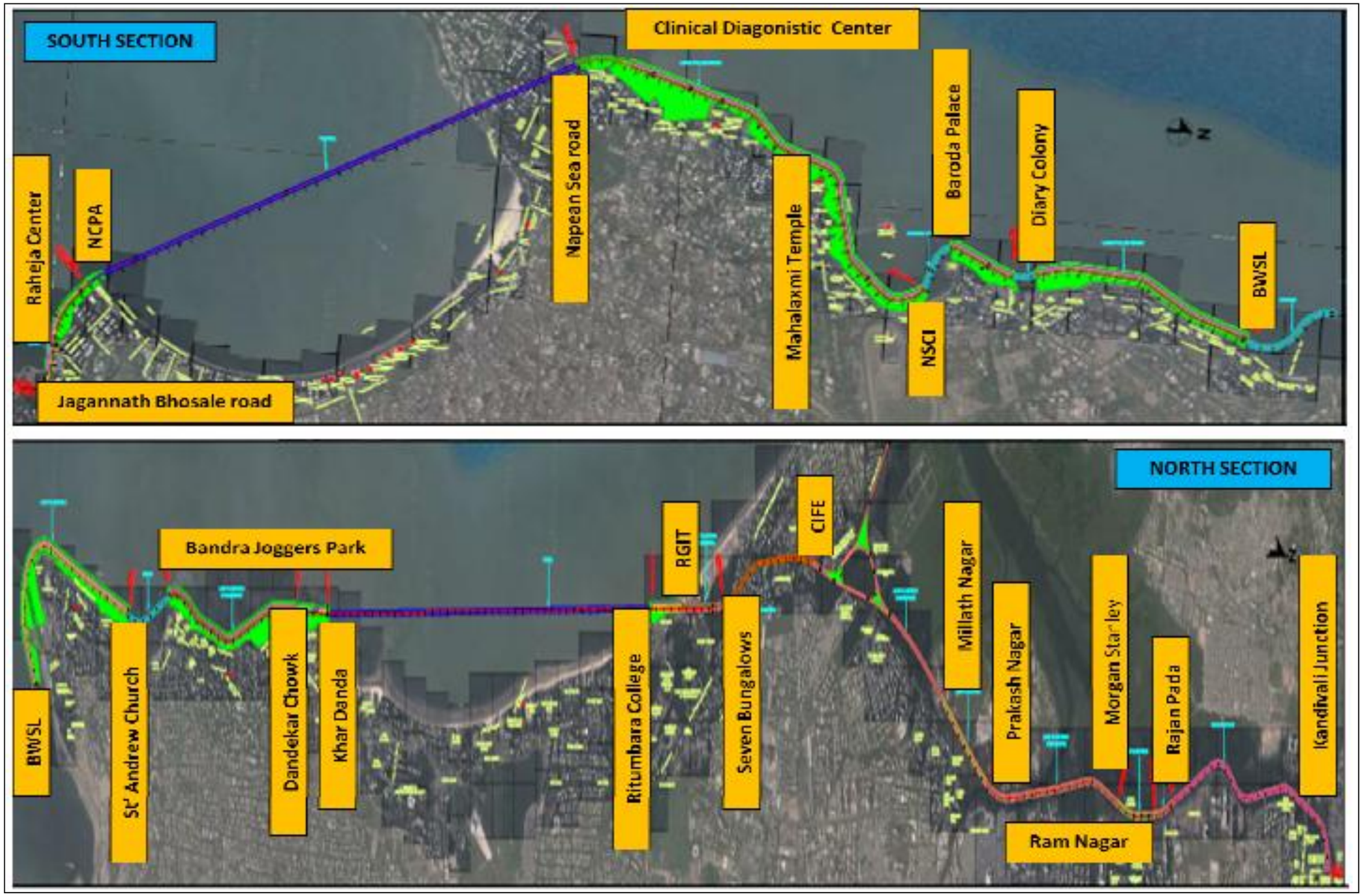


Figure 3.3: Alignment of Mumbai Coastal Road Project

4. Methodology Adopted for the Study

4.1 General

Methodology adopted for the study was initially presented in Inception Report. Design methodology relevant to each discipline is summarized in subsequent chapters.

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 MCGM. The secondary data includes:

Report on Coastal Road by Committee

- CTS for MMR
- Sub-surface and geo-technical data
- Sources of construction material
- Rainfall and flooding
- Coastal wave data including storm surges
- Data of Littoral drift
- Admiralty Charts

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 STUP's team and MCGM's officers. Identified alignments were visited to carry out ground reconnaissance survey. The data collected from the reconnaissance surveys was used for planning and programming the detailed surveys and investigations. All field studies are being undertaken on the basis of information derived from the reconnaissance surveys.

4.1.3 Field Investigations

The field investigations are being conducted on the approved alignment of project highway. Following surveys are being conducted on preferred alignment with their status as on 15 December 2012:

Stage 1:

- Traffic Surveys
- Classified Volume Count Survey
- Origin-Destination Survey
- Turning Movement Survey
- Axle Load Survey
- Speed and Delay Survey
- Topographic Survey

Satellite Imagery data and Shuttle Raddar Topography Mission (SRTM) covering project Area was completed in May 2014.

Strategic Environmental and Social Assessment and Screening

Stage 2:

Various permits necessary for carrying out engineering surveys and investigations were required to be obtained. The process of obtaining such permissions was started immediately after project inception. However, specific permissions related to location of surveys could be started only after finalization of preferred alignment alternative. Except security clearance from Indian Navy all significant permits have been obtained for the project investigations. Status of detailed investigations is as follows:

- Topographic Survey
- GPS survey completed in November 2014
- Total Station Survey Completed
- Bathymetry (ongoing)
- Geotechnical Studies: Ongoing
- Material Investigation: Completed
- Pavement Investigation: Completed
- Inventory of Structures: Completed
- Hydrological Survey: Completed
- Utilities Survey: Ongoing
- Environmental Monitoring: Completed
- Social Survey: Ongoing

4.1.4 Design Standards and Methodology

Primary objective of highway engineering 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 through Inception Report. The report is presented as Appendix—B to this report.

5. Traffic Studies and Analysis

5.1 Introduction

Traffic studies are essential for any road project, as it forms the basis for design of pavements, road capacity, and design of intersections and economic appraisal of the project. MMR has seen rapid geographic and economic growth over past two decades. This has lead to increased vehicle population causing traffic congestions during peak hours. CTS was carried out in 2006 by MMRDA to establish transportation networks necessary to cater for sustainable growth. Traffic studies for the project were conducted to relate the findings with CTS and conclusions were drawn.

5.2 Methodology

Traffic surveys were planned along the major highways at locations of inner cordon lines of CTS. This is to relate the current traffic with the CTS and update its impact on the project road. Seventeen locations were identified on the nodes of these inner cordon lines with existing arterial roads. Proposed traffic survey locations and its reasoning was presented to the MCGM for approval.

Following traffic surveys have been conducted along these nodes of cordon lines crossing major highways.

- 3 days Video Classified Traffic Volume Count & 4 days Manual count at 17 mid block locations
- One day Origin - Destination Survey at Seventeen midblock locations
- Speed and Delay Survey

The map at Figure 5.1 provides the Inter Cordon lines of Mumbai as per CTS report and Figure 5.2 provides traffic survey locations.

To build reliability into data collections, video surveys were carried out at all locations for minimum three days out of seven days traffic surveys. The data was then tabulated and analysed as per relevant IRC Codes. Proposed Coastal Road shall act as a bypass to existing traffic network being a completely new highway. It was necessary to establish traffic entering and exiting at each proposed interchange location. The traffic will predominantly get diverted from the current road network based on time and cost savings. Based on these parameters diversion factors were derived for each Origin & Destination (OD) data in OD matrix at each of the 17 traffic locations.

Figure 5.1: Inner Cordon lines from CTS Report

The traffic survey locations as per Inner Cordon lines given in the CTS report are shown below:

Figure 5.2: Traffic Survey Locations

Table – 5.20: Total Diversions to Coastal Road at each Traffic Survey Location based on O-D related Cost Savings

S.No	Location	ADT All Vehicles		ADT Divertable Vehicles	Zone ID	Productions %	Attractions %	Productions ADT	Attractions ADT	Total Diverted Traffic Both Directions
1	Kurar	In No's	184727	105029	13A	69%	62%	24068	22720	46788
		IN PCU	245648	133532				30600	28886	59486
2	Shankarwadi	In No's	216624	123727	11A	28%	26%	3577	3101	6678
		IN PCU	273544	153075				4426	3836	8262
3	Airport	In No's	270864	198981	9A	7%	7%	1785	1244	3029
		IN PCU	352508	221792				1990	1386	3376
4	Santacruz Flyover	In No's	222426	146282	9B	7%	10%	401	1724	2125
		IN PCU	307166	194527				533	2293	2825
5	Nanawati Hospital	In No's	66078	28486	11C	42%	43%	1677	1425	3102
		IN PCU	97955	32868				1935	1645	3579
6	Amboli	In No's	75026	34811	11B	26%	26%	1214	1584	2797
		IN PCU	104041	44396				1548	2020	3568
7	Malad west	In No's	38647	16827	13B	69%	60%	3891	3237	7128
		IN PCU	53464	20366				4710	3917	8627
8	Infinity mall	In No's	120235	46177	13C	71%	69%	10663	9699	20362
		IN PCU	164117	54571				12602	11462	24064
9	Sea link	In No's	49009	45544	9C	46%	45%	5195	3843	9038
		IN PCU	51544	47397				5407	4000	9406
10	Worli dairy	In No's	48699	46723	5	7%	8%	581	453	1035
		IN PCU	49326	47845				595	464	1059
11	Napean sea road	In No's	30349	24518	2B	8%	8%	38	502	540
		IN PCU	32161	27788				43	569	612
12	Peddar road	In No's	81943	73967	2A	4%	4%	685	533	1218
		IN PCU	83947	77967				722	562	1284
13	Marine drive	In No's	53466	45069	3	8%	8%	633	1067	1700
		IN PCU	53354	47057				661	1114	1775
14	Dadabhai Naoroji Road	ADT	59704	51270	1B	18%	52%	0	0	0
		IN PCU	64882	58556				0	0	0
15	P D Mellow Road	In No's	46008	36641	1A	15%	61%	0	0	0
		IN PCU	49220	38516				0	0	0
16	Gokhula road	In No's	37814	27077	7B	15%	14%	573	244	817
		IN PCU	40252	32200				682	290	971
17	Mahim	In No's	213769	143830	7A	8%	8%	1515	1582	3097
		IN PCU	220612	168148				1771	1850	3621

5.3 Traffic Demand Forecast

The number of total registered vehicles in Maharashtra (2008-2012) is growing at 11.46% per annum and is presented in Table 5.21.

The main influence area of the corridor has been considered as Greater Mumbai Region and Rest of MMR covering Thane, Kalyan, Vashi, Navi Mumbai and Vasai Overall increase in registered vehicles (2008-2012) in these regions is 8.46% and 8.99% respectively (Table 5.21).

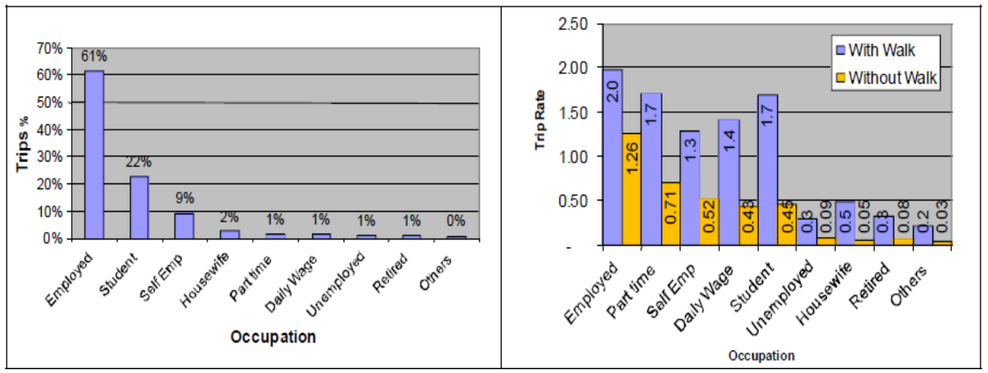
While the number of cars and taxis in Maharashtra is growing at 12.69% per annum, the growth of the same in Greater Mumbai (2010-2012) is 8.30% per annum.

Year	Total Registered Cars and Taxis as on31st March	
	Greater Mumbai	Rest of MMR
2010	598,710	465,270
2011	637,332	499,978
2012	702,157	537,275
Growth per Annum (2010-2012)	8.30%	7.46%

Since global economic downturn and high growth of Pune, population growth of Mumbai Island and MMR has slowed down significantly. Growth of traffic in CTS report was estimated based on almost linear growth in population till 2031. However due to economic downturn, competition by surrounding cities and acute rise in property prices the population growth of MMR has stabilised over past decade. This means that organic increase in the population was compensated by migration from MMR. However, it is expected that with correction property price, the inventory of unsold houses on market will be sold out over next 5 to 8 years along with new projects mainly aimed at low income and middle income groups. It is unlikely that the actual population growth in MMR will match organic growth in population. Therefore, an increase in population by 5% is assumed over next two decades, mostly towards Navi Mumbai.

Per Capita Trip Rates (PCTR)

The trip rates observed during CTS study and provided in the report are given below:



However, considering that coastal road traffic will mainly comprise of cars only the growth rate of traffic will be governed by car ownership. Car ownership per 1000 population in 2011 was 139 cars for MMR. CTS has estimated the car ownership of 204 cars per 1000 population of MMR in 2021 and 266 cars per 1000 population of MMR in 2031. However, considering estimates for other cities it is likely that Car ownership in MMR shall stabilise at 180 cars per 1000 population by 2031. Considering this along with 5% increase in population over next two decades and 3% growth thereafter till 2041, the growth in car traffic has been estimated as, presented in **Table 5.23**.

Table – 5.23: Growth Rates in Different Scenarios

Year	Growth Scenario – Per Annum in (%)
2015 -2019	3.00
2020 - 2024	2.72
2025 - 2029	2.30
2030 - 2034	1.32
2035 - 2039	0.30
2040 - 2043	0.30
Overall Growth	1.67

However for estimation capacity an overall growth rate of 2% has been considered.

5.4 Lane Capacity

Capacity analysis is fundamental to planning, design and operation of roads. Among other things, it provides the basis for determining the number of traffic lanes to be provided for different road sections having regard to volume, composition and other parameters of traffic. Alternatively, for an existing road network, the capacity analysis provides a means of assessing the traffic carrying ability of the number of traffic lanes provided for a given road link under the prevailing roadway and traffic conditions. Capacity standards can therefore help in rational evaluation of the investments needed for further road construction and improvements.

Level of Service:

As per IRC– 106:1990 "Guidelines for Capacity of Urban roads in plain areas". LOS is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by drivers/passengers. Under prevailing circumstances LOS B is considered an appropriate target. The volume of traffic will be 70% of the max. Capacity and this is taken as the "design service volume". In the LOS B condition is in the zone of stable flow, with the drivers still having reasonable freedom to select their desire speed and maneuver within the traffic stream. below. Construction of additional east-west links will result in significant increase in traffic volume along the coastal road considering overall traffic growth in MMR.

Figure – 5.9: Interchange Locations

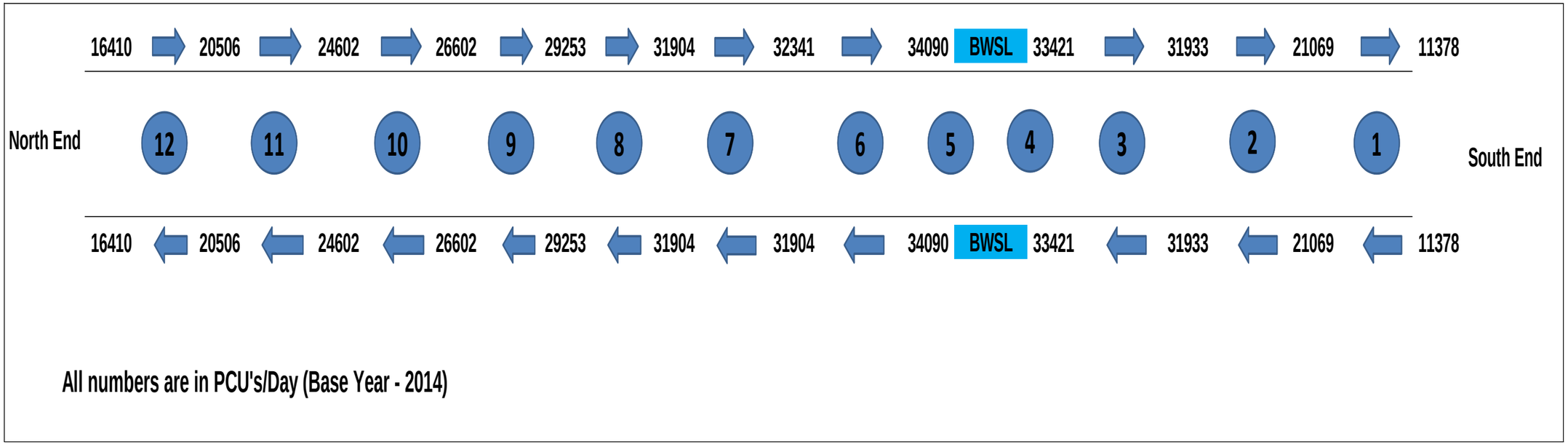


Figure – 5.10: Link Traffic between Interchanges – Base Year 2014

Figure – 5.11: Interchange Locations

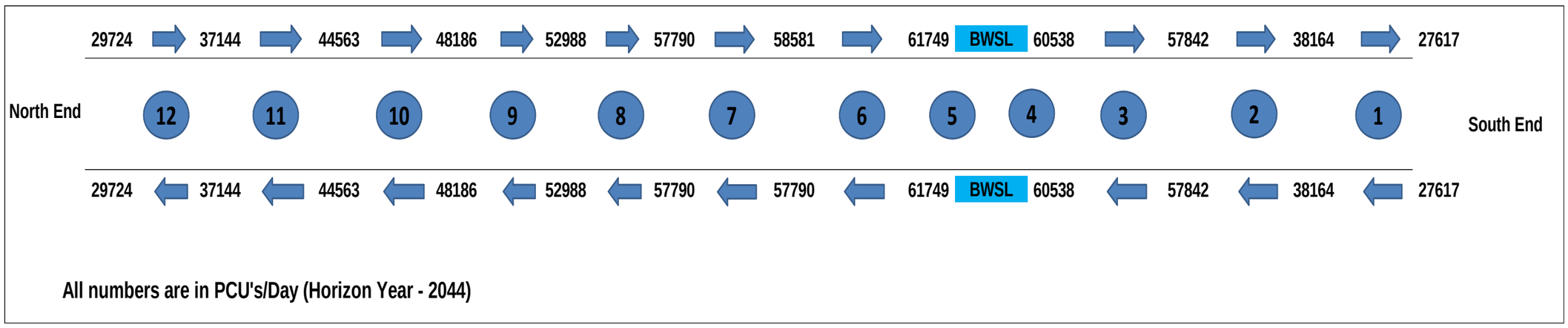


Figure – 5.12: Link Traffic between Interchanges – Base Year 2043

Table – 24a: Lance Capacity – North Bound Carriageway

Year	12	Lane Configuration	12 - 11	Lane Configuration	11 - 10	Lane Configuration	10 - 9	Lane Configuration	9 - 8	Lane Configuration	8 - 7	Lane Configuration	7 - 6	Lane Configuration	6 - 5	Lane Configuration	4 - 3	Lane Configuration	3 - 2	Lane Configuration	2 - 1	Lane Configuration	1	Lane Configuration
2014 (ADT)	910	2 Lane	1686	2 Lane	2555	3 Lane	2674	3 Lane	2727	3 Lane	2587	3 Lane	2552	3 Lane	2340	2 Lane	2128	2 Lane	1968	2 Lane	1640	2 Lane	1313	2 Lane
2015	928	2 Lane	1719	2 Lane	2606	3 Lane	2727	3 Lane	2782	3 Lane	2639	3 Lane	2603	3 Lane	2387	2 Lane	2171	2 Lane	2008	2 Lane	1673	2 Lane	1339	2 Lane
2016	947	2 Lane	1754	2 Lane	2658	3 Lane	2782	3 Lane	2837	3 Lane	2692	3 Lane	2655	3 Lane	2435	3 Lane	2214	2 Lane	2048	2 Lane	1707	2 Lane	1366	2 Lane
2017	966	2 Lane	1789	2 Lane	2711	3 Lane	2837	3 Lane	2894	3 Lane	2746	3 Lane	2709	3 Lane	2483	3 Lane	2258	2 Lane	2089	2 Lane	1741	2 Lane	1393	2 Lane
2018	985	2 Lane	1824	2 Lane	2765	3 Lane	2894	3 Lane	2952	3 Lane	2801	3 Lane	2763	3 Lane	2533	3 Lane	2304	2 Lane	2130	2 Lane	1776	2 Lane	1421	2 Lane
2019	1005	2 Lane	1861	2 Lane	2821	3 Lane	2952	3 Lane	3011	3 Lane	2857	3 Lane	2818	3 Lane	2584	3 Lane	2350	2 Lane	2173	2 Lane	1811	2 Lane	1449	2 Lane
2020	1025	2 Lane	1898	2 Lane	2877	3 Lane	3011	3 Lane	3071	3 Lane	2914	3 Lane	2874	3 Lane	2635	3 Lane	2397	2 Lane	2216	2 Lane	1847	2 Lane	1478	2 Lane
2021	1046	2 Lane	1936	2 Lane	2934	3 Lane	3071	3 Lane	3133	3 Lane	2972	3 Lane	2932	3 Lane	2688	3 Lane	2445	3 Lane	2261	2 Lane	1884	2 Lane	1508	2 Lane
2022	1066	2 Lane	1975	2 Lane	2993	3 Lane	3133	3 Lane	3195	3 Lane	3031	3 Lane	2990	3 Lane	2742	3 Lane	2493	3 Lane	2306	2 Lane	1922	2 Lane	1538	2 Lane
2023	1088	2 Lane	2014	2 Lane	3053	3 Lane	3195	3 Lane	3259	3 Lane	3092	3 Lane	3050	3 Lane	2797	3 Lane	2543	3 Lane	2352	2 Lane	1961	2 Lane	1569	2 Lane
2024	1110	2 Lane	2055	2 Lane	3114	3 Lane	3259	3 Lane	3324	3 Lane	3154	3 Lane	3111	3 Lane	2853	3 Lane	2594	3 Lane	2399	2 Lane	2000	2 Lane	1600	2 Lane
2025	1132	2 Lane	2096	2 Lane	3176	3 Lane	3324	3 Lane	3391	3 Lane	3217	3 Lane	3173	3 Lane	2910	3 Lane	2646	3 Lane	2447	3 Lane	2040	2 Lane	1632	2 Lane
2026	1154	2 Lane	2138	2 Lane	3240	3 Lane	3391	3 Lane	3459	3 Lane	3281	3 Lane	3237	3 Lane	2968	3 Lane	2699	3 Lane	2496	3 Lane	2081	2 Lane	1665	2 Lane
2027	1177	2 Lane	2180	2 Lane	3305	3 Lane	3459	3 Lane	3528	3 Lane	3347	3 Lane	3302	3 Lane	3027	3 Lane	2753	3 Lane	2546	3 Lane	2122	2 Lane	1698	2 Lane
2028	1201	2 Lane	2224	2 Lane	3371	3 Lane	3528	3 Lane	3598	3 Lane	3414	3 Lane	3368	3 Lane	3088	3 Lane	2808	3 Lane	2597	3 Lane	2165	2 Lane	1732	2 Lane
2029	1225	2 Lane	2268	2 Lane	3438	3 Lane	3598	3 Lane	3670	4 Lane	3482	3 Lane	3435	3 Lane	3150	3 Lane	2864	3 Lane	2649	3 Lane	2208	2 Lane	1767	2 Lane
2030	1250	2 Lane	2314	2 Lane	3507	3 Lane	3670	4 Lane	3744	4 Lane	3552	3 Lane	3504	3 Lane	3213	3 Lane	2922	3 Lane	2702	3 Lane	2252	2 Lane	1802	2 Lane
2031	1275	2 Lane	2360	2 Lane	3577	3 Lane	3744	4 Lane	3819	4 Lane	3623	4 Lane	3574	3 Lane	3277	3 Lane	2980	3 Lane	2756	3 Lane	2297	2 Lane	1838	2 Lane
2032	1300	2 Lane	2407	3 Lane	3649	4 Lane	3819	4 Lane	3895	4 Lane	3695	4 Lane	3645	4 Lane	3342	3 Lane	3040	3 Lane	2811	3 Lane	2343	2 Lane	1875	2 Lane
2033	1326	2 Lane	2455	3 Lane	3722	4 Lane	3895	4 Lane	3973	4 Lane	3769	4 Lane	3718	4 Lane	3409	3 Lane	3100	3 Lane	2867	3 Lane	2390	2 Lane	1913	2 Lane
2034	1353	2 Lane	2505	3 Lane	3796	4 Lane	3973	4 Lane	4052	4 Lane	3845	4 Lane	3793	4 Lane	3477	3 Lane	3162	3 Lane	2925	3 Lane	2438	3 Lane	1951	2 Lane
2035	1380	2 Lane	2555	3 Lane	3872	4 Lane	4052	4 Lane	4134	4 Lane	3921	4 Lane	3868	4 Lane	3547	3 Lane	3226	3 Lane	2983	3 Lane	2486	3 Lane	1990	2 Lane
2036	1407	2 Lane	2606	3 Lane	3949	4 Lane	4133	4 Lane	4216	4 Lane	4000	4 Lane	3946	4 Lane	3618	4 Lane	3290	3 Lane	3043	3 Lane	2536	3 Lane	2030	2 Lane
2037	1435	2 Lane	2658	3 Lane	4028	4 Lane	4216	4 Lane	4301	4 Lane	4080	4 Lane	4025	4 Lane	3690	4 Lane	3356	3 Lane	3104	3 Lane	2587	3 Lane	2070	2 Lane
2038	1464	2 Lane	2711	3 Lane	4109	4 Lane	4300	4 Lane	4387	4 Lane	4161	4 Lane	4105	4 Lane	3764	4 Lane	3423	3 Lane	3166	3 Lane	2639	3 Lane	2112	2 Lane
2039	1493	2 Lane	2765	3 Lane	4191	4 Lane	4386	4 Lane	4474	4 Lane	4245	4 Lane	4187	4 Lane	3839	4 Lane	3491	3 Lane	3229	3 Lane	2691	3 Lane	2154	2 Lane
2040	1523	2 Lane	2821	3 Lane	4275	4 Lane	4474	4 Lane	4564	4 Lane	4330	4 Lane	4271	4 Lane	3916	4 Lane	3561	3 Lane	3294	3 Lane	2745	3 Lane	2197	2 Lane
2041	1554	2 Lane	2877	3 Lane	4360	4 Lane	4564	4 Lane	4655	4 Lane	4416	4 Lane	4357	4 Lane	3995	4 Lane	3633	4 Lane	3359	3 Lane	2800	3 Lane	2241	2 Lane
2042	1585	2 Lane	2935	3 Lane	4448	4 Lane	4655	4 Lane	4748	4 Lane	4505	4 Lane	4444	4 Lane	4074	4 Lane	3705	4 Lane	3427	3 Lane	2856	3 Lane	2286	2 Lane
2043	1616	2 Lane	2993	3 Lane	4537	4 Lane	4748	4 Lane	4843	5 Lane	4595	4 Lane	4533	4 Lane	4156	4 Lane	3779	4 Lane	3495	3 Lane	2913	3 Lane	2331	2 Lane
2044	1649	2 Lane	3053	3 Lane	4627	4 Lane	4843	5 Lane	4940	5 Lane	4686	4 Lane	4623	4 Lane	4239	4 Lane	3855	4 Lane	3565	3 Lane	2972	3 Lane	2378	2 Lane

Table – 24b: Lance Capacity – South Bound Carriageway

Year	1	Lane Configuration	1 - 2	Lane Configuration	2 - 3	Lane Configuration	3 - 4	Lane Configuration	5 - 6	Lane Configuration	6 - 7	Lane Configuration	7 - 8	Lane Configuration	8 - 9	Lane Configuration	9 - 10	Lane Configuration	10 - 11	Lane Configuration	11 - 12	Lane Configuration	12	Lane Configuration
2014 (ADT)	910	2 Lane	1686	2 Lane	2555	3 Lane	2674	3 Lane	2727	3 Lane	2552	3 Lane	2552	3 Lane	2340	2 Lane	2128	2 Lane	1968	2 Lane	1640	2 Lane	1313	2 Lane
2015	928	2 Lane	1719	2 Lane	2606	3 Lane	2727	3 Lane	2782	3 Lane	2603	3 Lane	2603	3 Lane	2387	2 Lane	2171	2 Lane	2008	2 Lane	1673	2 Lane	1339	2 Lane
2016	947	2 Lane	1754	2 Lane	2658	3 Lane	2782	3 Lane	2837	3 Lane	2655	3 Lane	2655	3 Lane	2435	3 Lane	2214	2 Lane	2048	2 Lane	1707	2 Lane	1366	2 Lane
2017	966	2 Lane	1789	2 Lane	2711	3 Lane	2837	3 Lane	2894	3 Lane	2709	3 Lane	2709	3 Lane	2483	3 Lane	2258	2 Lane	2089	2 Lane	1741	2 Lane	1393	2 Lane
2018	985	2 Lane	1824	2 Lane	2765	3 Lane	2894	3 Lane	2952	3 Lane	2763	3 Lane	2763	3 Lane	2533	3 Lane	2304	2 Lane	2130	2 Lane	1776	2 Lane	1421	2 Lane
2019	1005	2 Lane	1861	2 Lane	2821	3 Lane	2952	3 Lane	3011	3 Lane	2818	3 Lane	2818	3 Lane	2584	3 Lane	2350	2 Lane	2173	2 Lane	1811	2 Lane	1449	2 Lane
2020	1025	2 Lane	1898	2 Lane	2877	3 Lane	3011	3 Lane	3071	3 Lane	2874	3 Lane	2874	3 Lane	2635	3 Lane	2397	2 Lane	2216	2 Lane	1847	2 Lane	1478	2 Lane
2021	1046	2 Lane	1936	2 Lane	2934	3 Lane	3071	3 Lane	3133	3 Lane	2932	3 Lane	2932	3 Lane	2688	3 Lane	2445	3 Lane	2261	2 Lane	1884	2 Lane	1508	2 Lane
2022	1066	2 Lane	1975	2 Lane	2993	3 Lane	3133	3 Lane	3195	3 Lane	2990	3 Lane	2990	3 Lane	2742	3 Lane	2493	3 Lane	2306	2 Lane	1922	2 Lane	1538	2 Lane
2023	1088	2 Lane	2014	2 Lane	3053	3 Lane	3195	3 Lane	3259	3 Lane	3050	3 Lane	3050	3 Lane	2797	3 Lane	2543	3 Lane	2352	2 Lane	1961	2 Lane	1569	2 Lane
2024	1110	2 Lane	2055	2 Lane	3114	3 Lane	3259	3 Lane	3324	3 Lane	3111	3 Lane	3111	3 Lane	2853	3 Lane	2594	3 Lane	2399	2 Lane	2000	2 Lane	1600	2 Lane
2025	1132	2 Lane	2096	2 Lane	3176	3 Lane	3324	3 Lane	3391	3 Lane	3173	3 Lane	3173	3 Lane	2910	3 Lane	2646	3 Lane	2447	3 Lane	2040	2 Lane	1632	2 Lane
2026	1154	2 Lane	2138	2 Lane	3240	3 Lane	3391	3 Lane	3459	3 Lane	3237	3 Lane	3237	3 Lane	2968	3 Lane	2699	3 Lane	2496	3 Lane	2081	2 Lane	1665	2 Lane
2027	1177	2 Lane	2180	2 Lane	3305	3 Lane	3459	3 Lane	3528	3 Lane	3302	3 Lane	3302	3 Lane	3027	3 Lane	2753	3 Lane	2546	3 Lane	2122	2 Lane	1698	2 Lane
2028	1201	2 Lane	2224	2 Lane	3371	3 Lane	3528	3 Lane	3598	3 Lane	3368	3 Lane	3368	3 Lane	3088	3 Lane	2808	3 Lane	2597	3 Lane	2165	2 Lane	1732	2 Lane
2029	1225	2 Lane	2268	2 Lane	3438	3 Lane	3598	3 Lane	3670	4 Lane	3435	3 Lane	3435	3 Lane	3150	3 Lane	2864	3 Lane	2649	3 Lane	2208	2 Lane	1767	2 Lane
2030	1250	2 Lane	2314	2 Lane	3507	3 Lane	3670	4 Lane	3744	4 Lane	3504	3 Lane	3504	3 Lane	3213	3 Lane	2922	3 Lane	2702	3 Lane	2252	2 Lane	1802	2 Lane
2031	1275	2 Lane	2360	2 Lane	3577	3 Lane	3744	4 Lane	3819	4 Lane	3574	3 Lane	3574	3 Lane	3277	3 Lane	2980	3 Lane	2756	3 Lane	2297	2 Lane	1838	2 Lane
2032	1300	2 Lane	2407	3 Lane	3649	4 Lane	3819	4 Lane	3895	4 Lane	3645	4 Lane	3645	4 Lane	3342	3 Lane	3040	3 Lane	2811	3 Lane	2343	2 Lane	1875	2 Lane
2033	1326	2 Lane	2455	3 Lane	3722	4 Lane	3895	4 Lane	3973	4 Lane	3718	4 Lane	3718	4 Lane	3409	3 Lane	3100	3 Lane	2867	3 Lane	2390	2 Lane	1913	2 Lane
2034	1353	2 Lane	2505	3 Lane	3796	4 Lane	3973	4 Lane	4052	4 Lane	3793	4 Lane	3793	4 Lane	3477	3 Lane	3162	3 Lane	2925	3 Lane	2438	3 Lane	1951	2 Lane
2035	1380	2 Lane	2555	3 Lane	3872	4 Lane	4052	4 Lane	4134	4 Lane	3868	4 Lane	3868	4 Lane	3547	3 Lane	3226	3 Lane	2983	3 Lane	2486	3 Lane	1990	2 Lane
2036	1407	2 Lane	2606	3 Lane	3949	4 Lane	4133	4 Lane	4216	4 Lane	3946	4 Lane	3946	4 Lane	3618	4 Lane	3290	3 Lane	3043	3 Lane	2536	3 Lane	2030	2 Lane
2037	1435	2 Lane	2658	3 Lane	4028	4 Lane	4216	4 Lane	4301	4 Lane	4025	4 Lane	4025	4 Lane	3690	4 Lane	3356	3 Lane	3104	3 Lane	2587	3 Lane	2070	2 Lane
2038	1464	2 Lane	2711	3 Lane	4109	4 Lane	4300	4 Lane	4387	4 Lane	4105	4 Lane	4105	4 Lane	3764	4 Lane	3423	3 Lane	3166	3 Lane	2639	3 Lane	2112	2 Lane
2039	1493	2 Lane	2765	3 Lane	4191	4 Lane	4386	4 Lane	4474	4 Lane	4187	4 Lane	4187	4 Lane	3839	4 Lane	3491	3 Lane	3229	3 Lane	2691	3 Lane	2154	2 Lane
2040	1523	2 Lane	2821	3 Lane	4275	4 Lane	4474	4 Lane	4564	4 Lane	4271	4 Lane	4271	4 Lane	3916	4 Lane	3561	3 Lane	3294	3 Lane	2745	3 Lane	2197	2 Lane
2041	1554	2 Lane	2877	3 Lane	4360	4 Lane	4564	4 Lane	4655	4 Lane	4357	4 Lane	4357	4 Lane	3995	4 Lane	3633	4 Lane	3359	3 Lane	2800	3 Lane	2241	2 Lane
2042	1585	2 Lane	2935	3 Lane	4448	4 Lane	4655	4 Lane	4748	4 Lane	4444	4 Lane	4444	4 Lane	4074	4 Lane	3705	4 Lane	3427	3 Lane	2856	3 Lane	2286	2 Lane
2043	1616	2 Lane	2993	3 Lane	4537	4 Lane	4748	4 Lane	4843	5 Lane	4533	4 Lane	4533	4 Lane	4156	4 Lane	3779	4 Lane	3495	3 Lane	2913	3 Lane	2331	2 Lane
2044	1649	2 Lane	3053	3 Lane	4627	4 Lane	4843	5 Lane	4940	5 Lane	4623	4 Lane	4623	4 Lane	4239	4 Lane	3855	4 Lane	3565	3 Lane	2972	3 Lane	2378	2 Lane

5.5 Interchanges

Interchanges will be necessary at all crossings of highway which are to be developed as completely access controlled. An interchange may be justified at the crossing of a major arterial road with another road of similar category carrying heavy traffic.

We have studied the requirement of traffic interchanges at the major junctions on project corridor as per IRC: 92-1985 (Guidelines for the design of Interchanges in Urban Areas) and IRC: SP: 41-1994 (Guidelines for the Design of At- Grade Intersections in Rural and Urban Areas) etc.

These studies are the base for deciding many components like approach width & exit width, approach & exit angles etc. However, the objective of the present study is to assess the Directional Traffic volumes at the proposed interchanges

Traffic flow diagrams for the twelve interchanges separately for the base year (2014) and horizon year (2043) are studied and given below.

5.5.1 Proposed Interchange Locations

The proposed Interchanges Locations for coastal road are listed below:

- Jagannath Bhosale Marg Interchange
- Amarsons Garden Interchange
- Haji Ali Interchange
- Bandra Worli Sea Link Interchange (Worli)
- Bandra Worli Sea Link Interchange (Bandra)
- Otters Club interchange
- Carter Road Interchange (Danda Village)
- Ritumbara College Interchange
- MADH Island Interchange (Institute of Fisheries Education)
- Oshiwara Interchange
- Malad Interchange
- Kandiwali Interchange

5.5.2 Directional Traffic

Table – 5.25: Peak Hour Link Traffic/Hr/Lane (Towards South)

Link	2014	2019	2024	2029	2034	2039	2043
12	1313	1449	1600	1767	1951	2154	2378
12 - 11	1640	1811	2000	2208	2438	2691	2972
11 - 10	1968	2173	2399	2649	2925	3229	3565
10 - 9	2128	2350	2594	2864	3162	3491	3855
9 - 8	2340	2584	2853	3150	3477	3839	4239
8 - 7	2552	2818	3111	3435	3793	4187	4623
7 - 6	2587	2857	3154	3482	3845	4245	4686
6 - 5	2727	3011	3324	3670	4052	4474	4940
4 - 3	2674	2952	3259	3598	3973	4386	4843
3 - 2	2555	2821	3114	3438	3796	4191	4627
2 - 1	1686	1861	2055	2268	2505	2765	3053
1	910	1005	1110	1225	1353	1493	1649

Table – 5.26: Peak Hour Link Traffic/Hr/Lane (Towards North)

Link	2014	2019	2024	2029	2034	2039	2043
1	910	1005	1110	1225	1353	1493	1649
1 - 2	1686	1861	2055	2268	2505	2765	3053
2 - 3	2555	2821	3114	3438	3796	4191	4627
3 - 4	2674	2952	3259	3598	3973	4386	4843
5 - 6	2727	3011	3324	3670	4052	4474	4940
6 - 7	2552	2818	3111	3435	3793	4187	4623
7 - 8	2552	2818	3111	3435	3793	4187	4623
8 - 9	2340	2584	2853	3150	3477	3839	4239
9 - 10	2128	2350	2594	2864	3162	3491	3855
10 - 11	1968	2173	2399	2649	2925	3229	3565
11 - 12	1640	1811	2000	2208	2438	2691	2972
12	1313	1449	1600	1767	1951	2154	2378

6. Alignment Studies

6.1 Project Influence Area

In order to formulate alignment options it is necessary to identify various site constraints that may affect the outcome of the alignment options studies. Site constraints for a road project can be of following nature or their combinations:

Engineering constraint

Socio-Environmental constraint

Financial constraint

Based on estimated capacity it is coastal road is proposed as a eight lane road. Various site constraints are defined in subsequent paragraphs.

6.1.1 Project Sections

Based on traffic pattern and probable construction aspects following broad sections were identified:

Part A: South (Jagannath Bhosale Road to Worli end of Sea Link)

Section 1: Jagannath Bhosale Road to Priya Darshini Park

Section 2: Priya Darshini Park to Mahalaxmi

Section 3: Mahalaxmi to Baroda Palace

Section 4: Baroda Palace to Worli End of Sea Link

Part B: North (Bandra end of Sea Link to Kandivali Junction)

Section 5: Bandra End of Sea Link to Juhu Sea Side Garden

Section 6: Juhu Sea Side Garden to Ritumbhara College

Section 7: Ritumbhara College to Kandivali Junction and Central Institute of Fisheries, Versova to Madh Island

6.1.2 Engineering and Social Constraints

Alignment passing through tidal zone requiring protection from waves and storm surge;

Highway to be designed to expressway standards considering its functionality;

Providing adequate cross sectional standards to accommodate future developments

Environmental Constraints:

- Alignment in CRZ/ coastal area
- Climate change/ sea level rise
- High pollution due to congestion
- Aesthetic and social aspects
- Land Availability
- Storm water and sewage discharges
- Locations of Archaeological and religious importance
- Social Aspects

Figure 6.1: Section 1: Jagannath Bhosale Road to Priya Darshini Park

In this section main constraints are Fisherman route near Manora, Ganpati visarjan area of Girgaon Chowpati and slum areas near Bimla House as shown in Figure 6.1. Also note that there are many structures of Archaeological importance having heritage value along the Marine Drive, which are highlighted with red

Figure 6.2: Section 2: Priya Darshini Park to Mahalaxmi

In this section main constraints are slum are near Clinical Diagnostic Centre, Heritage structure at Lincoln House (Grade II-B) and religious area of Mahalaxmi Temple as shown in Figure 6.2.

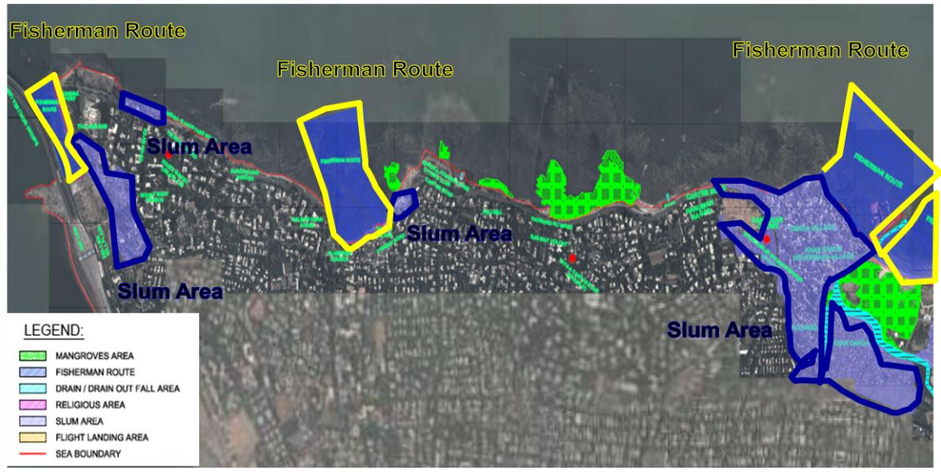
Figure 6.3: Section 3: Mahalaxmi to Baroda Palace

In this section main constraints are slum near Haji Ali, religious area of Haji Ali and at Baroda Palace are shown in figure6.3.

Figure 6.4: Section 4: Baroda Palace to Worli End of Sea Link

In this section main constraints are religious area at Baroda Palace; slum areas at near Poonam Chambers and near Worli Dairy, drainage outfall of Worli Dairy are shown in figure 6.4.

Figure 6.5: Section 5: Bandra End of Sea Link to Juhu Sea Side Garden

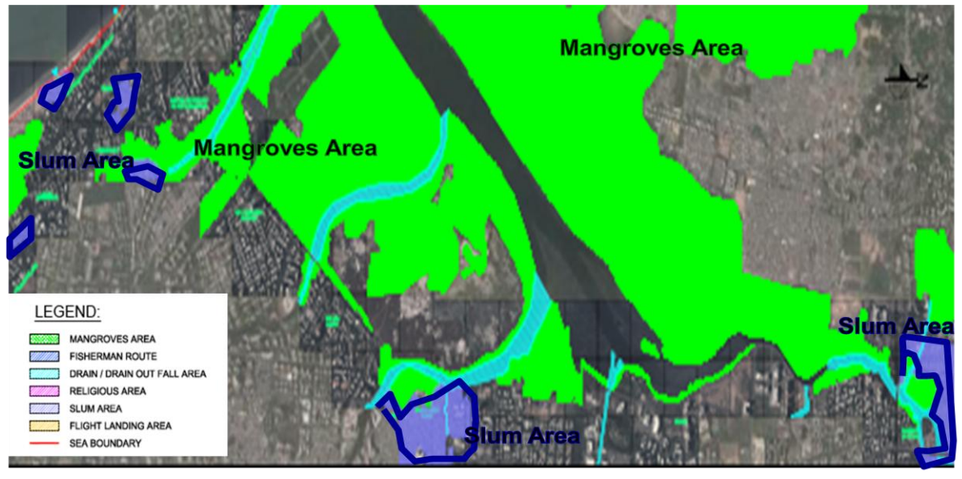


In this section main constraints are fishermen routes near Bandra Worli sea link toll plaza, Bandra Band Stand, Chimbai Village, near Khar danda village. There are large slum areas near Sea Link and Khar Danda village. Presence of protected mangroves forest was observed abutting existing shore line from Bandra Jogger's Park till Khar Danda village. These are depicted in figure 6.5.

Figure 6.6:Section 6: Juhu Sea Side Garden to Ritumbhara College

In this section main constraints are fishermen route near Juhu Sea Side Garden, Juhu airport Flight path and presence of numerous slum areas near Leela Bunglow, Indra Nagar, Juhu Koliwada, Moragaon Juhu and Mangroves area near Versova , Juhu beach, Rajiv Gandhi Institute of Technology, Bharat nagar as shown in figure 6.6.

Figure 6.7:Section 7: Ritumbhara College to Kandivali Junction and Central Institute of Fisheries, Versova to Madh Island



In this section main constraints are slum areas, drainage outfalls, and protected mangroves forest area as presented in figure 6.7.

6.1.3 Environmental Constraints

The proposed coastal road from Nariman point to Kandivali junction link road passes near to densely populated areas of Greater Mumbai. Presently traffic moves at an average speed of 20 kmph due to congestion on roads. Pedestrian facilities are lacking the serviceability needs. This has resulted air and noise pollution. Noise levels in most parts of city during day and night time have exceeded 65 decibels. Such high level of noise pollution results in long term impacts on citizens including degradation of mental health and loss of hearing. The air pollution at such high levels also results in various diseases. There are very less green spaces and public areas. Citizens of Mumbai also spend three hours average time every day in commuting for work in overcrowded public transport. All these aspects have resulted degradation of quality of life of citizens.

Therefore, the issues involved are:

- 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
- Pedestrian movement along and across the proposed road;
- Aesthetic issues related to flyovers or any other road structures;
- Aesthetic and social aspects
- Noise and air pollution due to fast moving, breaking and standing vehicles.

6.1.4 Financial Constraints

The proposed coastal road is expressway standard road. Therefore, it will be necessary to provide traffic connectivity i.e. Interchanges/at grade junctions wherever necessary and protection against tidal impact. This also will have to cater Environmental mitigation measures. It is also necessary to optimize the cost of road in order to achieve financial viability. Therefore, road alignment design will be constrained by the cost of construction, maintenance and operation.The following prime objectives are considered for selecting alignment options:

- Minimum length of tunnel
- Minimum length of flyovers, bridges and viaducts
- Maximum use of existing infrastructure and land
- Minimum rehabilitation and resettlement
- Minimum impact on Mangroves and other environmentally sensitive areas

6.2 Project Alignment

6.2.1 General

Report on "Mumbai Coastal Freeway Concept" by Joint Technical Committee towards this project has been made available by MCGM to us. This report presents two alternative alignment options.

After reviewing same we explored various other alignment options. This chapter describes all the options that have been made for various aspects of the project road.

We have studied various options for the proposed road, based on the objectives mentioned in chapter 3 of this report. Satellite imagery and levels extracted from Google Earth Pro software, assisted by site visits/reconnaissance survey were used to determine various alignment options. Six alignment options were considered including two options of joint Technical Committee and evaluated considering socio economic parameters. For each alternative block cost estimate is prepared. Total alignment is divided into two parts considering the terrain classification and further sub divided in sections as detailed below.

Part 1: South (Jagannath Bhosale Road to Worli end of Sea Link)

Section 1: Jagannath Bhosale Road to Priya Darshini Park

Section 2: Priya Darshini Park to Mahalaxmi

Section 3: Mahalaxmi to Baroda Palace

Section 4: Baroda Palace to Worli End of Sea Link

Part 2: North (Bandra end of Sea Link to Kandivali Junction)

Section 5: Bandra End of Sea Link to Juhu Sea Side Garden

Section 6: Juhu Sea Side Garden to Ritumbhara College

Section 7: Ritumbhara College to Kandivali Junction and Central Institute of Fisheries, Versova to Madh Island

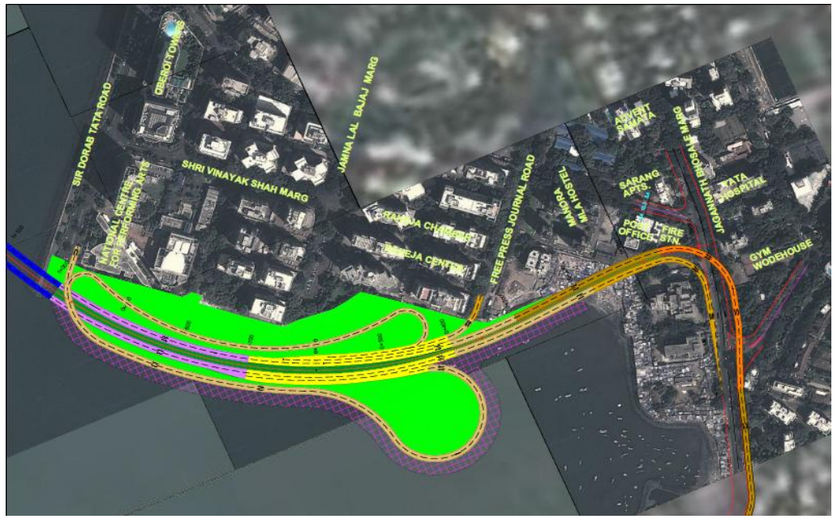
All six alignment options are briefed hereunder in subsequent paragraphs

6.2.2 Alignment Options

Six alignment options were considered with option-1 and Option-2 were adopted from the coastal road committee's recommendations. Section wise analysis of all options is included in subsequent paragraphs. Therefore review of options proposed by the committee is also included in each section. Option-7 was developed as a final option by combining preferred option for each section.

Based on above analysis alignment option-7 was formed and presented in figure---. The same is being considered for carrying out various engineering surveys and detailed design.

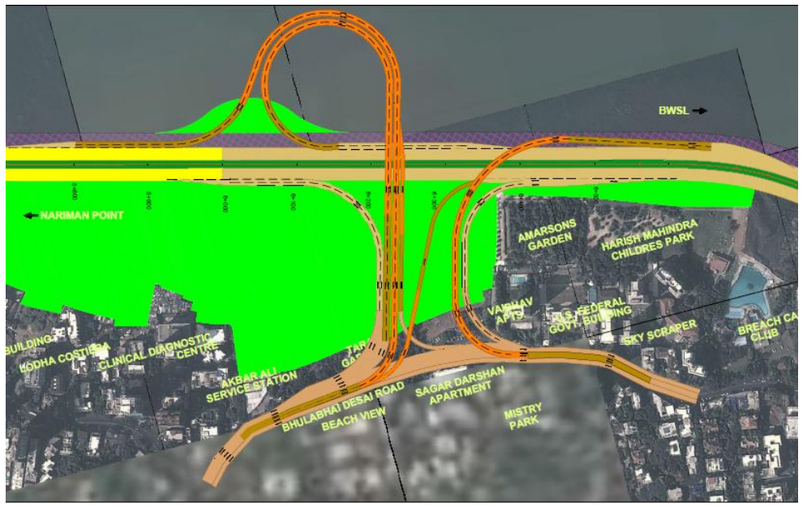
Interchange Design and Dispersal Scheme



The proposed project road alignment starts by providing acceleration or deceleration at entry and exit to connect the existing road. Entry and exit road of proposed alignment will connect to the Marine Drive road and Free Press Journal road respectively.

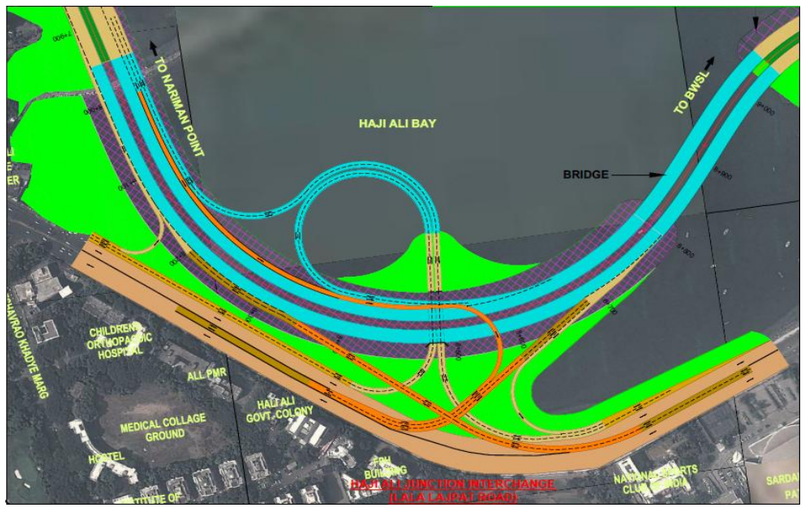
Amarsons Garden Interchange:

The proposed interchange connects the traffic to proposed alignment just after end of tunnel and ramp section. This trumped interchange will connect the traffic on Bhula Bhai Desai Marg (Warden Road). This interchange will give the connectivity to traffic from kalvadevi, Girgaon, Bhuleswar, Malabar Hill, Kemp's Corner Area. Entry ramp of this junction start from Tara Garden and exit ramp end near to the U. S. Federal Government Building on existing Bhula Bhai Desai Road.



This interchange has 8 free flow movement of traffic between existing road and proposed costal road without any traffic conflict. Interchange location is near to Ch. 6+250 of proposed costal road south alignment just after end of marin drive tunnel section.

Haji Ali Interchange:



This Junction is most important interchange to provide connection for religious place and business area. After crossing the Mahalxmi Temple and pedestrian underpass for Haji Ali Dargah provide the connectivity with Lala Lajpatrai Marg by using first level round about interchange. Interchange will provide the entry and exit connection for both traffic coming from south and north of Mumbai. This will provide the connectivity to the Mumbai Central Terminus, Cumballa Hill, Tradco, Tulsiwadi, Agripada, Maha Laxmi Race Course, Peddar Road, Pandit Madan Mohan Malviya Marg and Clarke Road area. Existing road and costal road traffic free from conflict. This interchange location is near to Ch. 8+500 of proposed costal road south alignment near Hahi Ali Dargah Junction.

Bandra Worli Sea Link Interchange (Worli):

South face of Bandra Worli Sea Link (BWSL) at worli will connect to proposed alignment and before this merging one interchange proposed to provide the connectivity with existing road. This trumped interchange will connect the Khan Abdul Gaffar Khan Marg near Gautam Buddha Udyan to proposed alignment by entry and exit facility. This interchange will provide the connectivity to the prabhadevi, dadar west, worli, parel, lower parel, worli dairy and upper worli area. This interchange provides conflict free traffic movement for all movement. Traffic coming from north of BWSL want to exit from costal road will follow the existing bridge of BWSL. Then it will conflict to existing road traffic, to avoid this conflict provide one VUP at existing road. Interchange location is Ch. 11+600 of proposed costal road south alignment before the existing Bandra worli sea linkroad.

6.2.3 Coastal Road Interchange (North Mumbai)

Bandra Worli Sea Link Interchange (Bandra):

North face of Bandra Worli Sea Link (BWSL) at Bandra will connect to proposed alignment and after end of existing BWSL near to toll plaza one interchange proposed to connectivity. This Interchange provides connection to entry and exit from the proposed alignment go to north and south of the Mumbai. Interchange will collect the traffic from Bndra kurla complex, Kalanagar, Bandra Terminus, Bandra East, Bandra West, Mahim and Dharavi Area. This interchange free from any traffic conflict. This interchange location is Ch. 0+000 on proposed costal road north alignment just after end of BWSL road toll plaza.

Otters Club interchange:

Interchange provides the entry and exit only on right side of the proposed alignment at ch. 3+500. The traffic coming from north Mumbai, they can take exit and traffic from bandra west area want to go south Mumbai they can take entry in our alignment. Entry ramp start in front of bandra joggers park and exit ramp will end in front of rajesh khanna's banglow on Carter road.

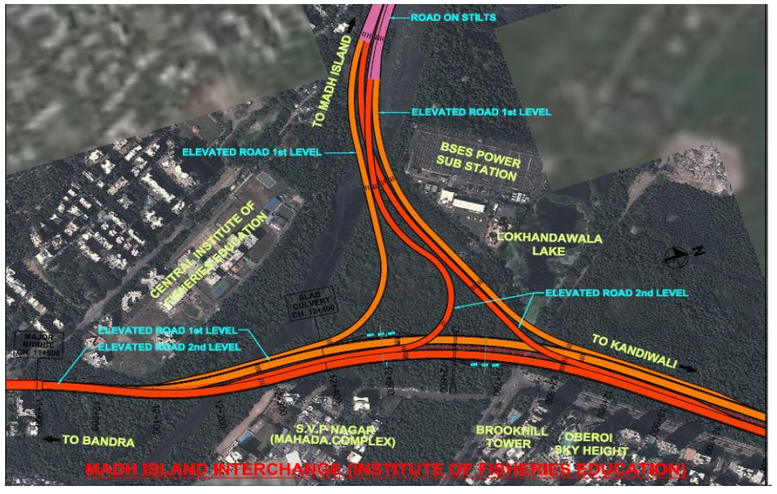
Carter Road Interchange (Danda Village):

This interchange provides connection to carter road in front of Danda khala macchi fish drying ground at ch. 4+500 before start of juhu tunnel ramp. Entry and exit ramp provided with acceleration and deceleration length towards south or north Mumbai. This provides connectivity to Khar east & west, Juhu, Santacruze east & west area. This interchange location is near to ch. 4+000 of proposed costal road North Alignment.

Ritumbhara Interchange collage:

Interchange passing near to Moragaon juhu and merging to the road in front of Ritumbra collage in juhu west. Entry and exit ramp provided for both sides moving traffic on proposed alignment. This interchange provides the connectivity for Andheri east & west and juhu area. Interchange location is near to Ch. 10+600 of proposed costal road north alignment just after end of juhu tunnel.

Madh Island Interchange (Institute of Fisheries Education):

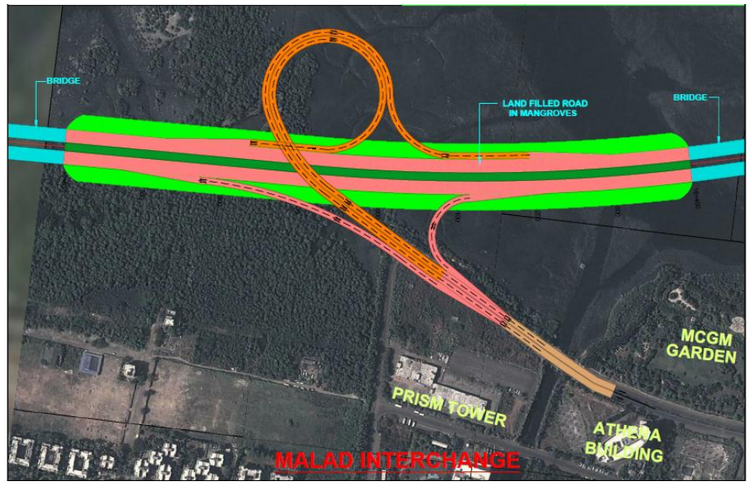


This interchange provides connectivity to MADH ISLAND using entry and exit for north and south Mumbai. Only one side connection towards MADH Island provided by this interchange located at ch. 12+600 of costal road north alignment.

Oshiwara Interchange:

This interchange provides connectivity to Goregaon east and west, Jogeshwari west area traffic. Entry ramp tapper starts from Park paradise Aparments and exit ramp tapper end near to Windmer CHS. This interchange provides free traffic flow in all directions at ch. 14+200 of north costal road alignment.

Malad Interchange:



Malad interchange at ch. 16+000 of north costal road alignment provides the connection on Chinchowali Bandra Link Road near to inorbit mall Malad west. Entry and exit ramp provides in this

intersection for both side movements with free flow traffic movement. Traffic movement area covered from Goregaon east & west, Malad east & west location.

andiwali interchange:

This interchange is end point of proposed north costal alignment at ch 19+450, which merges with the existing link road by providing tramped interchange. It gives connectivity of entry and exit on proposed alignment with required acceleration and deceleration. This interchange covered traffic from Malad east & west, Kandewali east &west, Boriwali east & west area

7. Engineering Survey and Investigations

7.1 Site Investigation

The Field investigations will be conducted on the approved alignment of Project Corridor. Various engineering surveys related to pavement investigations, traffic, topography, and soil investigations will be carried out, to have various input variables for the detailed pavement design, capacity for lane configuration and structural design. The surveys carried out are listed below.

Stage 1:

Topographic Survey

Traffic Surveys

Classified Volume Count Survey

Origin-Destination Survey

Stage 2:

Geological mapping for tunnel

Geo-Technical Investigation for tunnel, embankment and structures.

Material Investigation

Bathymetric survey

Hydrological Survey

Utilities Survey

7.1.1 Topographical Survey

General

To know the topographical conditions within the proposed roadway boundary topographic survey is necessary and hence, this survey work has been carried out along the preferred alignment.

Topography Survey along the preferred alignment

Once the route/alignment is selected through aforesaid investigation and surveys, a preliminary survey (a large scale instrument survey by running a traverse along the selected route/alignment) shall be conducted to capture all physical features which affects the location on new route/improvement alignment. Longitudinal and cross sections shall be taken for a width of 100m along the proposed alignment and Bench Marks will be established. Total station / Global positing system shall be used for conducting preliminary survey. Fly levels shall be taken along the traverse line at 50m interval and at all break in ground. Cross sections shall be taken an interval of 100m in plain terrain, 50m in rolling and 20m in hilly terrain. Permanent Control pillars and BM shall be established at suitable interval. The data collected through preliminary survey will form the basis for finalization of centre line of the road. The MCGM shall approve the finally selected centre line of the road.

Layout of centre line of the road in the field based on the alignment selected on map through preliminary surveys and collect necessary data for the preparation of project and working drawings. The Centre line of the road as determined in design office shall be translated on to the ground by means of continuous traverse survey and staking of the centre line as survey proceeds. Operations involved in this survey are staking out the final centre line of the road by continuous survey and detailed levelling.

The centre line shall be staked in the field at an interval of 50m in plain & rolling terrain and 20 m in hilly terrain. Distance measurements along the centre line shall be continuous following the horizontal curves where these occur. The traverse in case of road centre line would be open and shall be conducted by establishing control points to be established using sophisticated Global position system (GPS) or by astronomical observations.

Establish vertical and horizontal control points as necessary. All control points shall be concrete pillars with a suitable steel rod as the point of reference and are to be tied to Survey of India datum. All are to be referenced to a minimum of three permanent reference points. Both control points and reference points are to be located outside the anticipated construction limits. The maximum distance between control points is to be 2 km.

Undertake a topographical survey of the existing right of way, defined as extending a minimum of 15 m beyond either side of the center line of the existing road. Where developments and/or encroachments have resulted in a requirement for adjustments in the alignment, or where the consultant considers that the existing alignment can be improved upon through minor adjustments, the width of the surveyed corridor will be widened appropriately. Where existing roads cross the alignment, the survey will extend a minimum of 100 m either side of the road center line and will be of sufficient width to allow improvements, including at-grade intersections, to be designed.

Levels along the final centre line staked at site shall be taken at all control stations and at all breaks in ground. Cross sections shall be taken at 50 m interval for plain and rolling terrain and 20m for hilly terrain. Cross sections shall also be taken at the beginning and end of spiral transition curves, at the beginning, middle and end of circular curves and at other critical locations. All cross sections shall be taken with reference to the centre line extended up to the limit of right of way, showing levels at every 2 m intervals and break in the profile

For cross-drainage structures the following will apply.

Catchment areas 2.5 km^2 or less: 100m upstream and downstream of the right of way boundaries.

Catchment areas 2.5 – 10.0 km^2: 200m upstream and downstream of the right of way boundaries, or a sufficient distance to define the alignment of the waterway, whichever is greater,

Catchment areas greater than 10 km^2: 500m upstream and downstream of the right of way boundaries, or a sufficient distance to define the alignment of the waterway, whichever is greater

Minor Drainage Structures: Where not adequately defined within the general alignment survey, the survey is to be extended to an appropriate extent.

Topographic survey is under progress, survey data will be submitted separately as a part of Volume II of Final Feasibility report

7.1.2 Topographical survey for tunnel component:

A detailed topographical survey for tunnel will be conducted as per best international practices. Detailed topographic maps, plans and profiles must be developed to establish primary control for final design and construction based on a high order horizontal and vertical control field survey. A tunnel centreline developed during design should be composed of tangent, circular, and transition spiral sections that approximate the complex theoretical tunnel centreline within a specified tolerance (0.25 in.). This centreline should be incorporated into the contract drawings of the tunnel contract, and all tunnel control should be based on this centreline. Accurate topographic mapping is also required to support surface geology mapping and the layout of exploratory borings, whether existing or performed for the project. The principal survey technique which may be used includes:

- Conventional Survey
- Global Positioning System (GPS)
- Electronic Distance Measuring (EDM) with Total Stations.
- Remote Sensing
- Laser scanning

In carrying out the topographical survey, the equipment and procedures will use, which will result in the expeditious development of a computer based terrain model of the accuracy required for the final design of the proposed upgrading, and for the calculation of earthworks and other quantities required for the preparation of detailed cost estimates. The terrain model will show all features, both natural and man-made, within the surveyed area, the latter to include buildings by type irrigation and drainage structures and channels, utility installations, etc.

Topographic survey for Tunnel component is under progress and data will be submitted separately as a part of Volume II of Final Feasibility report.

7.1.3 Bathymetry survey

Bathymetry survey shall be carried out at about 1km sea ward side of the selected route of stilted road / sea road portion and shall cover area up to coast from alignment. The bathymetry survey shall also be carried out up to 1km sea ward side for the portion of road alignment on reclamation. The said studies shall be done with the help of echo sounder and DGPS System and other instruments, at 50 M. interval on either direction i.e. parallel and perpendicular to ward alignment. The survey grid shall

co-relate the and data shall be presented in both the grids. Ground mapping as detailed above with the help of GPR or side scan sonars shall also be conducted.

Bathymetry survey is under progress and data will be submitted separately as a part of Volume II of Final Feasibility report.

7.1.4 Sub grade Soil Characteristics for Widening Portion/New Alignment

In-order to assess the strength of the existing natural soil at the location of the additional/new Carriageway, test pit investigation will be conducted. Test pits on the natural ground will be taken on the widening side of the existing Carriageway beyond the toe of the existing road embankment and on the proposed centreline for new alignment.

For the widening of existing road within the ROW and for the roads along new alignment, the test pits for sub grade soil type will be taken at 2km interval or for each soil type, whichever is more. A minimum of three samples will be tested corresponding to each homogeneous segment or each soil type encountered, whichever is more.

Test pits will be dug to a size of 1m x 1m and to a depth of 1.0m. At 1.0m depth of test pit, the following tests will be conducted.

- Field density test using sand replacement method as per IS 2720 part 28
- Moisture content test as per IS 2720 (Part 2) -1973

Once the tests are completed, then the sub grade soil material not less than 50 Kg collected for laboratory testing. On the collected sample following tests will be conducted

- Grain size- as per IS 2720 (Part 4)-1985
- Soil classification- AASHTO and IS
- Atterberg limits- as per IS 2720 (Part 5)-1985 and IS 2720(Part-6)-1972
- Proctor Compaction- as per IS 2720 (Part- 8)
- CBR (soaked)- as per IS 2720 (Part -16)

7.2 Geotechnical Investigations for the Road Alignment

Bore holes at each major change in pavement condition or in deflection readings, or at 2 km intervals, whichever is the lesser will be taken. Additional bore holes will be excavated at major changes in soil condition as required. The bore holes will be excavated to rock or to a minimum of 2m below sub-grade level, whichever is the lesser, and are to be fully logged. Appropriate tests will be carried out on samples from the bore holes to determine the suitability of the various materials for use in widening of embankments or in parts of the new pavement structure.

7.3 Geotechnical Investigations for Bridges and Interchange Structures:

Bore holes at each abutment and at locations across the structure are not more than 200m intervals, subject to there being at least two intermediate bores for structures of more than one span will be taken. However, where a review of the feasibility study geotechnical reports and of information available from adjacent crossings over the same waterways (existing highway and railway bridges, for example) indicates that subsurface variability is such that testing at the intervals set out herein will be insufficient to adequately define the conditions for design purposes, the consultant will decrease the bore hole interval to the extent necessary.

7.4 Geo-Technical Investigation for Tunnel Component:

Geotechnical investigations will be critical for proper planning of a tunnel. Selection of the alignment, cross section, and construction methods is influenced by the geological and geotechnical conditions, as well as the site constraints. Good knowledge of the expected geological conditions is essential. The type of the ground encountered along the alignment will affect the selection of the tunnel type and its method of construction.

Geotechnical issues such as the soil or rock properties, the ground water regime, the ground cover over the tunnel, the presence of contaminants along the alignment, presence of underground utilities and obstructions such as boulders or buried objects, and the presence of sensitive surface facilities will be taken into consideration when evaluating tunnel alignment. The selection of a tunnel alignment will be taken into consideration site specific constraints such as the presence of contaminated materials, special existing buildings and surface facilities, existing utilities, or the presence of sensitive installations such as historical landmarks, educational institutions, cemeteries, or houses of worship. If certain site constraints cannot be avoided, construction methodologies, and special provisions will be provided. In order to plan, design and construct a road tunnel project requires various types of investigative techniques to obtain a broad spectrum of pertinent topographic, geologic, subsurface, geo-hydrological, and structure information and data. The geotechnical investigation program will be conducted for a tunnel project. To obtain necessary characteristics and properties for planning, design and construction of tunnel appropriate means and methods for carrying out the geotechnical investigations should be highlighted in this program. The extent of the investigations should be consistent with location and size of tunnel, the project objectives (i.e. risk tolerance, long term performance) and the project constraints i.e. geometry, constructability, aesthetics and environment impact. An investigation program for planning and design of a road tunnel project will include the following components.

- Existing Information Collection and Study
- Surveys and Site Reconnaissance

- Geologic Mapping
- Subsurface Investigations
- Environmental Studies
- Seismicity
- Geospatial Data Management

7.5 Hydraulic and Hydrological Investigations

This data is vital in deciding the bridge waterway, depth and type of foundations and protective works. The Catchment's area from the Topo Sheets shall be used to compute the discharge. The discharges computed by various methods shall be compared and design discharge shall be worked out as per guidelines in IRC: SP-13-1998. The foundation design shall, be calculated duly considering the clause 703 of IRC: 78-1983. This shall be compared with the discharge already used for existing bridges and appropriate discharge shall be adopted for the design of bridges in the present case. Wherever flow data is not available, design flood will have to be derived by forming an equation (Regression Equation) for run off from rainfall data.

For culvert and minor bridges, the design discharges shall be computed from Topo Sheets. These shall be compared with the data got from the department, actual study at site and from local enquiry regarding past flooding patterns. Depending on the study, improvement to the width of water way to existing structures and new CD structures where needed shall be recommended and provided.

7.6 Utilities Services

During the Road Inventory Survey, details of utility services such as Water lines, Telephone Cables, Power Cables etc., running along the project roads will be collected for consideration during the detailed project preparation.

7.7 Land acquisition plans

Cadastral maps will be prepared wherein the lands and properties which are getting affected on account of implementation of the project corridor. For preparation of maps for land acquisition the relevant information such as survey number, name of owners, and area etc will be collected for preparation of Land acquisition proposals. Available city survey maps shall be obtained and super imposed the Cadastral survey on the city survey maps. The ROW proposed to be acquired shall be set out on ground and joint measurements shall be made for the lands /structures affected along with revenue officials. In case the city survey maps are not available with the concerned authority, maps acceptable to the competent authority shall be prepared so as to enable it to initiate and complete the land acquisition proceedings. Also land acquisition proposal shall be prepared for MMRDA and comply with remarks which the competent authority may make during the process of Land Acquisition. The Land acquisition proposal will contain the following details

- Government owned; land unencumbered;
- Privately owned land unencumbered;
- Land in open setback owned by the Government or private falling within ROW;
- Built up setback to be acquired for till ROW; and
- Land occupied by the slum /land occupied by declared slum.

7.8 Material Survey and Investigation

A thorough understanding of sub-grade and other materials used in construction of pavement structures for road is very important. Sub-grade is normally defined as supporting structure on which pavement surface courses rest. In cut sections it is the original soil lying below base and sub-base material, while in fills sub-grade consists of stabilised earth from nearby borrow areas.

Sufficient information and data regarding the type of construction materials used and their suitability and availability, location of quarries in the project stretch and other useful information shall be collected.

Sub-Base

As far as possible suitable granular material such as murrum and gravel to be identified for use as sub base material. Gravel/murrum quarries within adequate yield shall be identified after preliminary studies. Where it becomes uneconomical to utilize gravel as sub base, adequate study shall be undertaken for establishing the use of highly weathered rock as sub base as an alternative.

Water Bound Sub-Base

Crushed aggregates available in various quarries in and around the project site shall be inspected and geological report obtained for each identified quarry.

Grade

The main function of sub-grade is to give adequate support to pavements with stability under adverse climate and loading conditions. Many of the defects noticed in pavement such as waves, corrugations, rutting and shoving, pumping, blowing etc., are generally attributed to poor sub-grade conditions. With increased vehicle speed and higher design standards, proper understanding and design of sub-grade soil has assumed great importance in modern roads.

High Embankment

High embankments shall be constructed using identified soils established after adequate testing. Suitable borrow pits shall be identified and the borrow material shall satisfy the necessary engineering criteria.

8. Tunnel Studies

8.1 Introduction

The idea of a traffic tunnel along the congested Mumbai city coastal line (Figure 8.1) was raised by MCGM in the year 2014 and a preliminary plan of sub-surface exploration by drilling is outlined. In general, the Coastal Road Traffic Tunnel would be excavated in comparatively soft Breccia strata with their lithological variants.

Figure 8.1 Mumbai Coastal Line

8.2 Tunnel Layout

The available background geological information is a reasonably good criterion for selecting the preliminary layout of the proposed 11m Coastal Road Traffic Tunnel. In all likelihood, the tunnel would pass through the Breccia and Tuff Basalt of Deccan Trap Formation. The fixed portal locations would leave little scope for adjustments of tunnel layouts on geological grounds.

Location of the NCPA and Priyadarshani Park portals of the Sub-Sea tunnel along the Marine Drive areas, allows the tunnel to bypass the main present day traffic bottlenecks. The tunnel length would be around 5 km. However, in view of the expected future expansion and development of the city, the option of placing the NCPA portal in the reclamation area may be considered on the basis of traffic density and flow. A straight tunnel alignment would be through the mostly unjointed strata. And therefore not prone to tunnelling problems associated with longitudinal weak rock zones. On average, the tunnel would be located about 20-30m below the ground level.

- The MHHW is considered as +4.00 around the tunnel alignment the depth of water may vary from 4 to 14m.
- Outward gradients of the tunnel from both the portals would allow drainage of the tunnel under gravity both during construction and operation towards the sump pit.
- Necessary levelling to accommodate TBM assembly shall be necessary at both the portals. Once the TBM is withdrawn, final gradients as per design shall be prepared.
- The finished tunnel would have a ridge-like gradient – rising from the end portals. In approaches the slopes shall be steeper.
- The tunnel gradients are kept as gentle as possible for facilitating traffic movement as well as allowing drainage under gravity.
- Gradient for Tunnel shall be 0.3%. For the ramp portion 6% (1:15) gradient was indicated. But depending on the available space 4% to 3% gradient shall be adopted.
- Drains shall be provided alongside the alignment these shall be leading to sump pits at entry and exit from where water is to be pumped out.
- Emergency exits are planned as cross passages at every 500m apart connecting the two Tunnels.

Figure 8.2 Proposed Tunnel Alignment

8.3 Advantages of Final Option

- Distance saving for 500m.
- Travel time saving.
- Away from built up infrastructure and high rise buildings.
- Smooth gradients.
- No fear of rock falls.
- Less pollution from vehicles.

- Reduced Accidents.
- No traffic jams and snarls.

8.4 Need for Investigation

The targets for the geotechnical investigations of the tunnel may include:

Detailed engineering geological mapping of the on 1:5000 scale for overall geological perspective and discontinuity data information. Identification of shears and faults will require utmost attention. Remote sensing techniques (aerial photographs and satellite imageries) may be used for identifying structural lineaments and continuity of major lithological units.

Interpretation of the geological section along the tunnel alignment with particular reference to the thickness of different lithological units close to the tunnel grade. This would require sub-surface exploration through core drilling that would include cyclic water percolation tests and Standard Penetration Tests (SPT). Boreholes shall be located along the alignment. At present available information is used.

Rate of drilling penetration, could serve as an important criterion for selection of plant for excavation. Geophysical surveys could provide vital information regarding sub-surface conditions. Resistivity surveys would be helpful in deciphering highly water bearing zone and seismic refraction surveys would indicate the strength of the rock in terms of seismic velocities.

Physio-mechanical properties of the rock such as compressive strength, tensile strength, Young's Modulus, abrasion value need to be determined as design parameters.

Based on the data collected, the tunnelling media would be divided into rock mass classes for deciding corresponding support systems – both primary as well as permanent. The regional geological setting favours rock mass classification using RMR (Bieniawski, 1974) rather than the more universal Rock mass Quality "Q" (Barton et al, 1974).

8.4.1 Tunnel Design

Tunnel design depends upon the following:

1. Design Criteria
2. Design Basis
3. Design Standard

Design Criteria

- Proposed speed of the vehicles shall be 80km/hr
- 4% gradient is allowed as per codal provisions. For approaches 4%-3% gradient and for Tunnel 0.3% gradient is to be adopted. 0.3% gradient is selected to restrict the depth of approach cut up to 30m.
- Axle load as per class 70 R
- Traffic requirement as per feasibility report + 30000 PCU
- Signalling system beyond entry & exit points.
- Number of Lanes = 2 + 2 both ways.

Design Basis

The key data shall be derived from different reports as follows;

- Traffic Data
- Geotechnical Data
- Gradient details as per the approved profile of the alignment
- Percentage share of different category vehicles
- Future traffic growth as per traffic study report

Design Standard

- PIARC
- SP-91
- European Directive on Tunnel Design, operation and maintenance

8.5 Design Basis for Tunnel at NCPA

This project involves designing of the tunnel cross section alignment, gradient drainage, fire ventilation lighting etc. The diameter of Tunnel is considered 11 m to accommodate 2 lane traffic + 1 service road and adequate headroom. Initial portion shall be cut and cover to accommodate up ramp and down ramps at entry and exit of tunnel length of tunnel is 5000 m.

Key Components

Lining: - Temporary support as and where required during construction is to be provided for safe construction. This shall be in the form of shotcrete, ribs etc. Permanent lining shall be RCC either precast or cast in site depending on construction methodology to be adapted.

Retaining Wall/ Diaphragms Wall: - In the ramp portion, diaphragm wall shall be constructed as enabling work to restrict width of excavation and also to provide safety to adjoining structures.

Sump & Pump House: - A deep sump shall be provided to collect drain water in tunnel and pump out enabling shaft shall be provided.

Cross Passage: - At every 500 m mandatory connection shall be provided between adjacent tunnels.

Safety Provisions: - Tunnel Lighting, Fire safety, ventilation shall be provided by twin fans located overhead of diameter 1.2m

Service buildings and ancillary spaces shall be as per requirements.

Space for casting yard and other mechanical, electric set ups.

8.6 Tunnel Geometric Design

Shape of the Tunnel:-

For underwater urban traffic tunnel, circular sections are ideally suited especially as the tunnel is to be excavated with tunnel boring machine Diameter of the tunnel is fixed as per the requirements for two lane traffic.

The space above shall be sufficient to accommodate ventilation fans, lighting and other features. The minimum function requirements that have been accommodated are given below as per SP-91.

- CP – Cross Passage
- VN – Ventilation
- LG – Lighting
- TE – Telephone at spacing about 200 m
- FS – Fire safety – Fire extinguished at spacing 50 m

Alignment: -

All the Alignment options have been studied in detail and Recommended alignment is proposed for following reasons;

- Straight alignment resulting in
- Length reduction by 500m
- Efficient and safe highway geometry
- Reduced ventilation and lighting load
- Increased visibility distance
- Far away from the existing infrastructure.
- Below the sea: reducing risk of damage to existing coastal Protection & heritage of marine drive.
- Reduced risk during construction

Geometry of the tunnel:-

The safety of the traffic is primary concern while deciding Geometrics of the tunnel i.e.

- Cross section
- Gradient
- Curvature
- Width of the tunnel:
- 8.25m minimum c/w width is considered. This shall be in tune with traffic lanes required outside the tunnel in the open air as per PIARC.
- Height of the tunnel:

The finished height of the tunnel is decided to accommodate minimum vertical clearance of 5.5m.

Vertical Alignment: -

Gentle gradient along the tunnel length is proposed. Maximum gradient for major tunnel projects, adopted are as below;

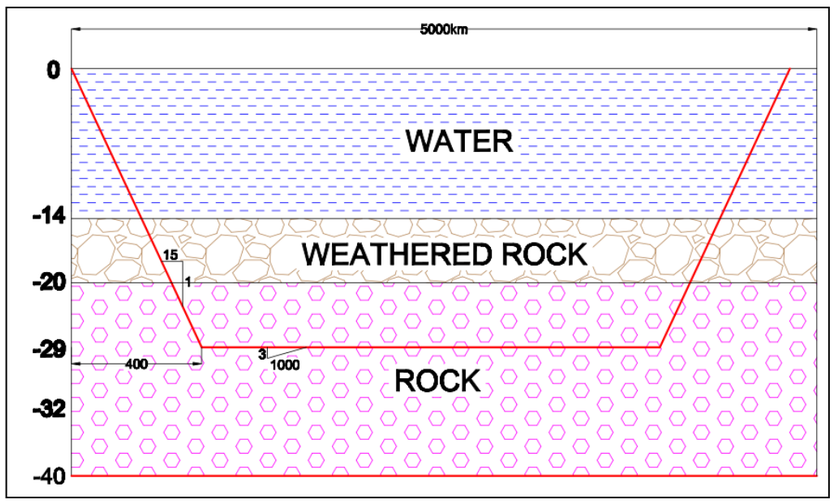
Tunnel	Gradient (%)
Seikan Tunnel Japan	1.2
Kanmon Tunnel Japan	2.2
Shin – Kanmon Tunnel Japan	1.8
English Channel Tunnel	1.1
Mersey Tunnel England	3.7
Severn Tunnel England	1.1
Mt. Macdonald Tunnel Canada	0.7
Bosphorus Tunnel, Turkey (Proposed)	1.8

For this project 0.3% gradient shall be adopted in viewing the length of the tunnel being 5km to break the monotony after 2.5 km reverse gradient shall be provided. Design speed is considered as 80 km/hr.

Horizontal Alignment:-

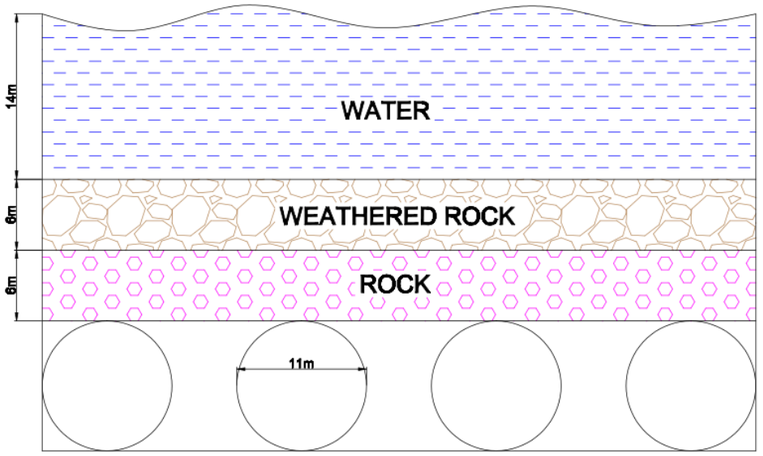
At the entry point alignment shall be straight. In the tunnel portion alignment shall be mostly straight.

At the exit point however, curvatures with radius of 100 m is proposed.



Crown Level of Tunnel:

The crown level of the tunnel shall be kept 6 m below the competent rock.



8.7 Assessment of Technical Feasibility

Geology: - Typical bore log near Marine lines is considered for preliminary assessment. The detail geotechnical assessment based on the studies made is in progress.

Soft Rock Tunnels in India

The case studies of projects executed in Tertiary formations in the Himalayan terrain, provide excellent information about the general features of tunnelling in soft rocks that could be indicative of the ground conditions for the tunnelling project at Aizawl. The Siwalik and Murree Group of rocks in NW Himalaya, confined between the Indo- Gangetic alluvium towards south and the MBF (Main Boundary Fault) in the north, include several important hydroelectric projects. In the northeast, hydroelectric projects have been executed in the rocks of Surma Group and Disang Formation.

- Two parallel, circular tunnels (each 1.3 km long, 6.2 m dia), were and sandrock with subordinate siltstone, claystone and grit at the Khara Hydel Project.
- Seven free-flowing tunnels (61-1896 m length, 2.13-2.43 m section) in Chenani Hydel Project have been driven in alternate bands of claystone, sandstone and siltstone the Yamuna Hydel Project. The crumpled red shales and siltstone with subordinate quartzite and black plastic clay of the 9m diameter tunnel
- For the 9m diameter tunnels in (sandstone) at Tuirial Hydroelectric Project in Mizoram, At Doyang in Nagaland, for the 12m diameter tunnel located in sandstone over a 100m length
- The 6.778 km long and 3.81 m diameter of Loktak Hydroelectric Project in Manipur, located in sandstone.

The rock cover of at the site is around 6m. The gradient is rising up to mid length thereafter it is falling gradient ±0.3%. For accommodating this constraint the depth of approach cut is to be around 30m.

Design speed is considered as 80 km/hr. However, pavement quality can be appropriately designed for higher speeds.

TBM progress per month on an average shall be 300m and at peak shall be 500m. NATM progress pee month may be 20m per face with lead time as 10 months and Tunnel boring time as 10-16 month. Total time shall be 20-26 months.

The feasibility adjudged in the absence of geological information along the alignment. For MCGM project, Tunnelling is done between S.K. Patil and Kilachand about which available information is used. This site is nearest to the water supply Tunnel alignment. Hence used.

Tunnel between S.K. Patil-Kilachand shafts between chainage 009 and 1679 i.e. between Kilachand shaft and S.K. PAtil Shaft 2.8m diameter water supply tunnel is excavated. Partly it is excavated below sea. The strata encountered are Tuff Breccia and Basalt as can be seen from the sketch attached.

Please see separate for drawing.

Design shall be for seismic zone III.

Tunnelling preferred for following consideration:

- Road Tunnel is feasible alternative to cross the water body in view of the geological set up in the continental shelf.
- This shall satisfy environmental and ecological requirements.
- Girgaon chowpaty is of special social and religious importance as a Ganesh idol immersion location and other festivals. This is to be preserved.
- Tunnel minimizes potential environment impact viz traffic congestion, pedestrian movement, air quality, noise pollutions.
- It minimizes visual intrusion to the bay watchers.
- It does not disturb the land use after reclamation in future.
- Drainage details shall be shown in good for construction drainages which shall be accommodated at either edge of the road cross section.

Tunnel Excavation

The depth of tunnel excavation, more than 20 to 30m, is of paramount importance in taking a decision regarding the preferred mode of excavation technique and installation of supports – both primary as well as permanent – with factor of safety kept at a high level.

Considering the shallow depth of the tunnel, it would be advisable to avoid conventional modes of tunnel excavation by drilling and blasting (DBM). The soft lithological assemblage could be an ideal sub- surface media for excavation using road headers. As an alternative, 4 TBM machine may be deployed.

TBM can produce up to 20-22 m of progress per day, as is the experience in earlier project.

Table 8.1: Parameter Comparison between NATM and TBM

Parameter	NATM	TBM
Suitability in Breccia	Yes	Yes
Shape	D	Circulate
Support	Shotcrete, Ribs, Bolts	Precast, Segments
Progress	22m per month	500m per day
Cost	120 Crore per Km	150 Crore per Km
Lead Time	3 Month	10 Month
Construction Time	110 Months	20 Months + 6 Months
No. of Set of Equipments	16	4

Supports

Simultaneous support erection and lining would be the key to a smooth and incident-free tunnelling operation. The need for a high level of safety would permit no compromise on design and implementation of support systems.

In general, the application of NATM (New Austrian Tunnelling Method) could be an economical and practical approach to the execution of the Tunnel. The method involves creation of a load-bearing ring of supported rock around the excavation, where the ground itself becomes an integral part of the support system. In general, steel supports are not used in this method and rock bolting and shotcreting form the main support elements.

To begin with, pre-excavation umbrella coverage for the overt portion of the tunnel may be provided through spile bolting or forepoling in the usual 3m long segments. The spacing of spile bolts would conform to the rock condition. The consecutive spile-bolted or forepoled segments would have appropriate overlap.

For a 3m long segment under umbrella support, excavation may be carried out for an approximate 2-2.5 m length by road-header, followed by erection of primary supports in the form of shotcreting, rock bolting and, if necessary, steel supports. These methods may have to be used in isolation or in combination depending upon the rock condition. For reinforced shotcrete, use of steel fibres may be considered as an alternative to coarse aggregate, for which there are few quarry sources within a reasonable haul distance.

In TBM method, precast liners shall be providing adequate support both during construction as well as in operation.

Table 8.2:Constraints in various options

Sr. No.	Parameters I	Option - I	Option - II	Option - V	Recommended option
1	Tunnel Alignment in Plan	It is curvilinear along the edge of the Marinedrive coast. Important high rise structures are to be protected.	It is curvilinear along the edge of the Marinedrive coast. Important high rise structures are to be protected.	It is straight alignment and is placed below the sea at maximum distance from sea shore upto 2.4km.	It is straight alignment and is placed below the sea at maximum distance from sea shore upto 2.4km.
2	Visibility	Affected by the curved alignment.	Affected by the curved alignment.	Visibility extremely good and navigation is possible easily.	Visibility extremely good and navigation is possible easily.
3	Ventilation	Needs extra efforts due to need for negotiating the curve	Needs extra efforts due to need for negotiating the curve	Less power required in the straight alignment.	Less power required in the straight alignment.
4	Length	5.5km	5.5km	5km	5km
5	Structures on Alignment	Special efforts needed to protect them during construction and control settlement	Does not affect the structures although the sea shore.	Does not affect the structures.	Does not affect the structures.
6	Girgaon Beach	Tunnel does not affect Girgaon beach	It is of social and religions importance and hence needs to be preserved. In this alignment it gets defunct.	Tunnel does not affect Girgaon beach.	Tunnel does not affect Girgaon beach.
7	Coastal Line	Existing coastal line as reclaimed is not affected.	Coastal line has to be pushed into the sea by 100m.	Existing Coastal line as reclaimed is not affected.	Existing Coastal line as reclaimed is not affected.
8	Cost	Cost of half km Tunnel is addition.	Cost of additional half km is added.	Reduction in length saves cost.	Reduction in length saves cost.
9	Fire Hazard	More pronounced as ventilation load increases	Not a concern	Ventilation load is fairly controlled in smooth, linear alignment.	Ventilation load is fairly controlled in smooth, linear alignment.

Sr. No.	Parameters I	Option - I	Option - II	Option - V	Recommended option
10	Currents and Tides	Not a concern	Road has to be above tidal level Min R.L. and protection against current.	Not a concern.	Not a concern.

Tunnel Boring Machine

8.8 Details of DSTBM Technique

TBM Technique for Tunnelling. TBM technique has high potential and versatility tunnel drivage by altering the physical size and strength of Tunnelling machines to match the wider range of rock hardness and geologically difficult conditions. Following aspects have significant bearing in selection of this technique. These are analysed for taking appropriate decision about suitability at the proposed Railway tunnel site at Gulbarga.

TBM excavation represents a big investment in an unflexible but potentially very fast method of excavating and supporting a rock tunnel (Barton, 1996). When unfavourable conditions are encountered without warning, time schedule and practical consequences are often far greater in a TBM driven tunnel than in a drill and blast tunnel.

The unfavorable conditions can be produced by either a rock mass of very poor quality causing instability of the tunnel or a rock mass of very good quality (i.e. strong and massive rock mass) determining very low penetration rates. However, it is to be observed that when using the full face mechanized excavation method, the influence of the rock mass quality on the machine performance has not an absolute value: the influenceis in fact to be referred to both the TBM type used and the tunnel diameter.

Following are the technical advantages of TBM:

- Reduction of over breaks
- Minimum surface and ground disturbance
- Reduced ground vibration eliminates damage to nearby structures which is an important consideration for Metropolis.
- Reduced rock excavation reduces handling cost
- The speed of work is several times that of conventional drill and blast technique
- Least disruption of traffic flow
- Unaffected public safety

8.9 Design of the tunnel in the TBM alternative

8.9.1 General

Contractor shall be solely responsible for the selection, design and supply of a tunnel boring machine and auxiliary equipment and for the design and execution of the reinforced concrete precast segmental lining system compatible complying with the characteristics of the TBM .The design work and shall be submitted for approval The tunnel boring machine (TBM) shall comply with the requirements of the country of manufacture, The machine shall be of a double-shield type supported by the precast lining rings or a machine with a side stabilizer (gripper) supported by the breccia rock The machine shall be new or shall have undergone refurbishment at an experienced plant specializing in this field that has brought it to a "like new" condition and will be compatible for all of the types of breccia rock as specified in the geological. During construction, the Contractor shall enable and assist the Supervisor and his representatives to reach the tunnelling machine with all of its various components at any time that he deems fit and shall assist him in all matters related to inspection and verification of the tunnel alignment including independent survey of the work of the Contractor's surveyor and the performance of geological mapping of the rock as actually exposed. Such assistance shall be included in the Contractor's work and will not be paid for separately.

Comparison of NATM and TBM techniques is presented below:

Table 8.3: Comparison of NATM and TBM technique

PARAMETER	NATM	TBM
quality	geologically dictated	acceptably
Chance of cost and time over run	high	low
Duration of Capital locking	Long	short
interest	High	low
Equipment utilization period	High	low
Commercial benefit	delayed	early
Overall profitability	Very low	high
Owner's image	destroys	improves
Geological set up at tunnel site	Does not necessitate on account of special rock condition	Preferred considering high PR at manageable energy level
Damage to existing structure	PPV induced during drilling blasting may be a deterrent and major adverse parameters	Continuous support by erecting the segmental lining ensures safety. No drilling blasting involved
Recommendation	Not advised	Strongly recommended

NATM involves slow speed of construction due to PPV controlled progress which will result in cost over runs and time over runs. Because of this reason DS TBM which will give 6m per day progress even with 32% efficiency of TBM utilization this DS TBM is strongly recommended.

Observations for Tunnel

Soft strata consisting of Breccia, Tuff is likely to be encountered which is suitable for cutting by road header as well as TBM.

- The likely progress shall be 20-22 m per day by each of the TBMs.
- In general subsea tunnelling is feasible geologically.
- For fast progress TBM tunnel is recommended.
- Diameter of Tunnel shall be 11m.
- Flat Gradient is to be adopted 0.3%.

In general feasibility of subsea tunnelling is feasible at this location as viable alternative.

9. Reclamation

9.1 Introduction

The Committee recommended about 34.56 km. coastal freeway comprising a combination of coastal roads based on reclamation, bridges, elevated roads and tunnels on western side of Mumbai. The Committee recommended this coastal freeway system with two options of alignments, both with a view to resolve the traffic congestion in Mumbai and to enable creation of the much needed recreational open spaces. STUP has evaluated seven alignment options and Option 7 is considered as final option for design after comparison of merits and demerits of each option. The constraints of the geography and the inability of the city to expand the alignment option 7 has considered total coastal freeway length of 34.56 km out of which 11.61 km is considered to be reclaimed road. The total area of reclamation will be 168.08 hectares.

9.2 Alignment Sections of Reclamation

As per the final alignment the reclamation is proposed at following sections:

Table 9.1: North Zone – Reclamation Length

Sr No	Section	Start	End	Length
1	BWSL(End) to Carter Road	Sea Link Toll Plaza	St'Andrew Church	2700
2	BWSL(End) to Carter Road	Bandra Joggers Park	CarterRoad Mandir	1200
3	Ritumbhara College to Kandivali	Madh Island Road	Yamuna Nagar	1335*
4	Ritumbhara College to Kandivali	Rajan Pada	Ryan International School	1550*
	Total		3900 + 2885*	6785

*Reclamation on mangroves

Table 9.2: South Zone – Reclamation Length

Sr No	Section	Start	End	Length
1	Jagannath Bhosale Road to Priyadarshini Park	Jagannath Bhosale Marg	Raheja Center	400
2	Priyadarshini Park to Mahalaxmi	Clinical Diagnostic Center	Mahalakshmi Temple	1300
3	Mahalaxmi to Baroda Palace	Mahalakshmi Temple	NSCI	650
4	Baroda Palace to BWSL (Start)	Baroda Palace	Markandeshwar temple	675
5	Baroda Palace to BWSL (Start)	Dairy Colony	Near BWSL	1795
	Total			4820

9.3 Conventional Structures

Conventionally Seawalls are used and designed as massive structures to protect the land behind them from direct wave attack.

Seawalls are designed to withstand direct attack by very large waves and hence they are usually trapezoidal in cross-section, and constructed of very heavy outer armor units placed on top of smaller rock or a solid core (soil berm or concrete). The top of the structure is typically set at an elevation that will prevent wave overtopping and minimizes the amount of saltwater spray crossing the structure.

Typically used sections of seawalls are shown in Figure 9.1 and Figure 9.2 below.

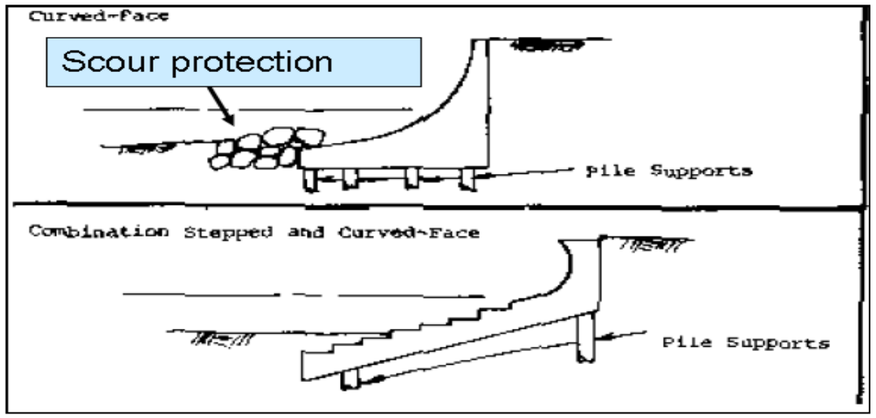


Figure 9.1: Typical Sections of Seawalls

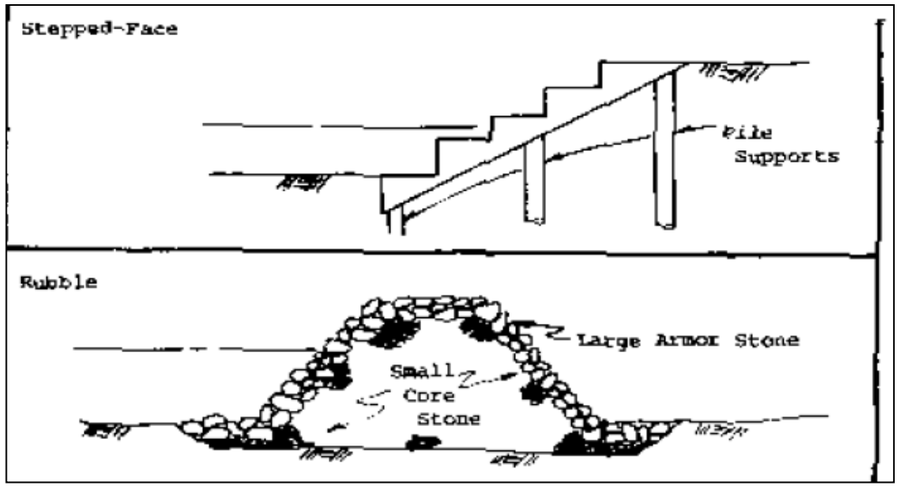


Figure 9.2: Typical Sections of Seawalls

The basic functions of the Seawalls are –

- Resists Wave Impact
- Protect upland from flooding and Overtopping
- Resist Scour
- To hold fill (Shoreline) in place

9.3.1 Conventional Methods of Reclamation

To get the desired density of the reclaimed material one of the following method can be adopted

Place the material and compact in layers

This method will be feasible if the height of reclamation is less. The dredge fill / borrow fill shall be placed in layers of 300 m / 500 mm and shall be compacted in layers. However, if the height of reclamation is high or if the compaction is required below the water level this method will not be feasible.

Use of Vibro-compaction

In this method the desired degree of compaction is achieved by vibrations produced by probe. Vibro-compaction can be done for the loose sandy deposits having less than 15% of fines for depths up to 10 m. Compaction is carried out by inserting the probe up to the design depth of improvement and allowing the soil around the probe to get compacted for certain time interval. Then the probe is raised by about 0.5m to compact the soil around the vibrator and the process is repeated.

Use of Preload with Prefabricated Vertical Drains (PVDs)

This method may be useful when the percentage fines is more and height of reclamation is high. In this method the drains are installed into the fill by stitcher and the preload is applied above the reclamation. The application of load drains out the pore water through the drains and the densification is achieved. However the handling of preload is a major concern in this method.

The choice of the method will depend on –

Type of material used for reclamation – Sand or Fly Ash

Time available

Height of reclamation

The major problems involved in the reclamation by conventional methods, are – Heavy magnitude of filling material and armour stones of specific size and weights requires more construction time

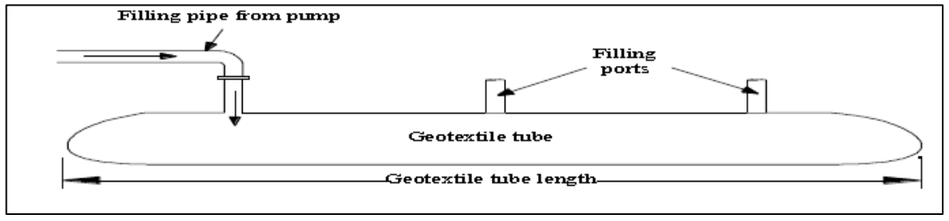
9.4 Modern Methods of Reclamation

Considering the problems involved in the conventional methods of reclamation, the other options can be considered for reclamation are –

Use of Geotubes or Geotextile Tubes

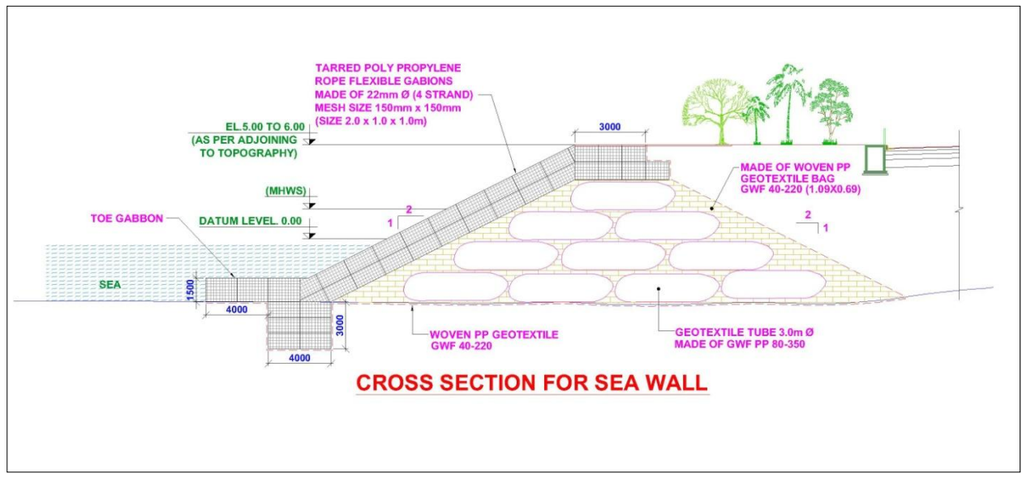
Geotextile tubes are tubular containers that are formed in situ on land or in water. Geotextile tubes are laid out and filled on site to their required geometrical form. The tubes are filled by hydraulically pumping fill into the tube. Geotextile tubes range in size from 1m to 5m in diameter, and up to 50m in length.

The Geotextile tubes are factory made tubular units which are supplied at site in lay flat manner. The tubes have filler ports at the top in order to fill the sand hydraulically into the tubes. The sand required for slurry preparation should be fine sand with % fines passing should be less than 15%. The sand used for the sand slurry, should be free from organic matter and other toxic impurities. The reasons for using sand in this type of fill are, fill can be placed with good density for hydraulic fill and it has good internal shear strength. Once filled the Geotextile tube behaves as mass gravity unit and can be considered in the designs accordingly. In this particular case the tubes can be either dumped in position similar to the Geotextile containers or can be filled in position with the help of divers. This decision depends on the wave nature and wave height, the possibility of fewer disturbances to the barge during installation would be criteria in selection of placing technique. If the disturbances and wave heights are more than dumping the Geotextile tubes in position using split barge would be the appropriate method of installation



The Filling ports are sewn together with proper thread through which discharge pipe is inserted. Since the tubes are being installed underwater, temporary guides or stacks are installed on either side of the tube. Once the tube is secured with anchorages along the proper alignment the slurry is filled into the tube from the filing ports. The slurry contains 5-15 % of sand and the filling is carried out as per the pressure required. The fill ports are closed once the tube is filled up to its desired height and the top of the port is sewed or tied up. Once the bottom tube is filled and it achieves its desired height after consolidation the hydraulic filling of second tube is started.

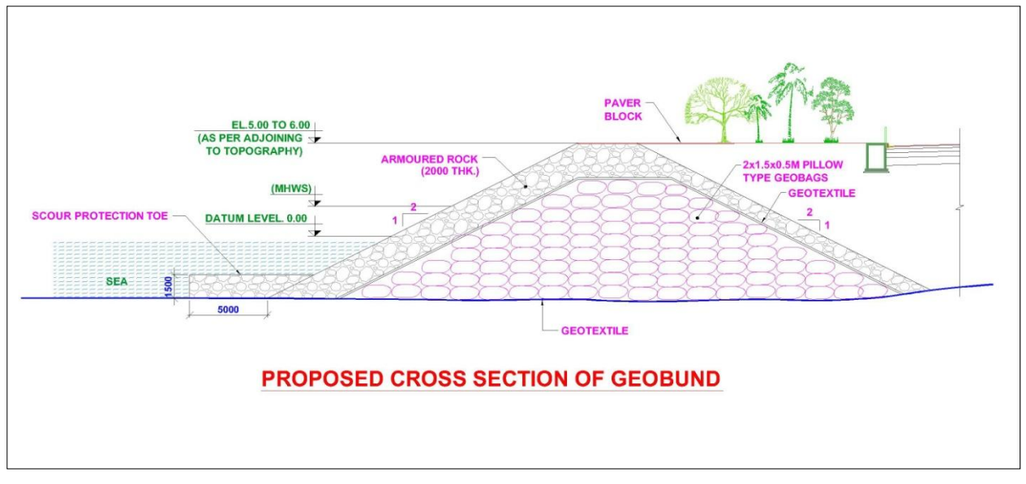
The typical section considering the Geotubes is shown below.



Use of Geobags or Geotextile bags

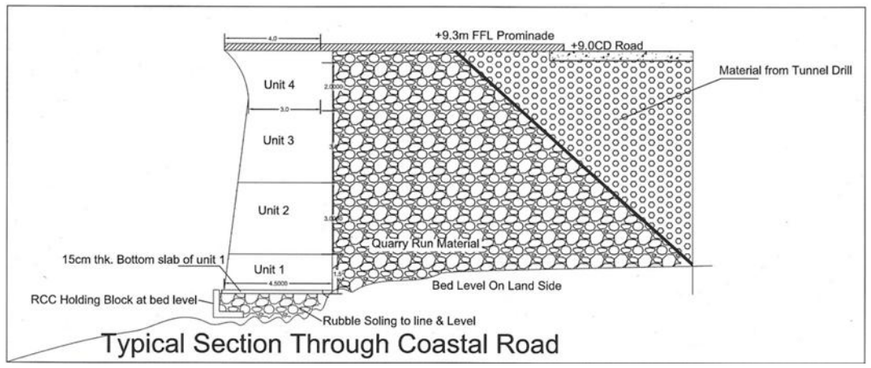
Geotextile bags are small volume containers that are filled on land or above water and then pattern-placed either near water or below water level. The function of these bags is similar to Geotextile tubes but the smaller size makes the ease in handling, placing and anchoring.

The typical section considering the Geobags is shown below



The construction of sea wall needs to be undertaken as an independent activity and then muck from tunnel construction either for the Coastal Road or planned Metro Line Phase-2 and phase 4 shall be used to back fill behind the walls. The quantity of tunnel muck expected from Coastal Road is 3.0million cubic meter, whereas the expected quantity required for the project is in the range of 8.0 million cubic meter. Hence the rest of the quantity shall be procured from the tunnel construction for phase-2 and phase 4 metro rail projects.

A option of sea wall is proposed through precast caisson type of segmental wall. As shown in figure---. The precast sections shall be constructed on main land and would have to be transported to the site using barges requiring temporary jetties to be constructed near casting yard and point of delivery. Precast units shall be lifted through cranes and placed at ready platform and filled with suitable material. These units will be constructed to have locking arrangements with adjoining sections.



Need for Investigation

The targets for the geotechnical investigations of the reclamation may include:

Interpretation of the geological section along the reclamation alignment with particular reference to presence of any soft / weak strata present.

In case the presence of cohesive soils, Index Properties of soil, Strength and Consolidation properties of the soil such as cohesion, friction angle, compression index, initial void ratio, coefficient of consolidation, pre-consolidation pressure need to be determined as design parameters.

In case the presence of cohesionless soils, Index Properties of soil, Strength properties of the soil such as SPT value and friction angle need to be determined as design parameters

Based on the data collected, treatment if any required to improve the sub-soil characteristics will be determined.

9.5 Methods of treatment for sub-soil improvement

9.5.1 Improvement by increasing the strength

In this technique the improvement is achieved by increasing the in-situ stress within the soil mass. The methods such as excavate and replace the in-situ soil with good engineering material or provide surcharge at the toe of the slope or embankment are used for this purpose. These are the simplest method to execute and cost effective solutions where the depth of treatment is less (i.e. 2 – 3 m) and the improvement ratio is small.

In this method the soil is excavated upto the required depth. The excavated portion is then backfilled with the good engineering material. The backfilling is done in layers of 150 / 200 mm thickness and compacted. The next layer is placed and compacted and the excavated area is backfilled upto OGL.

This is very fast and economical method. However the disadvantages with this technique are that while excavation the precautions are required to take care of dewatering or stability of adjacent structures if any. The disposal of excavated material is also major problem.

9.5.2 Improvement by Densification

The principle involved in this technique is that the soil particles are rearranged to tighter configuration and density increased. The densification can be achieved by way of vibrations / impact. 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. Dynamic Compaction also helps to reduce the liquefaction Potential. Dynamic Compaction is useful in silty / sandy deposits present upto a depth of 5 to 7 m. This method is also less expensive, faster and easy to construct for large plan area.

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.

9.5.3 Improvement by drainage

For the soils with low permeability, this technique is very useful, where the high permeability drainage elements are installed to decrease the drainage path in soil mass and providing the faster rate of dissipation for excess pore pressure.

Use of Prefabricated Vertical Drains (PVD) or Band Drains and Stone Columns are two methods which can be considered for improvement by drainage.

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. 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.

When the soft clays are present upto a greater depth, the treatment is required to increase the safe bearing capacity, reduce the settlements and accelerate the time required to achieve these settlements. This can be achieved by providing Prefabricated Vertical drains (PVD) or Band Drains.

In soft Clays the time required to expel the pore water is very high due to very low permeability of soils. However, the permeability or in turn coefficient of consolidation in horizontal direction is 1 to 3 times more than in the vertical direction. The use of band drains reduces the drainage path and also helps the consolidation in vertical as well as horizontal direction. The combined effect of the same reduces the time required for the settlements drastically. The time required for consolidation in soft clays is usually 3 to 20 years which can be reduced to 6 to 12 months depending on the spacing of band drains.

9.6 Design

Design of reclamation will depend upon the following:

- Height of reclamation
- Design wave height
- Properties of proposed fill
- Wave Period
- Slope angle of bed
- Depth of the water
- Wind Direction
- Wave Direction (Monsoon Period, Non Monsoon Period)
- Wave Velocity (m/sec)
- Beach Material (Sand Gradation from D10 – D90)

9.7 Marine Aspects of Coastal Road

9.7.1 Meteorological data:

Temperature

Range of variation: The diurnal range of temperature is around 4deg centigrade.

The maximum temperature recorded in the island of Mumbai is Max. 42.2 and min.7.4.

Table 9.3: Normal Temperature Range (^{0}C)

Month	Maximum	Minimum

Month	Maximum	Minimum
January	31	16
February	32	17
March	33	21
April	33	24
May	34	26
June	32	26
July	30	25
August	29	25
September	30	24
October	33	23
November	33	21
December	32	18

From the above observations, it may conclude that hottest months in the year are April, May and June, When the temperature reaches about 37^0 C. The temperature is optimum.

Wind:

Prevailing wind direction is from NW. Seasonal variation in the wind speed and direction is given in the following table:

Table 9.4: Seasonal Wind distribution

Month	Direction	Speed
Feb – May	NW	Max. 62 to 102 kmph Substantial 20 to 50 kmph
June – Sep	WNW	Max. 62 to 102 kmph Substantial 40 to 62 kmph
Oct – Jan	NNW	Max. 40 to 62 kmph Substantial 7 to 50 kmph

Humidity

Range of variation: The diurnal range of humidity is around 50%

Max. is 95% in July and Min. 86% around Jan around the year

Visibility

In general, on the West Coast, above latitude 16^0 N mist sometimes develops during sunrise but disperses thereafter. At Mumbai from November to March smog hangs over the land, obscuring everything in view. This happens only for short periods most often shortly after sunrise but also occasionally in the evenings. Visibility is generally good for most part of the year.

Rainfall

Nearly all the rainfall in Mumbai occurs in the SW monsoon. Average Rainfall in the Mumbai is as tabulated below:

Table 9.4: Monthly Rainfall

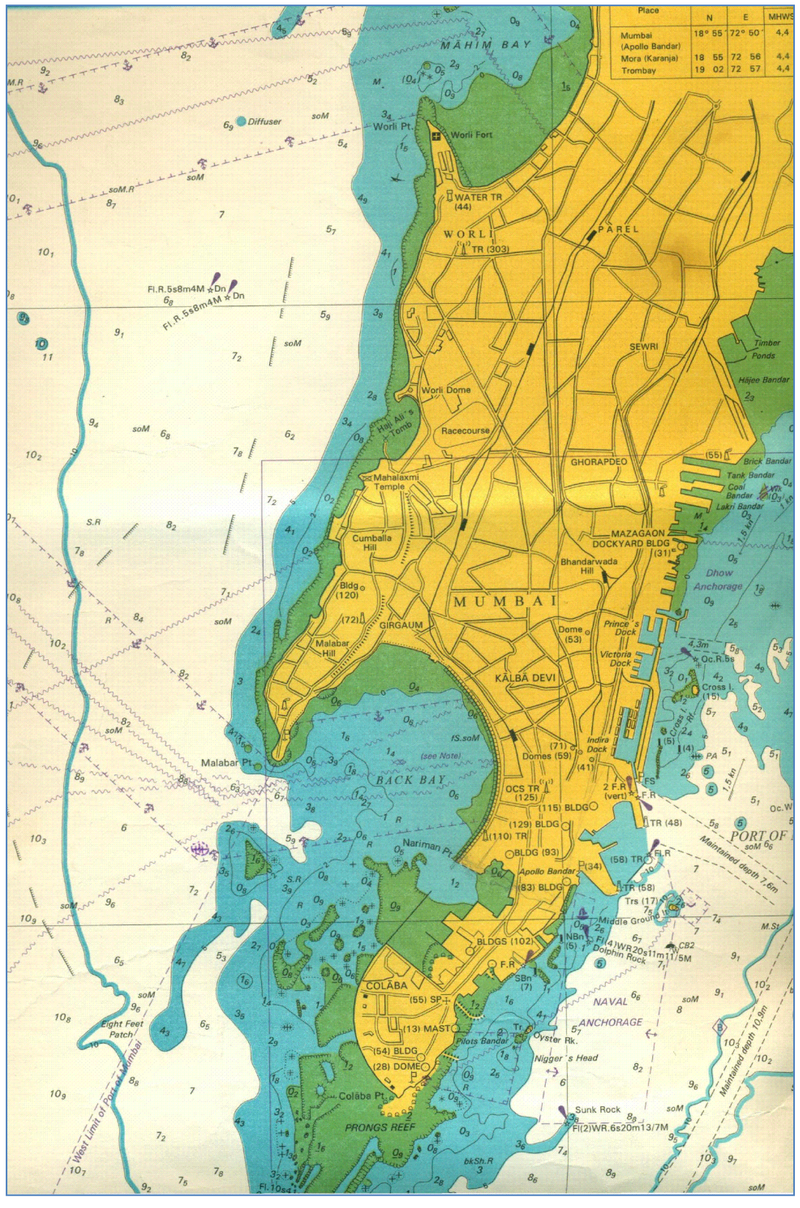
Month	Rainfall (mm)
January	15.1
February	1
March	0.1
April	0.5
May	20.6
June	504.2
July	819.4
August	546.8
September	325.2
October	81.1
November	113.2
December	4.1

Cyclones

These may occur in the period of May/June or October/November. The storms are mostly confined to the months of June and September, and the months of July and August are almost free of storms. The last severe cyclonic storm having winds of above 48 knots was experienced in 1982. Occasionally, sudden high winds also occur during the fine weather periods from NE.

Oceanographic Condition:

Admiralty chart:



The Project Datum Level is Chart Datum as defined by the Bombay Port Authority measured by the tide gauge located at Apollo Bunder. All land and sea levels in construction work shall be set out relative to Chart Datum. The relationships between Chart Datum, sea levels and infrastructure levels shall be taken as :-

- Highest recorded tide (HRT) + 5.040 CD
- Highest astronomical tide (HAT) + 5.400 CD
- Mean High Water Springs (MHWS) + 4.420 CD
- Mean High Water Neaps (MHWN) +3.300 CD
- Mean Sea Level (MSL) + 2.510 CD
- Mean Low Water Neaps (MLWN) +1.860 CD
- Mean Low Water Springs (MLWS) + 0.760 CD
- Lowest Low Water Recorded (-) 0.46CD

The chart datum is 2.51m below the GTS benchmark. The CD levels mentioned above when adjusted to GTS datum are as below:

- Highest recorded tide (HRT) + 2.53 R.L.
- Highest astronomical tide (HAT) + 2.89 R.L.
- Mean High Water Springs (MHWS) + 1.91 R.L.
- Mean High Water Neaps (MHWN) +0.79 R.L.
- Mean Sea Level (MSL) + 0.00 R.L.
- Mean Low Water Neaps (MLWN) - 0.65 R.L.
- Mean Low Water Springs (MLWS) - 1.75 R.L.
- Lowest Low Water Recorded - 2.97 R.L.

Waves:

The predominant waves are the swell waves generated by deep sea storms. These mainly arise just before and during the South West monsoon. The statistical analysis indicates that most wave periods fall between 6 seconds and 10 seconds. During the continuance of the North-East monsoon, North-Easterly winds known as "Elephantas" blow for short durations during the months of October-November. Significant Wave height with return period of 100years for the Mumbai coast shall be taken as 4.5m. (Ref. Inidan Journal of Marine Sciences Issue: June 1991).

Tides:

Current

In December and January sets north-westerly with the rates of upto 1knot. In July and August, when the S W Monsoon is well established, south easterly sets with rates of upto 2 Knots are experienced. Exceptionally onshore sets of upto 1.5Knots are experienced during the N E Monsoon and upto 3Knots during the S W Monsoon.

The tidal flow is unsteady and the magnitude and direction of the currents varies with respect to location, time and depth. Generally, the ebb currents are stronger than flood currents.

Siltation:

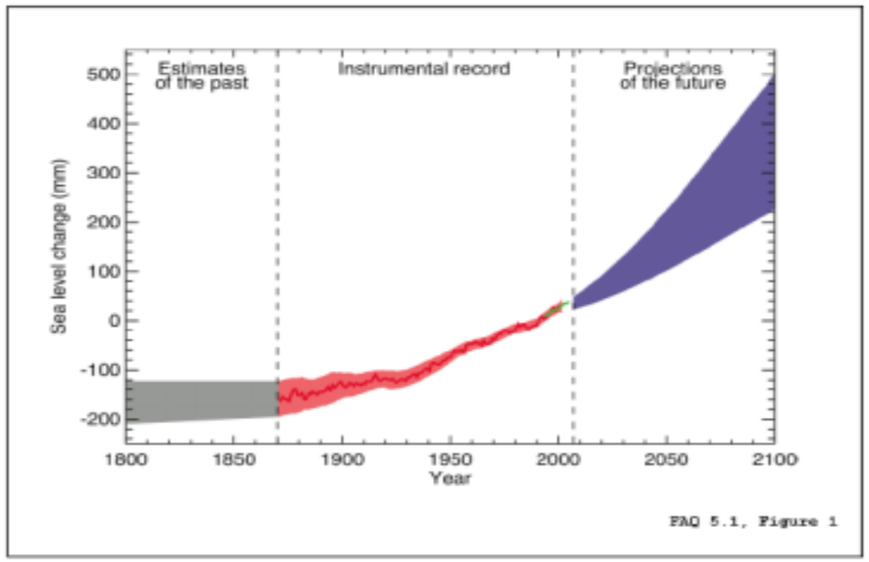
The average rate of siltation shall be taken as 3mm per day. The maximum rate of Siltation will occur during monsoon months and will be taken as 7mm per day. The siltation is maximum during the monsoon seasons. The rate reduces in the month's preceding and succeeding the monsoon. In the rest of months the phenomenon reverses and erosion occurs to a similar extent of siltation. The net effect of siltation over the entire year is minimal.

Littoral Drift

Longshore drift consists of the transportation of sediments (clay, silt, sand and shingle) along a coast at an angle to the shoreline, which is dependent on prevailing wind direction, swash and backwash. This process occurs in the littoral Zone, and in or close to the surf zone. The process is also known as littoral drift, long-shore current or long-shore transport.

Recent changes seen in sea behaviour patters:

No of Years of data	Trends (mm/Year)	GIA (Glacial Isostatic Adjustment) Corrections	Net Sea level rise (mm/Yr)
133	0.77	-0.43	1.20



Sea Level Changes – past, present and future

Table 9.5: Net Sea- level rise trends from past tide gauge data

Table 9.6: Matrix showing Structures inserted and effects on marine environment

Sr. No	Section	Proposed support for road	Effect on wave energy	Access for fishing boats	Obstruction to fish landing points	Presence of fishing villages	Area of religious activity along the shore	Mangroves	Heritage monument in the vicinity
1	Section -1	Tunnel	None	Access of fishing boats to sea should be considered in the Design of Bridge.	Alternative route is required.	Manora	Ganpati Imersion /Religious area near Girgaon Chowpati	No evident dense Mangrove Visible.	1.Govind Mahal, 2.Parijat, Meghdoot, 3.Parsi. Gymkhana, 4.Islam Gymkhana, 5.Hindu Gymkhana, 6.Wilson College, 7.Police Gymkhana Ground, 8.Zaver Mansion, 9.Wilson College
2	Section -2	Land filled Road	Energy absorption measures i.e. Breakwater may be required	Not applicable	No landing points are visible	Not in close vicinity	Mahalaxmi	No evident dense Mangrove Visible.	1.Lincoln House 2. Mahalaxmi
3	Section -3	Land Filled Road and Bridge on Sea	Partially reflects energy / Breakwater may be required	Not applicable	No landing points are visible	Not in close vicinity	Haji Ali	No evident dense Mangrove Visible.	1. Haji Ali
4	Section -4	Land Filled Road and	Energy absorption measures i.e. Breakwater may be required for Land filled Road. .	Not applicable	No landing points are visible	Not in close vicinity	Baroda Palace	No evident dense Mangrove Visible.	Not applicable
		2nos of Bridges on Sea	Reflects the Energy in the Pile Foundation Locations						
5	Section -5	Land filled Road, Bridge and Land filled Road on Mangroves	Energy absorption measures i.e. Breakwater may be required for Land filled Road.	Access of fishing boats to sea should be considered in the Design of Bridge.	Alternative arrangement during the construction stage is required.	Bandra Worli sea link toll plaza Bandra Band Stand, Chambai Village, near Khar danda village	Dandeshwar Shankar Mandir	Evidence of Mangrove Observed	1.Kekee Manzil 2.19/19-A Cartar Road 3.Dandeshwar Shankar Mandir
6	Section -6	Tunnel	Flow of under bottom currents required during Detailed Design Stage	Access of fishing boats to sea should be considered in the Design of Bridge.		Juhu Sea Garden	Not applicable	Evidence of Mangrove Observed	Theosophical society precincts
7	Section -7	Land filled Road	Road on Land side	Not applicable	Not applicable	Not in close vicinity	Not applicable	Evidence of Mangrove Observed	Not applicable

10. Environmental Impact Assessment

10.1 Introduction

This section covers the feasibility of preparing an Environment Impact Assessment Report for Mumbai Coastal Road Project.

10.2 Role of Environment screening into the overall project preparation

The environmental screening exercise is undertaken to determine the key environmental issues/concerns and the nature and magnitude of the potential environmental impacts that are likely to arise on account of proposed project interventions. The major or key environmental issues to be identified will be determined by the type, location, sensitivity and scale of the project. The results/findings from this exercise are/will be used to determine:

The extent and type of Environmental (Impact) Assessment requirement

The environmental category of the project/sub-project

The screening result will also be an important input for analyzing the 'feasibility' of the project/sub-project along with engineering/economics and social criteria.

10.3 Legal Framework

In 1976, the 42nd Constitutional Amendment introduced Article 48A and 51A, placing an obligation on every citizen of the country to attempt to conserve the environment. The legal framework for environmental issues related to road projects can be best described as National level and State level legislation:

The Government of India has laid out various policy guidelines, acts and regulations pertaining to sustenance of environment. The Environment (Protection) Act, 1986 provides umbrella legislation for the protection of environment. As per this Act, the responsibility to administer the legislation has been jointly entrusted to the Central Ministry of Environment and Forests (MOEF) and the Central Pollution Control Board (CPCB) / State Pollution Control Board (SPCB).

The lists of all applicable Government of India / State Government regulations are provided below with most relevant details.

Table 10.1:Summary of Applicable Regulations

Sl. No	Applicable GOI Policies & Regulations	Year	Objective	Reason for applicability
1	Environmental (protection) Act	1986	To protect and improve overall environment	Environment in general
2	Environment Impact Assessment (EIA) notification	1994	Requirement of Environmental impact Assessment	Direct
3	Environment Impact Assessment (EIA) notification	2006/ 2009 2013	For impact assessment of infrastructure projects	Environmental clearance
4.	Coastal Regulation Zone Notification	2011	To conserve and protect coastal stretches, its unique, environment and its marine area	CRZ Clearance
4	Air (prevention and control of pollution) Act as amended in 1987	1981	To control air pollution by controlling emission and air pollutants according to prescribed standards	Air pollution
5	Water (Prevention and Control of Pollution) Act and Cess Act of 1977 as amended in 1988	1974	To control water pollution by controlling emission & Water pollutants as per the prescribed standards	Water pollution
6	Indian Forest (Conservation) Act	1980	Protection of Mangrove forests	Forests
7	The Wildlife (Protection) Act	1972	Protection of Wild Life	Wildlife
8	Ancient Monuments and Archaeological sites & Remains Act	1958	Conservation of Cultural and Historical remains found in India	Archaeological remains
9	The Land Acquisition Act	1894 & 1989	Set out rule for acquisition of land by Government.	Land acquisition
10	Noise Pollution (Regulation and Control) rules 2000	2001	Noise pollution regulation and controls	Control of Noise pollution
11	NOC from Honorable High Court	Reference to PIL 87 of 2006	Conservation of Mangroves	Mangrove protection
12	Maharashtra Maritime Board Act 1996	1996	Permission for activities using water front	The proposed coastal road project involves activities using the waterfront, hence permission is required.

10.4 List of Vulnerable Eco-system Components

Following is a list of important ecosystem components that were identified as the valued eco system in the stretch during the field survey.

- On-shore /off-shore marine bio-diversity
- Impact on terrestrial and aquatic marine bio-diversity
- Mangrove Forests
- Impact on flora and fauna. Considered as reserve forest in Maharashtra.
- Road side Plantations
- Disturbance of flora having fruit bearing and fodder capability,
- Land
- Consumption of valuable coastal land and loss of top soil,
- Settlements
- Houses likely to be affected both residential and Business (Commercial),
- Trees within the corridor
- Matured and socially and culturally valuable trees,
- Water
- Water quality of ocean /river/stream/canal.
- Community water resources (wells, Tube wells)
- Construction water
- Drainage
- Distributed drainage system and flooding areas
- Cultural / Religious / Heritage Buildings
- Temples, mosques and Church
- Places of Pilgrimage and Tourism
- Landscape and the natural scenic beauty of the place
- Other sensitive issues identified along the proposed road are:
- fisherman route,
- drain out fall areas,
- slum area
- flight landing area in Juhu ,

10.5 Indicators used in selecting important issues

Impact on biodiversity

- Percentage of plantation land, orchards to be consumed;
- Mangrove forest area and amount mangrove forest land to be acquired
- Wildlife sanctuary
- Number of points over which the alignment crosses ocean, streams and drainage channels;
- Water resources near the proposed alignment within 200 m;
- Amount of coastal/commercial /private land likely to be acquired
- Percentage of kilometer stretches of the road cutting through the settlements
- Number of individual trees those are old, matured and traditional species.
- Heritage Buildings is getting affected due to the project
- Impact on community

10.6 Methodology Adopted for Environmental Screening Exercise

As a part of the project feasibility study, Environmental Impact Screening is undertaken in parallel with the Economic and Engineering Analysis in order to determine any significant economic, social or environmental issues which could require further analysis (including the analysis of alternative alignments) issues. The environmental screening analyze critical natural habitats (e.g. national parks, wildlife reserves, sanctuaries, sacred groves, protected areas, forests, water bodies etc.), major rivers and waterways, recorded cultural heritage sites and any other potentially sensitive areas, based on recent GOI census official data and information from NGOs and site visits. The results of this analysis plotted on maps and tabulated to clearly identify any major conflicts with proposed road improvements. The nature and extent of such conflicts and recommendations concerning how to resolve them (including recommendation for exclusion, analysis of alternative alignment and/or mitigation) as a precursor to preliminary engineering design and undertaking the required for environmental assessment studies.

10.7 Objectives of Environmental Screening

The objectives of the preliminary Environmental Screening are:

- To determine the magnitude of actual and potential impact
- To ensure that environmental consideration are given adequate weight in the selection of subsequent design of proposed highway improvements.

The results of the preliminary screening will enable us to identify:

Those stretches of the road with major environmental issues impacts which would require detailed EA in order to determine appropriate mitigation measures and

Those stretch with little to no potential impact and hence would require a limited environmental analysis.

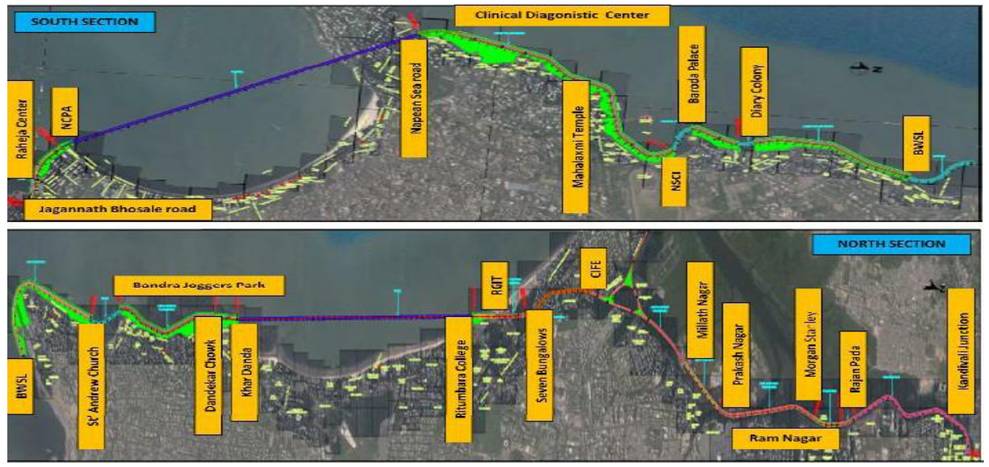
The environmental screening has made with the use of available information from official and non-official (e.g. Consultation with local people, NGOs etc.) sources concerning the location, type and sensitivity of all critical natural habitats (such as conservation areas, wildlife sanctuaries, sacred groves, , wetlands, side tree lines, etc.). These are also supplemented by adequate site visits. All this information were plotted on maps in such a manner as to identify any major potential environmental conflicts with the proposed road improvements.

10.8 Existing Baseline Environmental and Social Scenario

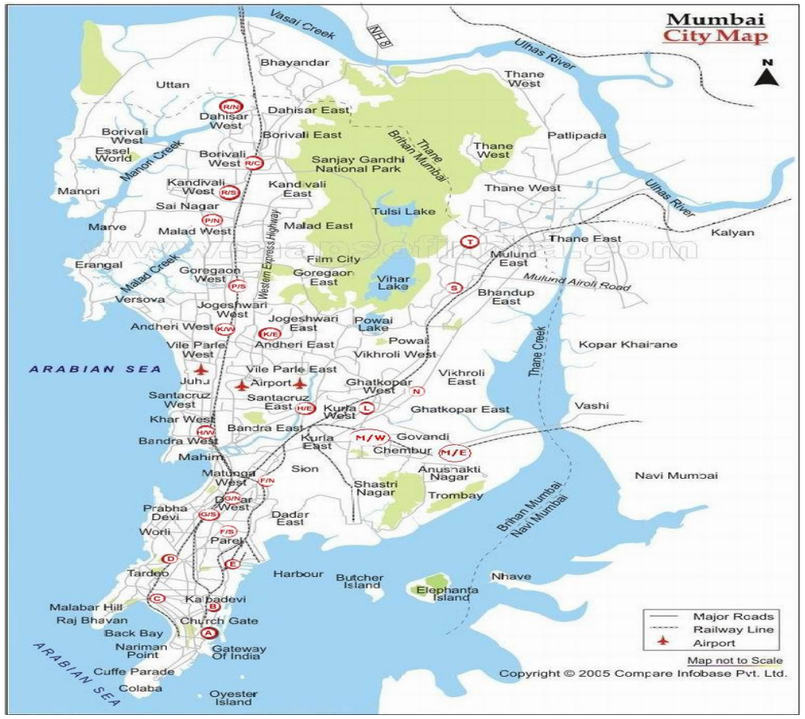
10.8.1 Location

Greater Mumbai district is located on the western most periphery of the Maharashtra State. Greater Mumbai district comprises South Salsete, Trombay and Bombay islands having a geographical area of 603 sq. km. (Mumbai City- 69 sq. km. and Mumbai Suburbs- 534 sq. km.). The district is bounded by north latitude 18°53' and 19°19' and east longitude 72°47' and 72°58'. Arabian Sea lies on the southern and western side of the district while it borders Thane district in the north and eastern side.

The proposed coastal road project (approximately 35 km) falls within Greater Mumbai district .It starts from Nariman Pointand ends at Kandivili. It is proposed to be extended further north connecting Madh Island, Gorai and Dahisar



Mumbai lies at the mouth of the Ulhas River on the western coast of India, Many parts of the city lie just above sea level, with elevations ranging from 10 m (33 ft) to 15 m (49 ft); the city has an average elevation of 14 m (46 ft). Northern Mumbai (Salsette) is hilly, and the highest point in the city is 450 m (1,476 ft) at Salsette in the Powai–Kanheri ranges.



Map of Greater Mumbai Region

10.8.2 Climatic Conditions

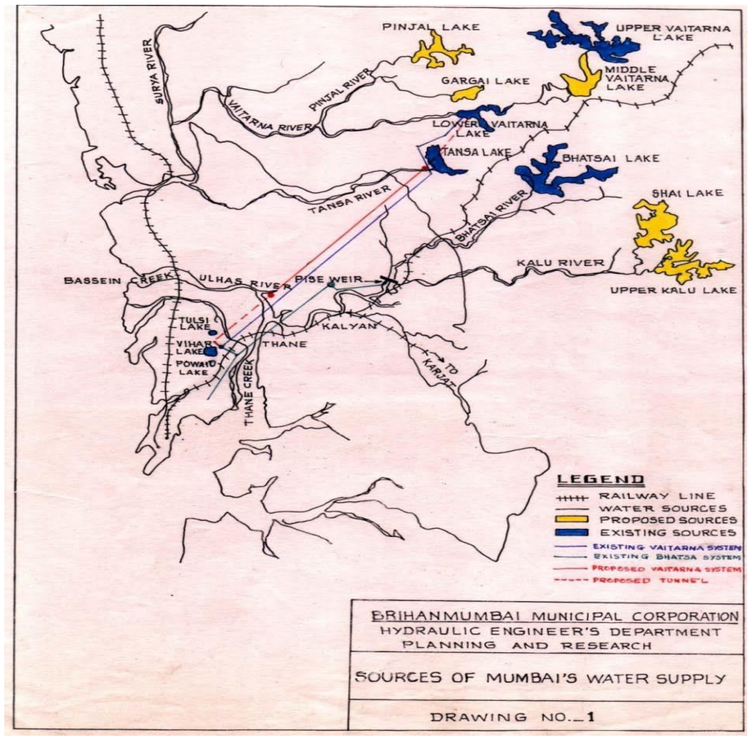
Mumbai, being on the seacoast, experiences a tropical savanna climate with a heavy southwest monsoon rainfall of more than 2100 millimeters a year. Mumbai experiences three seasons– summer from March to May, monsoon between June and September and winter during October to February. The city receives heavy rainfall during monsoon and relative humidity is quite high during this season. Similarly, winds are generally moderate but pick up during monsoon months

The mean minimum temperature is 16.3°C and the mean maximum temperature is 32.2°C a t Santacruze. The normal annual rainfall over the district varies from about 1800 mm to about 2400 mm. It is minimum in the central part of the district around Kurla (1804.9 mm). It gradually increases towards north and reaches a maximum around Santacruze (2382.0 mm).

Water resources

Apart from the Bhatsa Dam, there are six major lakes that supply water to the city: Vihar, Lower Vaitarna, Upper Vaitarna, Tulsi, Tansa and Powai. Tulsi Lake and Vihar Lake are located in Borivili National Park, within the city's limits. The supply from Powailake, also within the city limits, is used only for agricultural and industrial purposes. Three small rivers, the Dahisar River, Poinsar (or

Poisar) and Ohiwara (or Oshiwara) originate within the park, while the polluted Mithi River originates from Tulsi Lake and gathers water overflowing from Vihar and Powai Lakes. City pone to water shortages in years of scanty rainfall



10.8.3 Physiography and Soil Types

The broad physiographic features of are broad and flat terrain flanked by north – south trending hill ranges. The hill ranges form almost parallel ridges in the eastern and western part of the area. The Powai – Kanheri hill ranges are the other hill extending in the eastern and central part running NNE – SSW. The maximum elevation of the area is 450 m above mean sea level (mamsl) at some of the peaks of hill ranges. Trombay Island has north – south running hills with maximum elevation of 300 m above man sea level (m amsl). Malbar, Colaba, Worli and Pali hills are the isolated small ridges trending north – south in the western part of the district. The Powai – Kanheri hills form the largest hilly terrain in the central part of the Salsette Island and are the feeder zone for the three lakes viz., Powai, Vihar and Tulsi.

There are a number of creeks, dissecting the area. Among them, Thane is the longest creek. Other major creeks are Manori, Malad and Mahim which protrudes in the main land and give rise to mudflangs and swamps. The area is drained by Mahim, Mithi, Dahisar and Polsar rivers. These small rivers near the coast, form small rivulets which inter mingle with each other resulting in swamps and mud flats in the low lying areas.

Two types of soils have been observed in the district viz., medium to deep black and reddish colored soil. Soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy.

10.8.4 Geology and Geomorphology

The entire Greater Mumbai area is occupied by Deccan basalt flows and their acid and basic variants, poured out between the late Cretaceous and Early Eocene time. The basaltic flows are horizontally bedded and are more or less uniform in character over wide areas. Certain extrusive and intrusive mafic types are associated with basalts and are found in Mumbai Island and its vicinity. Further some fossiliferous sediments mainly of tufaceous origin and partly of fresh water origin, rich in fauna are also found in Mumbai area.

Mumbai Island has ridges along its western and eastern side. The city of Mumbai is built on central low-lying part of the Island. The western ridges comprise stratified ash beds.

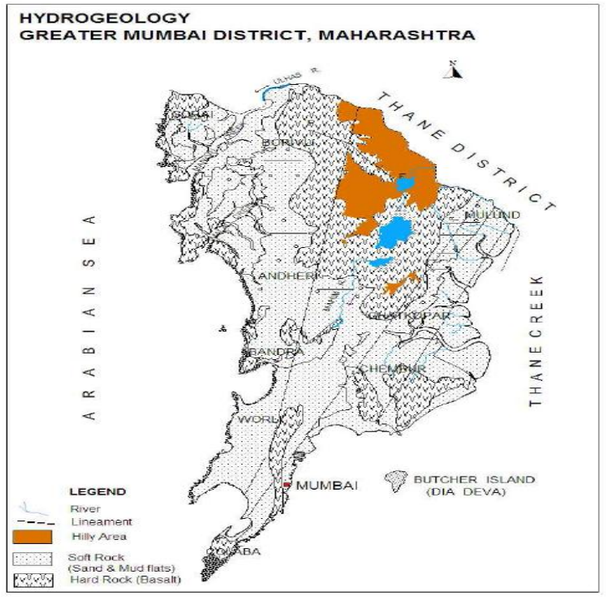
10.8.5 Ground Water Scenario

The entire area is underlain by basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow Alluvium formation of recent age also occur as narrow stretch along the major river flowing in the area

In hard rock areas the ground water exists in fractures, joints, vesicles and in weathered zone of Basalt. The occurrence and circulation of ground water is controlled by vesicular unit of lava flows and through secondary porosity and permeability developed due to weathering, jointing, fracturing etc., of Basalt. The ground water occurs under phreatic, semi confined and confined conditions. The leaky confined conditions are also observed in deeper aquifers. Generally the phreatic aquifer range down to depth of 15 m bgl. The water bearing zone down to depth of 35 m bgl forms the semi confined aquifer and below this deeper aquifer down to depth of 60 m bgl is observed. The yield of the dugwells varies form 10 to 1000 m3/day, whereas that of bore wells ranges between 50 and 1000 m3/day. It is expected that the potential of deeper aquifers would be much more limited as compared to the unconfined/phreatic aquifer.

In soft rock areas which constitutes most the study area , the river Alluvium patches along the course of rivers and Marine Alluvium in the coastal area, are highly potential aquifer but with limited areal

extent. The ground water occurs under water table condition in sandy / gritty layers. The alluvial fill of low lying areas underlain by weathered basalt has relatively better ground water potential.



Source : Central Gouundwater Board

Major Ground Water Problems and Issues

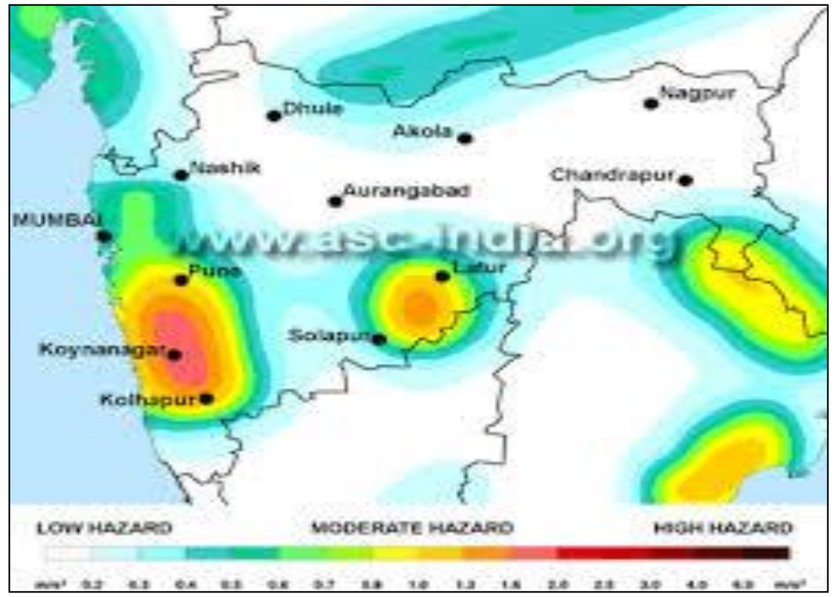
The pollution of ground water as well as surface water is the major problem in the area. The creeks in the region have become the dumping ground of sewage and industrial effluents. In addition to this, various industrial effluents from oil refineries, reactors, fertilizers plants at Chembur have polluted the sea water in eastern part and are hazardous to marine life.

The data of Maharashtra Pollution Control Board (MPCB) indicate high concentration of Mercury (Hg) than the prescribed limit of 1.90 ppm. The higher Arsenic (As) concentration of more than 2.00 ppm and slightly more is observed in fishes from Thane and Chembur. The other heavy metals like Lead (0.60 ppm), Cadmium (12.60 ppm) and Copper (8.84 ppm) are also reported from creek water.

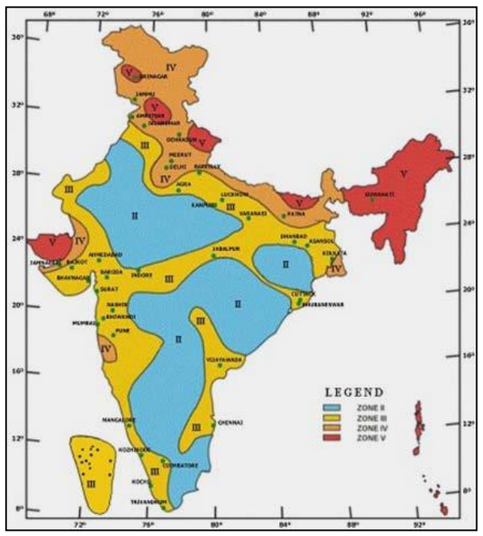
Ground water exploitation for commercial purpose is carried out in entire district and the water is extracted from existing dugwells and borewells, even new borewells are also being drilled for this purpose. The ground water is used for construction purposes, hotel industry and for domestic purpose of the housing societies. Excessive ground water development in the beach and coastal areas can lead to saline water intrusion as observed in some parts of Colaba, Dharavi and Khar from BMC data.

10.8.6 Seismic Hazards

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 may be expected.



Seismic Hazard Map showing Mumbai



Zone	Magnitude
Zone V	Very High Risk Quakes of Magnitude *8* and greater
Zone IV	High Risk Quakes upto Magnitude *7.9*
Zone III	Moderate Risk Quakes upto Magnitude *6.9*
Zone II	Seismic Disturbances upto Magnitude *4.9*

10.8.7 National Park

Sanjay Gandhi National Park (Borivali National Park) is located partly in the Mumbai suburban district, and partly in the Thane district, and it extends over an area of 103.09 km2 (39.80 sq mi) falls within 10 km radius area of the proposed alignment.

10.8.8 Religious/ Historical/Archaeological Places

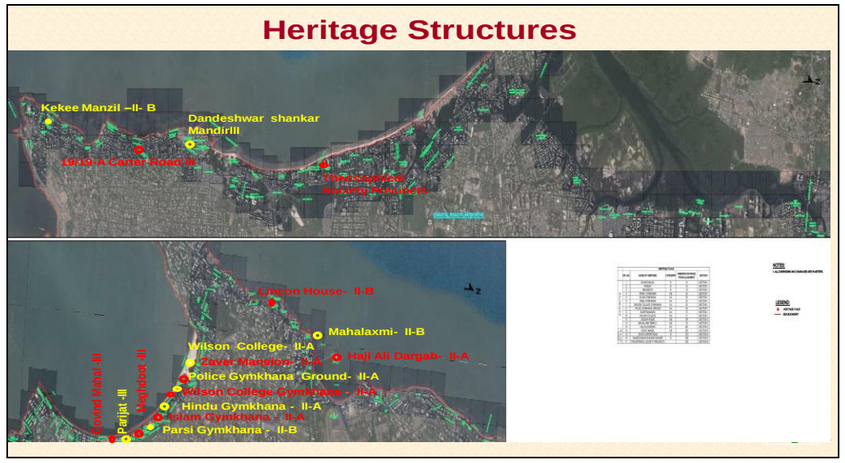
Details of 17 nos. of religious and heritage structures along the entire project stretch are given below.

Table 10.2: Details of Religious and Hertiage Structures along the project coastal road

Sl. No	Name of the Heritage	Grade	Minimum distance from alignment (m)
1	Govind Mahal	III	18
2	Parijat	III	19
3	Meghdoot	III	18
4	Parsi. Gymkhana	II-B	30
5	Islam Gymkhana	II-A	30
6	Hindu Gymkhana	II-A	25
7	Wilson College Gymkhana	II-A	33
8	Police Gymkhana Ground	II-A	36
9	Zaver Mansion	II-A	15
10	Wilson College	II-A	21
11	Lincon House	II-B	187
12	Mahalaxmi Temple	II-B	78
13	Haji Ali Dargah	II-A	281
14	Kekee Manzil	II-B	207
15	19/19 A Carter Road	III	210
16	Dandeshwar Shankar Mandir	III	330
17	Theosophical Society Precincts		232

Grade II (A & B) comprises of buildings and precincys of regional or local importance possessing special architectural or aesthetic merit or cultural or historical significance. They are local landmarks, which contribute to the image and identity of the region.

Grade III comprises building and precincts of importance for townscape; that evoke architectural, aesthetic, or sociological interest through not as much in Heritage Grade II.



10.8.9 Ecology

Mumbai Historical records indicate that there were several islands around Mumbai during 1670. However, the Britishers, who were ruling the country, identified the importance of these islands for commercial purpose. They deforested the fringing mangroves and reclaimed these islands into one continuous landmass, which later came to be known as "Greater Bombay". Since then the developmental and subsequently population pressure rapidly increased and being the coastal area, it took the toll of mangrove land. During the process of deforestation and reclamation, a few mangrove patches are still left in the heart of the city, which proves that today's megacity had a luxuriant past of mangrove forests Major mangroves are seen today in Mumbai along the Vasai Creek, Thane Creek, Manori and Malad, Mahim - Bandra, Versova, Siwari, Mumbra - Diva and few more places.

Importance of Mangroves for Mumbai

By trapping silt, mangroves maintain the integrity of Mumbai's shoreline. This is a vital service to the city of Mumbai as it is very prone to erosion, having been built on reclaimed land that is battered by the sea on all three sides. The recent rains in Mumbai and the disaster that followed demonstrated the

consequence of tampering with the ecology of fragile ecosystems like mangroves. Had Mumbai's Mithiriver and Mahim creek mangroves not been destroyed by builders, fewer people would have died and the property damage would have been dramatically less.

10.8.10 Mangrove community of Mumbai

In the early nineties, perhaps over 37 sq. km. of mangroves existed in Mumbai, largely in the Thane creek, Mahim, Versova, Gorai and Ghodbunder, with sporadic patches in places such as Bandra, Malabar Hill and Colaba. Mumbai has probably lost 40 per cent of all its mangroves in the past decade or so, largely because of reclamation for housing, slums, sewage treatment and garbage dumps. The Soonabai Pirojsha Godrej Marine Ecology Centre has undertaken several measures to protect the mangroves locally. Vast area under mangroves has been conserved by the Centre in Vikhroli a suburb of Mumbai. . Well diversified and well protected, these are the last- quality mangroves in the city.

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. Because of the high salinity of the soil, something like 60 per cent of Mumbai mangroves comprise Avicennia marina. Nor surprisingly this species also tolerates pollution including heavy metals such as lead, mercury and chromium,

10.8.11 Land slides

Greater Mumbai also faces risk of Landslides with pressure on land, many vacant sites on hill slopes or bottoms of hills have turned into inhabited area and thereby become vulnerable to landslides. Most cases of landslides occur during heavy rain associated with high velocity winds. It sometimes results in loss of human lives and damage to structures.

10.8.12 Road Accidents

The major road sections in Mumbai are accident –prone.

10.8.13 Industrial and Chemical Accidents

Mumbai also plays host to around 900 industries that are involved in manufacturing or processing or storage of hazardous goods. Many of these are in close proximity to residential and commercial areas, thereby increasing the risk of fires and explosions. The major concentration of such industries is in the Chembur-Trombay belt (Wards M-West and M-East). The area has major chemical complexes, refineries, fertilizer plans, atomic energy establishment and thermal power plant. The presence of such industries only enhances the vulnerability in case of extreme weather events.

10.8.14 Climate change and Sea level rise

A study conducted by the Tata Energy and Resource Institute (TERI) in partnership with Met Office Hadley Centre, U.K's climate change research center on " Assessing climate change vulnerabilities and adaption strategies for Maharashtra" indicates that the mean sea level along Mumbai's cost is likely to raise by around 4 cm while warmer nights, increaded rainfall, decline in crop productivity and health issues stare Maharasthra in the next 100 years.

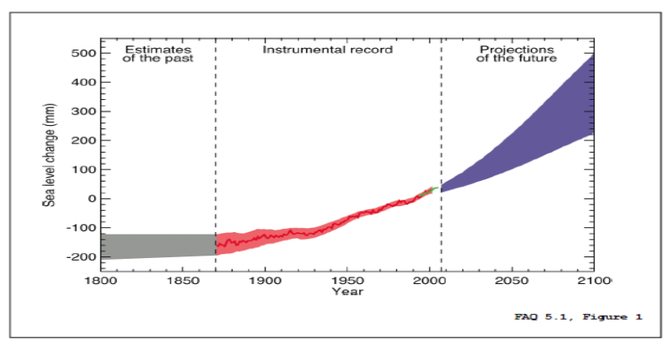
Study conducted by TERI showed that coastal flooding could lead to reduction in availability of fresh water due to saltwater intrusion as well as contamination of water supply through pollutants fro submerged waste dumps. The temperature of Mumbai and Maharashtra is likely to increase by 1-3 degrees in the next 50 years and evening nights would be warmer by 1.5 to 2 degrees.

According to the report in 2050s the increase in the mean sea level along the Mumbai coast may be around 2 cm and it would increase to around 4 cm by 2100. Due to increasing temperature and rainfall , coastal and Eastern Maharasthra are vulnerable to malaria outbreaks in future.

Net sea-level-rise trends from past tide-gauge data

Station	No of years of data	Trends (mm/year)	GIA (Glacial Isostatic Adjustment) corrections	Net sea level rise (mm/yr)
Mumbai	113	0.77	-0.43	1.20
Kochi	54	1.31	-0.44	1.75
Vishakhapatnam	53	0.70	-0.39	1.09
Diamond Harbour (Kolkata)	55	5.22	-0.52	5.74 sinking of delta

Sea level changes- past, present and future (Bindoff et al., 2007)



10.8.15 Cyclones & Flooding

Being a coastal city, Mumbai is prone to cyclones and gusty winds. There are a number of wards along the coast (Arabian Sea and Thane Creek) that are vulnerable to cyclonic impacts. For instance, in wards A – D, G-North, G-South, S and T, the Greater Mumbai Disaster management Action Plan (DMAP) has identified settlements that are acutely vulnerable to cyclones. There settlements were originally fishing communities, but are now home to many slums along the coast.

In addition to this, there are 40 chronic flooding locations identified in the DMAP report that are spread over the island city, eastern and western suburbs. The problem of flooding is acute when heavy rainfall coincides with high tide; i.e. more than 4.5 meters (average: 20 times during the monsoon)

10.8.16 Coastal Protection

Mumbai area as a whole is a lowland area on the west of Sayhadri Hills ranges. The area region has a 167 km long coastline that has estuaries bays, creeks, and beaches. The city of Mumbai needs to prepare itself against any natural calamities likely to occur in future. The city due to its peculiar geography acts as a natural breakwater of its own. The existing sea wall which is weakening due to wave attack requires be strengthening and protecting.

Table 9.9: Coastal Stretches proposed for Protection

Coastal Stretches proposed for Protection Description	Island city (km)	Mumbai Suburban (km)	Total length (km)
Total coast line	29.430	43.785	73.215
Artificially protected	14.745	11.075	25.820
Naturally protected including beaches	8.300	25.650	33.950
To be protected	6.385	7.060	13.445

Source: Mumbai City Development Plan (2005 – 2025)

10.8.17 Demographic profile

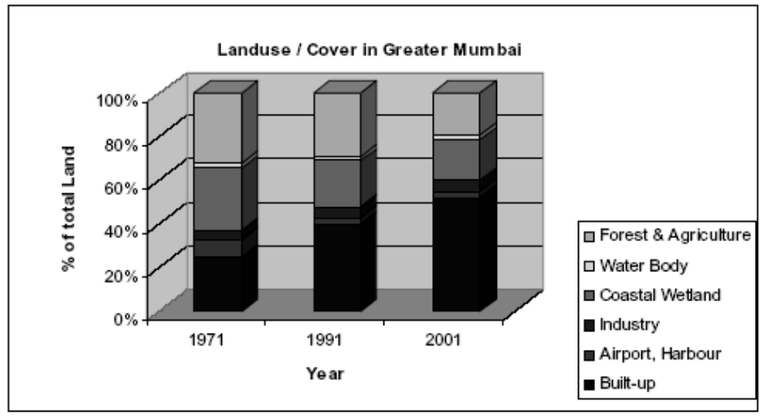
According to the 2011 census, the population of Mumbai was 12,479,608. The population density is estimated to be about 20,482 persons per square kilometre. The living space is 4.5sq metre per person. As Per 2011 census, Greater Mumbai, the area under the administration of the MCGM, has a literacy rate of 94.7%, higher than the national average of 86.7%. The number of slum-dwellers is estimated to be 9 million; up from 6 million in 2001, that is, 62% of all Mumbaikers live in informal slums.

The sex ratio 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.

There are in all 2335 slum settlements as per 1985 data in Mumbai. These slums are considered as vulnerable settlements due to their location and access to infrastructure.

10.8.18 Land use pattern

The Mumbai Metropolitan Region (MMR) is one of the fastest growing regions of India. Its population increased from 7.7 million in 1971 to 18.3 million in 2001 (Census of India, 2001) and is projected to increase to 22.4 million by 2011(MMRDA, 1999). High population growth, inward migration and urbanization put stress on resources. Increasing economic activity and per capita income further stresses the resources and has resulted into changing land-uses pattern.



Source: -Mumbai city development plan 2005-25)

This development process changed the character of the natural environment of the region. Land reclamation, vegetation clearances, changes in land use etc. created a new man-made environment. The ecology of the region also adapted to these changes. In the last four decades the population of Mumbai has been increasing rapidly. To cater this sudden rise in population, rapid and unplanned development took place, which has led to serious environmental degradation.

In the past 10 years alone, built-up land in Mumbai has soared nearly 114 percent, in the same period, forest and wetland areas shrank by 35 percent (H.P.Sawant.2004). Mangrove ecosystems which exist along the Mithi River and Mahim creek are being destroyed and replaced with construction. Hundreds of acres of swamps in Mahim creek have been reclaimed and put to use for construction by builders. The Bandra-kurla complex was created by replacing such swamps. The systematic destruction of about 1,000 acres of the city's mangrove cover - what's left, about 5,000 acres, is under

threat - has deprived Mumbai of its natural flood-barrier and silt trap. July 2005 flooding is a result of ecosystem change.

10.8.19 Status of Air, water and noise pollution

The latest Environment Status Report of Greater Mumbai 2012-13 observes that with widespread construction activities and increasing number of vehicles, suspended particulates in the ambient air exceed the air quality standards set by Central Pollution Control Board (CPCB).

The report, prepared by the municipal corporation, also suggests that the contamination level found in the water supplied to the city too has gone up, by 19%. Noise pollution has exceeded the prescribed CPCB standards all over the city. And the irony is that the highest noise levels, especially during evening and night, have been recorded in silence zones.

In the report, of National Environmental Engineering Research Institute it shows that rapid population growth has contributed to some serious environmental problems in Mumbai. "Some of the areas have population densities of around 46,000 per sqkm (among the highest in the world), which have adversely affected the basic life-sustaining resources, water and air,"

Some of the major concerns of the city are the non-availability of a sewer system in slum areas and absence of treatment of waste water flowing in storm water drains. Mumbai is facing a catastrophic situation when it looks at the total waste generated and its management.

The report also says that coasts, rivers and creeks are subjected to degradation. On the one hand, authorities show their wish to save mangroves and, on the other, mangroves are expanding in creeks/creeklet regions due to illegal disposal of silt. This hampers the water-carrying capacity of water bodies leading to ecological damage.

As per the report, while 60% of Mumbai resides in slums, slum sanitation programme works at a snail's pace. Creeks and coastlines are deteriorating due to littering and garbage, and open defecation and waste water discharge are rampant.

Deteriorating air quality

Concentration levels of air pollutants in the city show mixed observations. The report is based on the regular monitoring and evaluation of the ambient air through six receptor-oriented monitoring sites — Worli, Khar, Andheri, Bhandup, Borivli and Maravali (Chembur) — and states that level of air pollutants in the city is alarmingly high. While sulphur dioxide and lead are found to be below prescribed standards at all six sites, nitrogen dioxide has exceeded in Khar, Andheri and Maravali (Chembur). Level of ammonia is the highest in Chembur. Suspended particulate levels are high in all six sites

Water contamination

It has been observed that water contamination is high during the monsoon. The contamination level, generally bacterial, found in water supplied to the city during 2012-13 has been recorded between 14% and 42%. Waterborne diseases, such as gastroenteritis, typhoid and hepatitis (A and E) are recorded in the city every year. A maximum numbers of cases of water contamination are found in areas between Marine Lines and Charni Road (C ward — 42%) followed by Goregaon (P-south — 31%), while a minimum percentage of contaminated samples were from Malad (P-north — 14%), followed by Ghatkopar (N-ward — 15%).

In almost all civic wards across the city, water contamination has risen since last year. The average water contamination level is 20%.

Noisy silence zones

Increasing noise pollution in the city has been affecting the health of citizens. In Mumbai, noise levels have exceeded the prescribed standards of CPCB. Though a stringent law has been formed as per a high court order to curb noise pollution, it has not been implemented properly. Besides silence zones, residential and commercial zones too exceed the limits. During festivals, noise levels are found to be on a rise. Ironically, authorities don't keep a record of noise pollution during these days.

Transportation Galore

For obvious economic reasons and also for their love for it, Mumbaikars prefers two-wheelers over four-wheelers. Besides being cheaper, they are easy to navigate during traffic jams and easy to park on congested roads.

The transport sector is the major contributor of air pollution in the city, followed by the industrial sector. Mumbai has registered 1,80,441 vehicles between 2012 and 2013, contributing the highest amount of carbon monoxide, suspended particulates, lead, sulphur dioxide, hydrocarbons and oxides of nitrogen, among other pollutants. The total number of vehicles in the city as on March 2013 was 22, 08,954.

Suspended particulates from vehicle emissions lead to respiratory problems. Authorities, however, have started various initiatives to control air pollution. CNG and LPG are regarded as clean fuels and used by over 93% of metered taxis and all autorickshaws.

10.9 Analysis of Alternatives

Various alternatives were considered for finalization of alignment. Comparative study is required to assess the pros and cons of each alternative which is presented in chapter 6 of this report.

10.10 Major Findings & Environmental Implications

The Coastal road (35 Kms appox.) from Nariman Point to Kandivili is proposed comprising a combination of coastal roads based on reclamation, bridges, elevated roads and tunnels on western side of Mumbai.

Land reclamation The CSIR-NIO team has examined the aspect of impact if any on tidal movements or coastal erosion entailed by reclamation for the coastal road. The Committee has found that the proposed reclamation in an average width of about 100 m does not cause any impact on the tidal movements and no adverse effects to the coastline are envisaged. Appropriate amendments be made in the current CRZ notification (which does not allow reclamation) for the proposed coastal road system in Mumbai

Tunneling: Tunnel options both cut and cover type and the bored type may have to be envisaged at some locations.

Bridge on sea : Disturbance to aquatic habitats

***Stilt road*:** Stilt road is permissible in CRZ but would cause a visual obstruction to the view of the sea and In Mumbai, coastal roads on stilts, is not an environment-friendly and feasible option, where large scale **development has already taken place in the neighbourhood.**

The coastal road also involves land reclamation in mangroves which are considered as reserve forests in Maharashtra and crossing creek that are ecologically sensitive.

17 nos. of religious and heritage structures are along the entire project stretch.

Other sensitive issues identified along the proposed road are

- fisherman route,
- drain out fall areas,
- slum area
- flight landing area in Juhu ,

Rapid developments like housing, industrialization, pollution and increasing population of Mumbai has resulted into degradation of mangroves. The worst affected area in Mumbai is the entire western front excepting Carter Road where the mangroves have grown and have also registered an increase in height in the last 10 years. This has been possible due to the participation of citizen's forums fighting individually. In India, a legal protection is afforded to this ecosystem by way of legislation in the form of Coastal Regulation Zone Notification. Recently Mumbai High Court has ordered freeze on destruction of mangrove forests in Maharashtra and has banned construction within 50 metres of them. The court has also directed to notify mangrove areas as protected forests.

Deteriorating air, water and noise quality.

Environment Impact assessment study should be conducted and an Environmental Management plan is to be prepared to get CRZ Clearance and to minimize the environmental impact during construction and operation of the project **.**

Forest clearance from Forest Department/MoEF is required as construction in mangrove area is involved. NOC from HighCourt is also required in reference to PIL 87 of 2006

The project falls within 10 km radius area of Sanjay Gandhi National Park (Borivali National Park) hence SBWL and NBWL clearances are necessary.

Management plan for reclamation area, coastal protection and mangrove should be formulated.

Future scope of work

Steps of future scope of work are summarized below:

- Screening and Feasibility report
- Base line Environmental data generation and preparation of Environmental Impact Assessment (EIA) report
- Preparation of Environmental Management Plan report
- Public Consultation
- Project layout superimposed on the CRZ map indicating HTL and LTL in 1:4000 scale and submission FORM 1 to MCZMA for CRZ clearance
- Submission of documents for Forest Clearance
- NOC from NWBL
- Submission of necessary documents to obtain of High Court permission.

10.10.1 Environmental Impact Assessment Study

Execution of the project will have direct impact on Environment. It is therefore necessary to undertake Environment Impact Assessment (EIA) study for the project to assess the potential critical impact of the project on environment in order to suggest mitigate measures, which are required to be incorporated during the initial planning stage. Environment Impact Assessment and Management Plan shall be prepared in conformity with TOR.

Purpose of EIA report preparation is to establish the baseline environmental aspects of the Project road corridor and to analyze all the expected impacts, required avoidance and the possible cost effective mitigation measures. Further these mitigation measures need to be stream lined with the engineering design and the contracting process for effective implementation.

The objectives of the environmental study will be achieved adopting the methodology outlined below:

Study Corridor

The study corridor will comprise a 10 km wide strip on either side of the proposed alignment.

Secondary Data Collection & Analysis

The work on data collection from the secondary sources has been initiated. The objective is to gather information on the regional orientation of the basic elements of environment, like lithology, drainage, climate (the wind speed, wind direction, relative humidity, temperature, rainfall, etc.), archaeological places, biotic wealth including forests, wetlands, wildlife reserves, sanctuaries, sensitive, critical natural habitats, if any.

The data on human environment, the demographic profile and occupational pattern will be collected from Census of India. The data collection on social attributes and amenities available such as literacy rate and utilities, incidence of scheduled tribes and castes, general land use pattern and settlement systems, major market centers and transport system, etc., has been initiated.

Review of Policy, Legal and Administrative Framework

This step discussed the policy, legal framework within which the Environmental Assessment (EA) is prepared and also reviewed the existing institutions and legislations relevant to the project corridor, at the, national level and at the state level.

Assessment of Baseline Environmental Status

Baseline conditions within the defined area have to be determined as per MoEF requirements for infrastructure projects. The database for working out the baseline status was from both secondary and primary sources.

Field surveys for assessment of baseline levels will be taken up subsequently. These will include:

Air Quality & Meteorology

The ambient air quality monitoring at selected locations of the road will be carried out to establish the baseline concentrations of various parameters like Particulate Matter (PM10 & PM 2.5), Sulphur Dioxide (SO2), Oxides of Nitrogen (NOx), Hydrocarbon (HC), Carbon-monoxide (CO) and Lead (Pb) at residential, commercial, and sensitive areas. Meteorological parameters like wind direction, wind speed, relative humidity, temperature and rainfall will be collected during the entire monitoring period. The air quality data will be used for developing a suitable model for the future air quality prediction.

Water Quality

Water quality sampling locations will include various groundwater and surface water sources along the alignment such as rivers, ponds, canals and ground water. The samples will be analyzed for various physical, chemical and biological parameters.

Noise Level

Background noise level will be monitored for both day time and night time values at various residential, industrial and sensitive areas, equivalent sound level (Leq) values will be computed.

Soil / Sediment Quality

Soil/sediment samples will be collected from agricultural and dry lands, river banks and river sediments. Samples will be analyzed for various physical, chemical and biological parameters.

Assessment of Alternatives

Assessment of various environmental issues due to various cross sections alternatives has been carried out.

Assessment of Potential Impacts

Based on the baseline conditions, the significant impacts needing mitigation have to be identified. The direct and indirect impacts likely to be induced due to the project need to be adequately identified and addressed.

Integration of Environmental Assessments in the Design Process

The design and decision-making process integrated with environmental, resettlement and rehabilitation issues to be carried out. This has prompted the early identification of appropriate actions. Such actions included, for example, shifts in alignments based on awareness of the locations of cultural resources, and biological resources.

Community Consultations

Public participation and community consultation to be taken up involving public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved.

Mitigation & Environmental Enhancement Measures

Positive actions to not only avoid adverse impacts, but also to capitalize on opportunities to correct environmental degradation or improve environmental conditions to be determined.

Preliminary Environmental Management Plan (EMP)

Environmental Management Plan (EMP) to be prepared to specify the steps necessary to ensure that the mitigation measures have been suggested. A suitable environmental management plan shall be prepared containing (a) mitigation measures against impacts during construction and operation phases (b) monitoring requirement of mitigation measures (c) environmental enhancement plans (d) institutional arrangements required and (e) cost of implementation of mitigation and monitoring requirements.

10.10.2 Considerations for EIA study

Environmental Impact Assessment Guidance Manual for Highways and Port & Harbours prepared by Administrative Staff College of India, Hyderabad in February 2010 will be considered as model ToR for Preparation of EIA/EMP report. During EIA study consideration will be given to:

- Impact on land to be acquired for construction of the road.
- Impact on Mangrove forest land and eco- system
- Analysis of alternative alignments.
- Assessment of the environmental impacts on the virgin areas due to the proposed alignment.
- Impact on road side trees and orchards
- Impact on religious/heritage structures
- Impact on water resources and water storage structures
- Impact on natural drainage pattern due to the high embankments.
- Analysis of alternative materials for embankment construction
- Impact on quality life of the Project Affected Persons (PAPs)
- Road safety and safety during construction and operation of the road.
- Documentation of land ownerships and updating the land record.
- Disbursement of compensation to the title holders
- Identification of sites for relocation Mangroves

10.10.3 Generic Structure of EIA report

This EIA report will be organized in as per guidelines of Environmental Impact Assessment Notification of 14th September 2006 (EIA notification 2006), of MOEF Environmental. Accordingly the entire document is organized as follows:

- Introduction
- Project Description
- Description of the Environment
- Anticipated Environmental Impacts & Mitigation Measures
- Analysis of Alternatives (Technology & Site)
- Environmental Monitoring Program
- Additional Studies (Community Participation and Public Consultation)
- Environmental Enhancement
- Environment Management Plan (EMP)
- The Summary EIA shall be a summary of the full EIA Report condensed to few pages. It should necessarily cover in brief the following Chapters of the full EIA Report:
- Project Description
- Description of the Environment
- Anticipated Environmental impacts and mitigation measures
- Environmental Monitoring Programme
- Public Consultation
- Project Benefits
- Environment Management Plan

10.10.4 Procedure for clearance of project attracting CRZ notification

Procedure for clearance of project attracting CRZ notification shall be considered for CRZ clearance as per the following procedure, namely:-

To apply with the following documents seeking prior clearance under CRZ notification to the concerned State or the Union territory Coastal Zone Management Authority,-

(a) Form-1:

(b) Rapid EIA Report including marine and terrestrial component

(c) Disaster Management Report, Risk Assessment Report and Management Plan;

(d) CRZ map indicating HTL and LTL demarcated by one of the authorized agency (in 1:4000 scale;

(e) Project layout superimposed on the above map indicated at (d) above;

(f) The CRZ map normally covering 7km radius around the project site.

(g) The CRZ map indicating the CRZ-I, II, III and IV areas including other notified ecologically sensitive areas;

The MCZMA shall examine the above documents in accordance with the approved CZMP and in compliance with CRZ notification and make recommendations within a period of sixty days from date of receipt of complete application:

(a) MoEF or State Environmental Impact Assessment Authority (hereinafter referred to as the SEIAA) as the case may be for the project attracting EIA notification, 2006;

(b) MoEF for the projects not covered in the EIA notification, 2006 but attracting para 4 (ii) of the CRZ notification:

MoEF or SEIAA shall consider such projects for clearance based on the recommendations of the concerned CZMA within a period of sixty days.

The clearance accorded to the projects under the CRZ notification shall be valid for the period of five years from the date of issue of the clearance for commencement of construction

10.11 Conclusion & Recommendations

Mumbai is a linear city which is expanding in the northern and eastern sides with decentralization of business activities and Government functions. The transportation needs have become very complex, though north-south corridors still play the major role. With major North-South arterials being saturated and no possibility for any capacity augmentation. The Coastal Freeway (33 Kms appox.) from Nariman Point to Kandivili is proposed comprising a combination of coastal roads based on reclamation, bridges, elevated roads and tunnels on western side of Mumbai. . The Coastal road is proposed to be extended further north connecting Madh Island, Gorai and Dahisar.

The present CRZ notification issued in January 2011does not allow coastal roads on reclamation .The MoEF, Central Government of India, is constantly instrumental for strengthening existing policies for protecting and improving the quality of the coastal environment. The legal system of coastal zone management in India came into force in 1991. The Coastal Regulation Zone (CRZ) notification, under the environment Act, is one of the major norms limiting the activities in the coastal zone. It includes various laws for regulation of anthropogenic interferences by permitting environmental friendly developments. The Notification was later amendment in January 2001.

Coastal stretches of seas bays, estuaries, creeks, rivers and backwaters influenced by tidal action up to 500 m from High Tide Line (HTL) and the area between HTL and low tide line (LTL) is classified as CRZ Distance from HTL applied to both sides in rivers, creeks, backwaters and distance shall not be less than 100 m or width of water bodies whichever is less

CRZ I Zone consists of ecologically sensitive and important areas, and includes mangrove wetlands, national parks, sanctuaries, and wild life habitats, places of outstanding natural beauty or historical heritage. Areas close to breeding and spawning grounds of fish, those likely to be inundated due to sea level rise (consequent upon global warming), and the area between LTL and HTL are covered under this category.

Land reclamation, bunding or disturbing the natural course of seawater is not allowed in CRZ I area. The CSIR-NIO team has examined the aspect of impact if any on tidal movements or coastal erosion entailed by reclamation for the coastal road. The Committee has found that the proposed reclamation in an average width of about 100 m does not cause any impact on the tidal movements and no adverse effects to the coastline are envisaged. Appropriate amendments be made in the current CRZ notification (which does not allow reclamation) for the proposed coastal road system in Mumbai

Most of the road passes through coastal area; hence CRZ notification 6th January 2011 is applicable.

The EIA notification September 14, 2006, states that prior environmental clearance from the concerned authority is required only for National, State Highways and Expressways. The coastal road is yet to be notified; depending on the type of the proposed road the EIA Notification 2006 will be applicable.

But an Environment Impact assessment study should be conducted and an Environmental Management plan is to be prepared to get CRZ Clearance and to minimize the environmental impact during construction and operation of the project.

Forest clearance from Forest Department/MoEF is required as construction in mangrove area is involved. NOC from High Court is also required in reference to PIL 87 of 2006

The project falls within 10 km radius area of Sanjay Gandhi National Park (Borivali National Park) hence SBWL and NBWL clearances are necessary.

Management plan for reclamation area, coastal protection and mangrove are to be formulated.

11. Initial Construction Cost Estimates

11.1 General

The primary project cost has been proposed considering the various items of worked associated with identified improvements so as to assess for evaluating visibility of the project.

11.2 Methodology

All broad work items have been identified. Unit rate of different work items have been derived on the basis of available schedules of rate of MCGM / Thane and experience of consultants in project of similar nature. Quantities of different work have been worked out considering the typical cross section, proposed improvements road alignment.

11.3 Estimation of Quantities and Cost

The quantities of following major items of work were considered for preliminary cost estimation.

Table 11.1 List of Major Items of work

Sr. No	Items of work
1	Site Clearance
2	Earthwork, Erosion Control And Drainages
3	Sub-Bases, Bases (Non-Bituminous) and Shoulders
4	Bases and Surface Courses (Bituminons)
5	Cement Concrete Pavement
6	Pipe/Box Culverts
7	Major Bridge
8	Minor Bridge
9	Fly Over
10	Break water wall
11	Railway Over Bridge
12	Vehicular Underpass
13	Pedestrian Underpass
14	Foot over bridges
15	River/Channel (Creek) Training & Protection works
16	Geosynthetic & Reinforced Earth Wall
17	Junctions
18	Traffic Signs, Marking and other Road Appurtenances
19	Miscellaneous
20	Promenades
21	Horticulture
22	Construction of Tube Tunnel
23	Interchanges

Cost Estimate for finally recommended alignment is presented in Table 11.4 below for comparison purpose. Based on Typical cross section sample BOQ and Cost Estimate is prepared and further converted to per Km cost. Details pertaining to these are given in Appendix C.

Table 11.2 Cost Estimate of the Alignments Options 7

ABSTRACT SHEET FOR NORTH SECTION

Item	Unit	Total Scope in Unit	Cost in Rs.	Cost in Cr.	Cost per Unit
Reclamation of Land	Km	3.000	2,149,314,096.00	214.93	72.00
Road on Land Filled	Km	2.700	2,234,572,571.00	223.46	83.00
Road on Land Filled on Mangroves	Km	2.885	1,890,403,423.00	189.04	66.00
Surface Road	Km	1.500	511,240,055.00	51.12	34.00
Tunnel including Ramp Portion	Km	5.875	27,363,648,281.25	2736.36	466.00
Costing for Structure (Bridge in Sea/Road on Stilit / Elevated Road)	Km	4.400	19,810,216,267.56	1981.02	450.00
Interchanges	Nos.	8	20,952,607,262.65	2095.26	262.00
Foot over Bridge	Nos.	9	1,009,743,441.00	100.97	11.22
Costing for CD Works	Nos.	30	180000000	18.00	0.60
Bus Bays & Bus Terminal including Bus Shelter	Nos.	12	265,279,175.00	26.53	2.21
Grand Total	Km		76,367,024,572.46	7636.70	

ABSTRACT SHEET FOR SOUTH SECTION

Item	Unit	Total Scope in Unit	Cost in Rs.	Cost in Cr.	Approx. Cost per Unit
Reclamation of Land	Km	6.400	8,165,321,535.00	816.53	128.00
Road on Land Filled	Km	4.820	5,655,016,348.00	565.50	117.00
Road on Land Filled on Mangroves	Km	0.000	-	0.00	0.00
Surface Road	Km	0.000	-	0.00	0.00
Tunnel including Ramp Portion	Km	5.600	9,928,268,858.70	992.83	177.00
Costing for Structure (Bridge in Sea / Road on Stilt / Elevated Road)	Km	2.042	6,477,076,360.00	647.71	317.00
Interchanges	Nos.	4	12,864,432,357.72	1286.44	321.61
Foot over Bridge	Nos.	8	462,826,560.00	46.28	5.79
Costing for CD Works	Nos.	42	252000000	25.20	0.60
Bus Bays & Bus Terminal including Bus Shelter	Nos.	12	177,365,689.00	17.74	1.48
Grand Total	Km		43,982,307,708.42	4,398.23	

Table 11.3 Operation and Maintenance cost

Sr. No	Year	Total Project length (KM)	For Routine Maintenance		Toll Management		Major / Periodic		Total Cost of O & M
			Routine Maintenance in Cr per year per km	Amount in Cr.	Toll Management for one Toll Plaza	Amount in Cr.	Major Maintenance	Major / Periodic Maintenance	
			in Cr.	in Cr.	in Cr.	in Cr.	in Cr.	in Cr.	in Cr.
1	2014-15								
2	2015-16	34.560							
3	2016-17	34.560							
4	2017-18	34.560	0.035	1.20	1	1.36	4.625	4.63	7.19
5	2018-19	34.560	0.073	2.52		2.86			5.38
6	2019-20	34.560	0.077	2.65		3.00			5.65
7	2020-21	34.560	0.080	2.78		3.15			5.93
8	2021-22	34.560	0.084	2.92		3.31			6.22
9	2022-23	34.560	0.089	3.06		3.47	0.66	22.70	29.23
10	2023-24	34.560	0.093	3.22		3.65	0.69	23.83	30.69
11	2024-25	34.560	0.098	3.38		3.83	0.72	25.02	32.23
12	2025-26	34.560	0.103	3.55		4.02			7.57
13	2026-27	34.560	0.108	3.72		4.22			7.94
14	2027-28	34.560	0.113	3.91		4.43			8.34
15	2028-29	34.560	0.119	4.11		4.65			8.76
16	2029-30	34.560	0.125	4.31		4.89	2.43	83.99	93.19
17	2030-31	34.560	0.131	4.53		5.13	2.55	88.19	97.85
18	2031-32	34.560	0.138	4.75		5.39	2.68	92.60	102.74
19	2032-33	34.560	0.144	4.99		5.66			10.65
20	2033-34	34.560	0.152	5.24		5.94			11.18
21	2034-35	34.560	0.159	5.50		6.24			11.74
22	2035-36	34.560	0.167	5.78		6.55			12.32
23	2036-37	34.560	0.176	6.07		6.87	2.33	80.51	93.45
24	2037-38	34.560	0.184	6.37		7.22	2.45	84.53	98.12
25	2038-39	34.560	0.194	6.69		7.58	2.57	88.76	103.03
26	2039-40	34.560	0.203	7.02		7.96	2.70	93.20	108.18
27	2040-41	34.560	0.213	7.37		8.36	2.83	97.86	113.59
28	2041-42	34.560	0.224	7.74		8.77	2.97	102.75	119.27
29	2042-43	34.560	0.235	8.13		9.21	3.12	107.89	125.23
30	2043-44	34.560	0.247	8.54		9.67	3.28	113.28	131.49
			Total in Cr.	**130.03**		**147.36**		**1109.73**	**1387.13**

12. Economic Analysis including Sensitivity Analysis

12.1 Introduction

The construction of the Coastal Road along with the interchanges is to be examined for implementation with respect to its economic viability. However, since the project of this nature involves certain social costs in terms of utilization of scarce resources and public investment, to have significant benefits flowing to the society, it becomes imperative to undertake an economic analysis to examine whether such projects are significantly beneficial to the society or the economy.

Construction of the new link connecting Nariman Point and Kandivili brings about a reduction in vehicle operating costs, travel time, accidents, environmental pollution, etc. In the present analysis the cost stream comprises land acquisition, resettlement and rehabilitation, environmental costs, construction and maintenance costs required for the proposed alignment whereas the savings constitute vehicle operating costs (VOC) and travel time savings for passengers and goods. The following sections describe the steps followed in the economic analysis considering inputs from the prevailing ground situation, considering a design life of 30 years including the construction. The analysis has been carried out as per the IRC-SP 30-2009 guidelines. As the equations presented in the IRC code is limited to 4-lane roads, the economic analysis has been done taking one-way traffic (assumed 50% of ADT) and 50% cost, which may not have any impact on the results.

Traffic Assignment

The section-wise traffic assignment along the proposed alignment has already been carried out based on the traffic volume survey, origin-destination surveys and interchange location/ layout. For economic analysis, the southern section (between Nariman Point and BWSL) and northern section (between BWSL and Kandivili) have been considered separately. The average traffic along existing roads (S V Road/ Western Expressway/ Link Road/ Pedder Road/ Gokhale Road etc) has been estimated considering representative survey locations (approximately matching with the average assigned traffic). The alternatives considered are;

Alternative I: Existing Road through above mentioned roads – without Coastal Road (Do Nothing situation)

Alternative II: Existing Road through above mentioned roads – with Coastal Road (With Project)

Alternative III: Construction of Coastal Road (With Project)

It may be noted that while Alternative-I can be considered as the base alternative (Do Nothing), Alternative-II and Alternative-III together are 'with project' alternative. The assigned traffic for northern and southern parts has been presented in Table 12.1 and Table 12.2.

Table 12.1: ADT (One Way) and Assigned Traffic on Southern Part of Coastal Road

ADT-One way	Alternative-I			Alternative-II	Alternative-III
	Pedder Road - one way 50%	Mahim - one way 50%	Average	Average-49% diversion of cars	Average-51% of cars
Standard Bus	565	2,611	1,588	1,588	0
Mini Bus	46	53	50	50	0
Cars/Jeeps	36,006	64,395	50,201	25,602	24,598
2-Wheeler	3,987	34,965	19,476	19,476	0
Auto Rickshaw	0	4	2	2	0
2Ax Truck	30	114	72	72	0
3Ax Truck	6	3	5	5	0
MAV	0	0	0	0	0
LCV	332	4,739	2,536	2,536	0
Total No.	40,972	106,884	73,928	49,330	24,598
Total PCU			76,140	51,542	24,598
Peak Hour (PCU)- 6.68% as observed			5,086	3,443	1,643

Table 11.2: ADT (One Way) and Assigned Traffic on Northen Part of Coastal Road

ADT-One way	Alternative-I			Alternative-II	Alternative-III
	Airport- one way 50%	Infinity Mall-one way 50%	Average	Average-49% diversion of cars	Average-51% of cars
Standard Bus	1172	550	861	861	0
Mini Bus	71	58	65	65	0
Cars/Jeeps	92,229	20,271	56,250	29,250	27,000
2-Wheeler	5,219	15,399	10,309	10,309	0
Auto Rickshaw	30,722	2,1612	26,167	26,167	0
2Ax Truck	972	169	571	571	0
3Ax Truck	291	52	172	172	0
MAV	3	19	11	11	0
LCV	4,753	1,989	3,371	3,371	0
Total No.	135,432	60,119	97,776	70,776	27,000
Total PCU			129,156	102,156	27,000
Peak Hour (PCU)- 6.5% assumed			8,395	6,640	1,755

12.2 Assumptions for Analysis

The approach to the economic analysis along with various assumptions is as follows;

The economic cost is considered as 90% of financial cost.

The design life for the analysis is taken as 30 years including the construction period.

The existing road length for the southern part is taken as 15.4 Kms, while the length of the proposed road is 12.6 Kms.

The existing road length for the northern part is taken as 25 Kms, while the length of the proposed road is 21.94 Kms.

For the entire stretch the width of existing road in one direction is taken as 2-lane, while the same for the proposed road considered as 4-lane.

The Rise and Fall (RF) for existing and proposed road is assumed as 6m/Km and 4m/Km respectively. The Roughness (RG) is considered as 4000mm/ Km and 2000mm/Km respectively.

As per the WPI, the escalation between 2009 and 2014 has been worked out as 1.33.

All the parameters for VOC are calculated as per IRC SP-30-2009 guidelines. Distance related and Time related congestion factors has been worked out using the equations and considering the capacities of 2-lane and 4-lane roads as 3,400 PCU/Hr and 5,100 PCU/Hr respectively (Refer IRC 106-1990).

Discount rate is taken as 12%.

12.3 Project Cost and Scheduling

For the purpose of carrying out the economic analysis, a detailed cost estimate of the road has been prepared considering road, structures and other amenities and facilities separately. Land acquisition costs and costs for environmental mitigation measures have been added to arrive at the total cost estimate of the project. Some of the activities will start in 2015 and the construction is expected to be completed in the year 2018, construction period being estimated as 48 months.

The total financial cost of the new link has been worked out as Rs 2,999 crores for southern part and Rs 6,661 crores for northern part at current financial prices. The distribution of cost has been estimated as 10% in first year, 30% in second year 30% in third year and 30% in fourth year. The economic cost for all the items has been assumed as 90% of the financial cost. It may be noted half the cost is considered for the analysis as one way traffic volume is taken.

Maintenance Cost

The facility is to be maintained in good condition to ensure that the level of service provided to the users is not below their expectation. It normally consists of different maintenance packages provided in the program and its periodicity. The economic cost of the construction, maintenance like crack sealing, patch works etc has been incorporated in recurring cost. The financial cost various maintenance has been considered as;

Existing Road (2 Lane-One way width)

Routine maintenance (Yearly)	-	Rs 1,200,000/ Km
Periodic maintenance (Every fifth year)	-	Rs 3,500,000/ Km

Proposed Road (4 Lane-One way width)

Routine maintenance (Yearly)	-	Rs 2,000,000/ Km
Periodic maintenance (Every fifth year)	-	Rs 6,000,000/ Km

12.4 Project Benefits

Road user benefits will be from vehicle operating cost (VOC) savings, travel time saving, accident cost saving and saving in maintenance costs. The benefits are likely to accrue from 2019 onwards.

Vehicle Operating Cost

For various types of vehicles the cost for fuel and lubricant and tyre has been worked out from the equations developed in IRC: SP-30-2009. The 2009 prices have been escalated for the base year 2014 using WPI.

Travel Time Saving

The average journey speed along the proposed link has been assumed as 75 Kmph for cars, whereas for the existing road it is around 21 Kmph. However, for the existing road with reduced traffic in Alternative II, the average journey speed is assumed as 45 Kmph. To have an estimate of value of travel time for passengers and cargo, the guidelines from the IRC code has been followed as far as possible. The total economic cost including VOC, travel time cost etc in three Alternatives for the southern and northern part separately is shown in **Table 12.9** and **Table 12.10**.

Table 12.9: Economic Costs for Vehicle Operating and Travel Time – Southern Part

Year	Economic Costs for Various Categories of Vehicles (Rs/ Km)																	
	Alternative - I						Alternative - II						Alternative - III					
	Car	2-Wh	Bus	LCV	2Axl Truck	MAV	Car	2-Wh	Bus	LCV	2Axl Truck	MAV	Car	2-Wh	Bus	LCV	2Axl Truck	MAV
201	8.1	2.5	33.2	12.0	13.4	21.5	8.1	2.5	33.2	12.0	13.4	21.5	7.2	2.4	29.2	11.2	12.0	19.8
2015	10.0	3.3	54.8	20.0	18.1	36.2	9.2	2.9	44.2	16.4	15.3	32.3	7.2	2.4	29.2	11.2	12.0	20.1
2016	10.2	3.4	56.1	20.6	18.5	36.6	9.3	3.0	45.5	16.8	15.7	33.3	7.2	2.4	29.3	11.2	12.0	20.2
2017	10.4	3.5	56.7	21.0	19.0	37.0	9.4	3.0	46.7	17.2	16.0	34.2	7.2	2.4	29.4	11.3	12.0	20.4
2018	10.7	3.6	57.4	21.2	19.5	37.5	9.4	3.1	48.1	17.7	16.3	34.7	7.2	2.4	29.6	11.3	12.1	20.7
2019	10.9	3.7	58.1	21.5	20.1	37.9	9.6	3.1	49.5	18.2	16.7	35.1	7.2	2.4	29.8	11.4	12.2	21.0
2020	11.1	3.8	58.8	21.8	20.6	38.4	9.7	3.2	51.0	18.7	17.1	35.4	7.2	2.4	29.9	11.4	12.3	21.3

2021	11.4	3.8	59.6	22.1	21.2	38.9	9.8	3.3	52.6	19.3	17.5	35.7	7.2	2.4	30.1	11.5	12.4	21.6
2022	11.7	3.8	60.4	22.4	21.9	39.5	10.0	3.3	54.3	19.9	17.9	36.1	7.2	2.4	30.3	11.6	12.4	22.0
2023	12.0	3.8	61.3	22.7	22.5	40.1	10.2	3.4	55.9	20.5	18.4	36.5	7.2	2.5	30.5	11.6	12.5	22.3
2024	12.3	3.8	62.2	23.1	23.2	40.7	10.4	3.5	56.6	20.9	18.9	36.9	7.2	2.5	30.7	11.7	12.6	22.7
2025	12.6	3.8	63.2	23.4	24.0	41.3	10.6	3.6	57.2	21.2	19.4	37.3	7.2	2.5	31.1	11.8	12.9	23.1
2026	12.9	3.8	64.2	23.8	24.8	42.0	10.8	3.6	57.9	21.4	19.9	37.8	7.2	2.5	31.4	12.0	13.1	23.5
2027	13.3	3.8	65.3	24.0	25.6	42.7	11.1	3.7	58.6	21.7	20.5	38.3	7.3	2.5	31.8	12.1	13.3	24.0
2028	13.5	3.8	66.4	24.0	26.2	42.9	11.3	3.8	59.4	22.0	21.1	38.8	7.3	2.5	32.2	12.3	13.6	24.4
2029	13.7	3.8	66.5	24.0	26.6	42.9	11.6	3.8	60.2	22.3	21.7	39.3	7.4	2.5	32.6	12.5	13.8	24.9
2030	13.8	3.8	66.5	24.0	26.8	42.9	11.9	3.8	61.0	22.6	22.3	39.9	7.4	2.6	33.1	12.7	14.1	25.4
2031	14.0	3.8	66.5	24.0	26.8	42.9	12.2	3.8	61.9	23.0	23.0	40.5	7.5	2.6	33.5	12.9	14.4	26.0
2032	14.1	3.8	66.5	24.0	26.8	42.9	12.5	3.8	62.9	23.3	23.8	41.1	7.5	2.6	34.0	13.1	14.7	26.6
2033	14.3	3.9	66.5	24.0	26.8	42.9	12.8	3.8	63.9	23.7	24.5	41.8	7.6	2.6	34.5	13.3	15.0	27.1
2034	14.5	3.9	66.5	24.0	26.8	42.9	13.2	3.8	64.9	24.0	25.4	42.5	7.7	2.6	35.0	13.5	15.4	27.8
2035	14.7	3.9	66.5	24.0	26.8	42.9	13.5	3.8	66.1	24.0	26.0	42.9	7.7	2.7	35.6	13.8	15.7	28.4
2036	14.9	3.9	66.5	24.0	26.8	42.9	13.6	3.8	66.5	24.0	26.5	42.9	7.8	2.7	36.2	14.0	16.1	29.1
2037	15.1	4.0	66.5	24.0	26.8	42.9	13.8	3.8	66.5	24.0	26.8	42.9	7.9	2.7	36.8	14.3	16.5	29.8
2038	15.3	4.0	66.5	24.0	26.8	42.9	13.9	3.8	66.5	24.0	26.8	42.9	8.0	2.7	37.4	14.5	16.9	30.6
2039	15.6	4.0	66.5	24.0	26.8	42.9	14.1	3.8	66.5	24.0	26.8	42.9	8.0	2.8	38.1	14.8	17.3	31.4
2040	15.8	4.1	66.5	24.0	26.8	42.9	14.3	3.9	66.5	24.0	26.8	42.9	8.1	2.8	38.8	15.1	17.7	32.2
2041	16.1	4.1	66.5	24.0	26.8	42.9	14.4	3.9	66.5	24.0	26.8	42.9	8.2	2.8	39.6	15.5	18.2	33.1
2042	16.2	4.1	66.5	24.0	26.8	42.9	14.6	3.9	66.5	24.0	26.8	42.9	8.3	2.9	40.4	15.8	18.7	34.0
2043	16.2	4.2	66.5	24.0	26.8	42.9	14.8	3.9	66.5	24.0	26.8	42.9	8.4	2.9	41.2	16.1	19.2	35.0
2043	16.2	4.2	66.5	24.0	26.8	42.9	15.0	4.0	66.5	24.0	26.8	42.9	8.5	2.9	42.1	16.5	19.8	36.0

Table 12.10: Economic Costs for Vehicle Operating and Travel Time – Northern Part

Year	Economic Costs for Various Categories of Vehicles (Rs/ Km)																	
	Alternative - I						Alternative - II						Alternative - III					
	Car	2-Wh	Bus	LCV	2Ax Truck	MAV	Car	2-Wh	Bus	LCV	2Ax Truck	MAV	Car	2-Wh	Bus	LCV	2Ax Truck	MAV
2014	8.1	2.5	33.2	12.0	13.4	21.5	8.1	2.5	33.2	12.0	13.4	21.5	7.2	2.4	29.2	11.2	12.0	19.8
2015	12.4	3.8	62.6	23.2	23.5	40.9	11.1	3.7	58.8	21.8	20.6	38.4	7.2	2.4	29.3	11.3	12.0	20.3
2016	12.7	3.8	63.5	23.6	24.3	41.6	11.4	3.8	59.6	22.1	21.2	38.9	7.2	2.4	29.5	11.3	12.1	20.5
2017	13.0	3.8	64.6	24.0	25.1	42.2	11.7	3.8	60.4	22.4	21.9	39.5	7.2	2.4	29.7	11.4	12.1	20.8
2018	13.4	3.8	65.7	24.0	25.9	43.0	11.9	3.8	61.3	22.7	22.5	40.1	7.2	2.4	29.8	11.4	12.2	21.1
2019	13.6	3.8	66.5	24.0	26.3	42.9	12.3	3.8	62.2	23.1	23.2	40.7	7.2	2.4	30.0	11.5	12.3	21.4
2020	13.7	3.8	66.5	24.0	26.7	42.9	12.6	3.8	63.2	23.4	24.0	41.3	7.2	2.4	30.2	11.5	12.4	21.7
2021	13.9	3.8	66.5	24.0	26.8	42.9	12.9	3.8	64.2	23.8	24.8	42.0	7.2	2.4	30.4	11.6	12.5	22.1
2022	14.0	3.8	66.5	24.0	26.8	42.9	13.3	3.8	65.2	24.0	25.6	42.7	7.2	2.5	30.6	11.6	12.6	22.5
2023	14.2	3.8	66.5	24.0	26.8	42.9	13.5	3.8	66.4	24.0	26.1	42.9	7.2	2.5	30.8	11.7	12.7	22.8
2024	14.4	3.9	66.5	24.0	26.8	42.9	13.7	3.8	66.5	24.0	26.6	42.9	7.2	2.5	31.2	11.9	12.9	23.3
2025	14.6	3.9	66.5	24.0	26.8	42.9	13.8	3.8	66.5	24.0	26.8	42.9	7.2	2.5	31.6	12.0	13.2	23.7
2026	14.8	3.9	66.5	24.0	26.8	42.9	14.0	3.8	66.5	24.0	26.8	42.9	7.3	2.5	31.9	12.2	13.4	24.1
2027	15.0	3.9	66.5	24.0	26.8	42.9	14.1	3.8	66.5	24.0	26.8	42.9	7.3	2.5	32.3	12.4	13.7	24.6
2028	15.2	4.0	66.5	24.0	26.8	42.9	14.3	3.9	66.5	24.0	26.8	42.9	7.4	2.6	32.8	12.6	13.9	25.1
2029	15.4	4.0	66.5	24.0	26.8	42.9	14.5	3.9	66.5	24.0	26.8	42.9	7.4	2.6	33.2	12.7	14.2	25.6
2030	15.6	4.0	66.5	24.0	26.8	42.9	14.7	3.9	66.5	24.0	26.8	42.9	7.5	2.6	33.7	12.9	14.5	26.2
2031	15.9	4.1	66.5	24.0	26.8	42.9	14.9	3.9	66.5	24.0	26.8	42.9	7.6	2.6	34.2	13.2	14.8	26.8
2032	16.2	4.1	66.5	24.0	26.8	42.9	15.1	4.0	66.5	24.0	26.8	42.9	7.6	2.6	34.7	13.4	15.1	27.4
2033	16.2	4.1	66.5	24.0	26.8	42.9	15.3	4.0	66.5	24.0	26.8	42.9	7.7	2.7	35.2	13.6	15.5	28.0
2034	16.2	4.2	66.5	24.0	26.8	42.9	15.6	4.0	66.5	24.0	26.8	42.9	7.8	2.7	35.8	13.8	15.8	28.7
2035	16.2	4.2	66.5	24.0	26.8	42.9	15.8	4.1	66.5	24.0	26.8	42.9	7.8	2.7	36.4	14.1	16.2	29.4
2036	16.2	4.3	66.5	24.0	26.8	42.9	16.1	4.1	66.5	24.0	26.8	42.9	7.9	2.7	37.0	14.4	16.6	30.1
2037	16.2	4.3	66.5	24.0	26.8	42.9	16.2	4.1	66.5	24.0	26.8	42.9	8.0	2.8	37.7	14.6	17.0	30.9
2038	16.2	4.4	66.5	24.0	26.8	42.9	16.2	4.2	66.5	24.0	26.8	42.9	8.1	2.8	38.4	14.9	17.4	31.7
2039	16.2	4.4	66.5	24.0	26.8	42.9	16.2	4.2	66.5	24.0	26.8	42.9	8.2	2.8	39.1	15.3	17.9	32.5
2040	16.2	4.5	66.5	24.0	26.8	42.9	16.2	4.3	66.5	24.0	26.8	42.9	8.2	2.8	39.8	15.6	18.4	33.4
2041	16.2	4.5	66.5	24.0	26.8	42.9	16.2	4.3	66.5	24.0	26.8	42.9	8.3	2.9	40.6	15.9	18.9	34.4
2042	16.2	4.6	66.5	24.0	26.8	42.9	16.2	4.3	66.5	24.0	26.8	42.9	8.4	2.9	41.5	16.3	19.4	35.4
2043	16.2	4.7	66.5	24.0	26.8	42.9	16.2	4.4	66.5	24.0	26.8	42.9	8.5	3.0	42.4	16.7	19.9	36.2
2043	16.2	4.7	66.5	24.0	26.8	42.9	16.2	4.5	66.5	24.0	26.8	42.9	8.7	3.0	43.3	17.0	20.5	36.7

12.5 Economic Internal Rate of Return (EIRR)

Based on the assumptions the saving from vehicle operating costs and travel time costs have been calculated separately. The year-wise cost and benefit streams are presented in **Table 12.11**.

It has been observed that EIRR values for southern and northern parts work out to be **15.19%** and **12.86%** respectively. The Net Present Values (NPV) in these Alternatives are Rs 384.46 crores and Rs 205.65 crores respectively. For the total combined stretch the EIRR and NPV values for are **13.64%** and Rs 590.11 crores respectively.

Table 12.11: Economic Costs and Benefit Streams for the Project

(Rs in Crores)

Year	Southern Part			Northern Part		
	Cost Stream $	Benefit Stream $	Net Benefit	Cost Stream $	Benefit Stream $	Net Benefit
2015	135.00	0.00	-135.00	299.75	0.00	-299.75
2016	404.91	0.00	-404.91	899.24	0.00	-899.24
2017	404.91	0.00	-404.91	899.24	0.00	-899.24
2018	404.99	0.00	-404.99	899.24	0.00	-899.24
2019	0.04	142.17	142.13	0.00	296.70	296.70
2020	2.31	157.00	154.69	3.95	309.51	305.56
2021	2.31	171.53	169.22	3.95	322.29	318.34
2022	2.31	186.42	184.11	3.95	336.34	332.39
2023	2.39	202.89	200.50	3.95	356.71	352.76
2024	6.85	223.09	216.25	11.85	385.16	373.31
2025	2.31	245.75	243.44	3.95	415.87	411.92
2026	2.31	270.16	267.85	3.95	449.58	445.63
2027	2.31	296.38	294.07	3.95	486.31	482.36
2028	2.39	319.25	316.86	3.95	526.35	522.40
2029	6.85	334.57	327.72	11.85	570.05	558.20
2030	2.31	350.22	347.91	3.95	617.75	613.80
2031	2.31	366.37	364.05	3.95	669.85	665.91
2032	2.31	383.01	380.70	3.95	726.81	722.86
2033	2.39	400.13	397.74	3.95	757.11	753.16
2034	6.85	418.31	411.47	11.85	778.71	766.86
2035	2.31	440.27	437.96	3.95	799.16	795.21
2036	2.31	474.57	472.26	3.95	818.13	814.18
2037	2.31	513.14	510.83	3.95	845.84	841.89
2038	2.39	555.27	552.87	3.95	889.54	885.59
2039	6.85	601.24	594.39	11.85	935.25	923.41
2040	2.31	651.44	649.12	3.95	983.04	979.09
2041	2.31	706.29	703.98	3.95	1,032.96	1,029.02
2042	2.31	750.90	748.59	3.95	1,085.09	1,081.14
2043	2.39	776.54	774.15	3.95	1,139.47	1,135.52
2043	6.85	801.78	794.93	11.85	1,196.16	1,184.32

$ - As one way traffic (50%) is considered, cost is taken at 50%

Sensitivity Analysis

The sensitivity analysis is required to be done through three different situations as;

Case – I : Cost increased by 15%

Case – II : Benefit decreased by 15%

Case – III : Cost increased by 15% and Benefit decreased by 15%

It has been observed that IRR values are only moderately sensitive for cost and benefit changes, more sensitivity has been observed for decrease in benefits. The results of sensitivity analysis for the combined stretch are presented in Table 12.12.

Table 11.12: Sensitivity Analysis for the Project for the Project

Situation	EIRR	NPV (Rs in Crores)
Base situation	13.64%	590.11
Case –I : Cost increased by 15%	12.27%	106.87
Case –II: Benefits decreased by 15%	12.05%	18.36
Case –III: Cost increased by 15% + Benefit decreased by 15%	10.78%	(-) 464.88

12.6 Conclusion for Economic Analysis

From the results it may be concluded that, the construction of the proposed Coastal road may be considered as **economically viable.**

13. Financial Analysis and Funding Options for Development, Maintenance and management

13.1 Approach & Methodology

For determining the viability of the Project, the capital cost involved in construction and operation & maintenance cost has been matched against the total revenues accruing from the project. The Discounted Cash Flow method has been used for working out the Project Internal Rate of Return (IRR). This covers aspects like financing through debt and equity, loan repayment, debt servicing, depreciation, etc.

The viability of the project is evaluated on the basis of:

Project IRR on total investment, and

Equity IRR on equity investment

13.2 Project Timelines

The Concession Period for the project as per CA is 30 years (up to 2043/44).

Project Timelines		
Event	Date	Comment
Construction Commencement Date	Year 2014-15	Expected commencement date
Construction Completion Date	Year, 2017-18	Construction Period of 30 months
Concession Period End Date	Year 2043-44	Concession Period of 30 years (including construction)

13.3 Total Investment Costs

13.3.1 Phasing of Construction

The project's construction is expected to be phased out over a period of 30 months (2.5 years). The exact expenditure phasing adopted for the financial modelling purpose is detailed below:

Phasing of Construction				
Ye	FY 15	FY 16	FY 17	Total
Completion	10%	43%	47%	100%

13.3.2 Interest during construction (IDC)

During the construction period, interest accruing on debt during construction shall be capitalized and included in Total Project Cost.

13.3.3 Means of Finance

As per the guidelines of National Highway Authority of India (NHAI), terms of financing for the project has been assumed as follows for the financial analysis:

Terms of Financing	
Debt Equity ratio	70:30
Interest Rate	11.75 % p.a.
Moratorium Period	2.5 Years (Construction period of 2years plus 6 months)
Loan Tenure	13 Years
Debt drawdown	After 100% equity infusion

13.4 Final Alignment Option

The financial projections and key indicators have been drawn for the Mumbai Coastal road project encompassing a total length of 35.6 km. However Final Alignment option length is 34.54 km which is adopted for calculation.

Total Project Cost

Based on the above assumptions, + 25 years period +7 years p.a.)assumptions have been made, The Total Project Cost (TPC) has been calculated as follows:

S.No	Project Cost (Millions INR)	Cost
1	Civil Construction Cost	94,238.50
2	Contingencies	942.39
3	Base Cost (1+2)	95,180.89
4	IC/Pre-Operative Expenses	951.81
5	Total Cost (3+4)	96,132.69
6	Escalation in EPC during construction	6,638.87
7	Total Cost (with Escalation) (5+6)	102,771.56
8	Financing Expenses	767.15
9	Project Cost without IDC (7+8)	103,538.71
10	Interest During Construction (IDC)	9,443.93
11	Total Project Cost (9+10)	112,982.64

13.5 Operation and Maintenance Costs

The principal O&M expenses in the project include administrative expenses including salary, toll collection expenses, routine repair expenses and periodic overlay costs. The assumptions with regard to O&M expenses are as tabulated below:

Year		Amount in Cr.		
		Routine Maintenance including tolling	Periodic Maintenance	Total
1st	2014-15	-	-	-
2nd	2015-15	-	-	-
3rd	2016-17	-	-	-
4th	2017-18	2.56	4.20	6.76
5th	2018-19	5.37	-	5.37
6th	2019-20	5.64	-	5.64
7th	2020-21	5.93	-	5.93
8th	2021-22	6.23	-	6.23
9th	2022-23	6.53	70.15	76.68
10th	2023-24	6.86	73.66	80.52
11th	2024-25	7.21	77.34	84.55
12th	2025-26	7.56	-	7.56
13th	2026-27	7.94	-	7.94
14th	2027-28	8.34	-	8.34
15th	2028-29	8.75	-	8.75
16th	2029-30	9.20	128.55	137.75
17th	2030-31	9.65	134.97	144.62
18th	2031-32	10.14	141.72	151.86
19th	2032-33	10.65	-	10.65
20th	2033-34	11.18	-	11.18
21st	2034-35	11.74	-	11.74
22nd	2035-36	12.32	-	12.32
23rd	2036-37	12.93	41.90	54.83
24th	2037-38	13.59	43.99	57.58
25th	2038-39	14.26	46.19	60.45
26th	2039-40	14.98	48.50	63.48
27th	2040-41	15.73	50.93	66.66
28th	2041-42	16.51	53.47	69.98
29th	2042-43	17.33	56.15	73.48
30th	2043-44	18.21	58.95	77.16
TOTAL		277.320	1030.680	1308.000

The annual O & M cost of the project in the year of commencement is estimated at Rs 13080 million. The O & M cost (annual as well as periodic) over the operating period of 30 years are presented in the table below. The rate of inflation assumed in updating the O & M cost is 5% p.a.

13.6 Profitability Projections

Traffic Assumptions

Toll income collected from vehicles using the facility is the principal income for the project over the years. Toll income would be product of toll rates and traffic volumes. The traffic volume figures have been provided to us by the Technical Consultant. The same have been used for the purpose of computing the toll revenues.

The traffic volumes in terms of ADT for the year 2013 are described in the table below:

S.No.	Vehicle Type	PCU Factor	Toll Plaza after the tunnel before NH4 (2013-14)
1	Cars, passenger vans, jeep	1	184,458
2	LCV	2	9,506
3	Mini Buses	2	143
4	Buses	3.7	2,343
5	Trucks of 2 Axle	3.7	1,944
6	3 Axle trucks	3.7	582
7	MAV	3.7	5
8	Oversized vehicle	5	0
9	Total Traffic (in numbers)	ADT	198982

The traffic has been projected over the years with a year on year escalation of 5%.

Further, for revenue calculation, a leakage of 3% has been applied for Cars/Jeeps/Vans and traffic is discounted by 20% for Cars/Jeeps/Vans and 10% for other vehicles. The local traffic who will pay 50% of toll has been taken as 15% for Car/Jeep/Man, 30% for Mini buses, Buses and LCVs, 20% for Trucks and 3-Axles and 0% for other vehicles.

Toll Structure

The toll rates have been assumed as per the Maharashtra State Toll Policy NHAI Toll Policy 2008 and 2011. The base toll rates are as follows:

S.No.	Vehicle Type	Four Lane Highway (Rs./Km/Vehicle)
1	Car/ Jeep/Van/LMV	0.65
2	LCV/LGV/Mini Bus	1.05
3	Truck/Bus	2.20
4	3 Axle Commercial Vehicle	2.40

5	HCM/MAV	3.45
6	Over sized vehicle	4.20

Note: As per NHAI Toll policy, additional fee for structures with civil construction cost greater than Rs. 50 Cr has been considered.

Toll rates over the years are escalated based on the WPI index till the date is available. Later, the rates are escalated by 5% p.a.

Total Revenues

From	To	Total In INR Million
1-Apr-17	31-Mar-18	3,511.04
1-Apr-18	31-Mar-19	3,868.06
1-Apr-19	31-Mar-20	4,270.29
1-Apr-20	31-Mar-21	4,713.55
1-Apr-21	31-Mar-22	5,211.58
1-Apr-22	31-Mar-23	5,749.26
1-Apr-23	31-Mar-24	6,351.00
1-Apr-24	31-Mar-25	7,011.90
1-Apr-25	31-Mar-26	7,749.32
1-Apr-26	31-Mar-27	8,557.73
1-Apr-27	31-Mar-28	9,468.68
1-Apr-28	31-Mar-29	10,453.30
1-Apr-29	31-Mar-30	11,559.13
1-Apr-30	31-Mar-31	12,783.38
1-Apr-31	31-Mar-32	14,137.62
1-Apr-32	31-Mar-33	15,633.21
1-Apr-33	31-Mar-34	17,300.36
1-Apr-34	31-Mar-35	19,138.37
1-Apr-35	31-Mar-36	21,181.62
1-Apr-36	31-Mar-37	23,448.80
1-Apr-37	31-Mar-38	25,962.88
1-Apr-38	31-Mar-39	28,745.15
1-Apr-39	31-Mar-40	27,144.92
1-Apr-40	31-Mar-41	30,055.28
1-Apr-41	31-Mar-42	33,276.10
1-Apr-42	31-Mar-43	36,863.10
1-Apr-43	31-Mar-44	40,827.95

13.7 Key Financial Indicators

Based on the above financial projections, profitability of the Project has been calculated as below:

Results	
Concession Period	30.00 Years
Construction Period	2.50 Years
Mortorium Period	3.00 Years
Loan Repayment	10.00 Years
EIRR	-2.55%
PIRR	1.47%
NPV at 12% discount rate	-
TPC (Rs. in Crore)	11298.26
Grant in %	3.00%
Grant in Rs.	338.95
Premium quoted Annually (Rs. in Crore)	-

14. Bus Rapid Transit

14.1 Introduction

Bus Rapid Transit is a public transportation system that provides faster, more efficient service than an ordinary bus line. Often this is achieved by making improvements to existing infrastructure, vehicles and scheduling. The goal is to approach the service quality of rail transit while still enjoying the cost savings and flexibility of bus transit.

Bus Rapid Transit (BRT) is a high-quality bus based transit system that delivers fast, comfortable and cost effective urban mobility through:

- The provision of right-of-way infrastructure.
- Rapid and frequent operations.
- Excellence in marketing and customer service.

A BRT system can use existing road systems or be built with dedicated pathways and station systems depending on the resources available for the project.

Key features of BRT systems include:

- Reliability: ensured by high frequency and real time information on buses
- Security and comfort: ensured by secured, safe pedestrians access to all weather and secured bus stops
- Quality: improved riding quality by using quality buses with low floor;
- Speed: dedicated bus lanes and supporting infrastructure

BRT offers cost effective, environmentally beneficial and high performance mass transit where population density often does not justify the construction of costly fixed rail systems and the need for greater flexibility in route mapping is better served by wheel-to-road transport systems.

How much does BRT cost?

A BRT system will typically cost 4 to 20 times less than an equivalent Light Rail system and up to 100 times less than an equivalent metro rail system.

There are a number of ways in which BRT can save on cost:

- BRT systems can save millions of dollars in cheaper initial build costs and construction times as well as reductions in traffic and neighbourhood disruption during construction.
- BRT systems can carry the same number of people as light rail systems for a typical cost of four to twenty less times than an LRT system and 10 to 100 times less than a heavy rail system.
- By using existing road systems BRT can be built in phases and integrated with existing road systems.
- BRT offers almost immediate public transport solutions and comes with cost effective expansion options.

What are the Benefits of BRT?

In corridors where it has been implemented Bus Rapid Transit (BRT) has delivered well documented modal shift travel time savings and operational benefits. (See table 1)

There has been less documentation of the secondary and co-benefits of BRT in relation to pre-existing bus systems and in comparison with alternative modes such as light rail.

Secondary benefits flowing from the implementation of BRT include:

- Land use – positive changes to land use including transit oriented development.
- Land value – impacts of BRT on land value along corridors and in relation to distance from station.
- Accessibility – increased accessibility to public transport along BRT corridors.
- Modal shift to walking and cycling – increased pedestrianisation of land and consequent impacts on mode share of active transport.
- Employment – ancillary growth in employment as a result of BRT related development.
- Time savings in bus operating times five minutes and eight to nine minutes generate secondary benefits by causing mode shift.
- Time savings above nine minutes acting to change land use in a positive manner.

The Environmental Performance of BRT

- BRT can produce significantly greater Carbon Dioxide (CO_2) reductions than LRT systems
- The electricity used in LRT generated from fossil fuels produces a large amount of CO_2 and because BRT costs significantly less to build than LRT more services can be provided, thereby reducing motor vehicle use across a wider geographical area and amongst a higher number of commuters
- Recent studies have shown only medium and high investment BRT systems can reduce transport related CO_2 emissions
- Using the right combinations of vehicle capacity and fuel technology BRT systems can achieve significantly higher reductions in emissions than LRT systems over a 20 year life of the project
- BRT systems have been shown to be quieter and more energy efficient than equivalent LRT systems.

14.2 Project Background

In order to implement a public transport system it is necessary to understand characteristics of existing and planned development zones. Figure--- presents Development Plan for Greater Mumbai area with proposed land use. It is evident that there is lack of adequate public spaces, especially in North-Western parts of the city. Need for the proposed Coastal Road was identified in Comprehensive Transport Studies (CTS) carried out MMRDA in 2006. Which is further confirmed by the traffic studies carried out for the Coastal Road project and is presented in Traffic Report.

CTS along with need for Coastal Road had also identified need for strengthening existing public transport facilities. Figure 14.4 provides share of rail and BEST bus service.

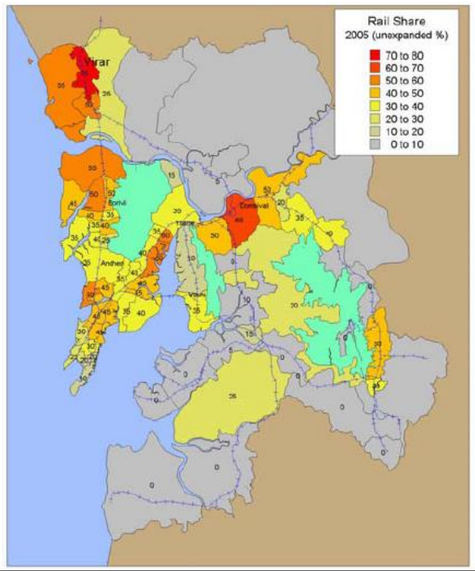


Figure 4-20: Rail Share by Areas (Morning Peak Period – Work Purpose)

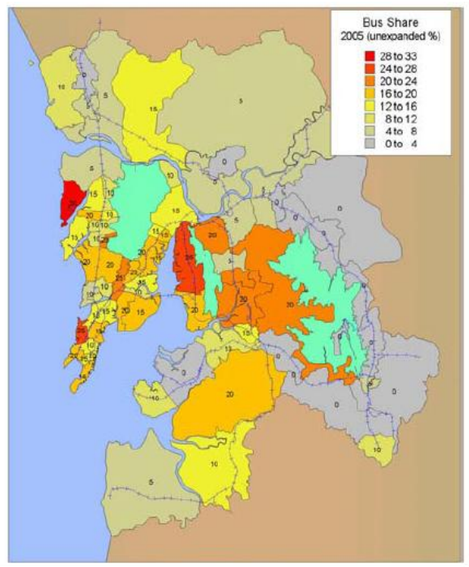
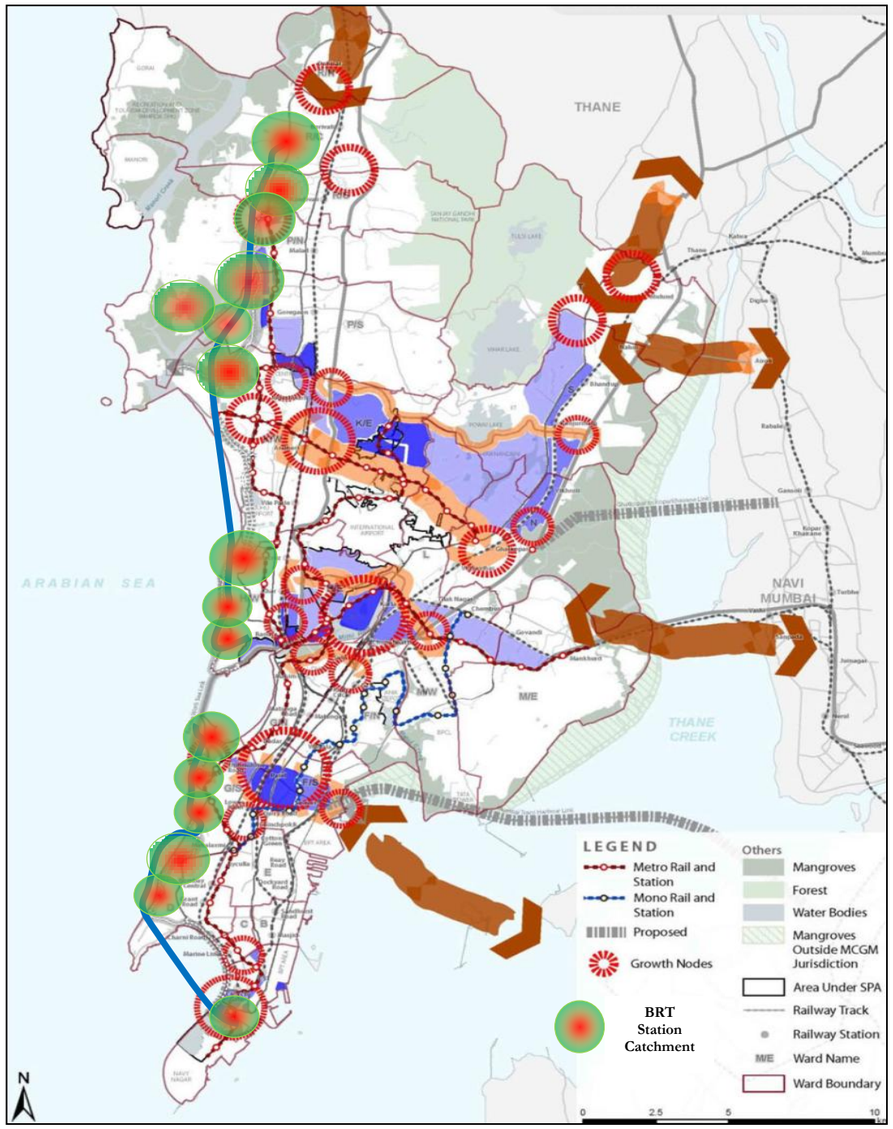


Figure 4-21: Bus Share by areas (Morning Peak Period – Work Purpose)

The CTS report also identifies that for existing bus services 99% of the passenger access/egress stations by walk and rest by Auto Rickshaw. Where as in case of train the percentage of access by walk is 82%, by bus is 13% and rest by other means like Auto Rickshaw or Taxy.

Growth centers for the island city are indicated in above figure, which is likely to add further passenger trips on to public transport and on roads.



Western Line serving the project influence area is overcrowded and handles passengers in excess of 1.5million during peak hours with a daily ridership of 3.6million passengers. Passenger trips during various times of day are presented in above figure as found by the CTS report.

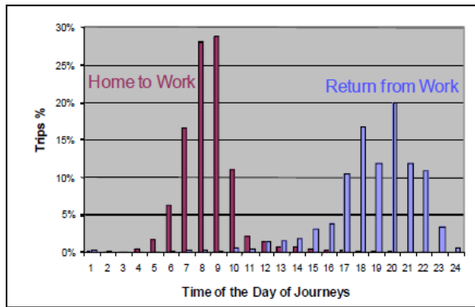


Figure 4-35: Time of the Day of Journeys to Work (and back)

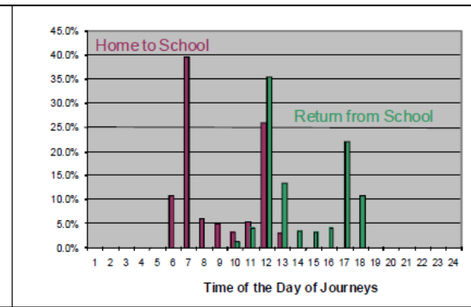


Figure 4-36: Time of the Day of Journeys to School (and back)

Figure 4.35 and 4.36 presents planned BRT stations along proposed coastal road and its influence zones business districts and catchments of western line respectively. It is evident that the BRT system shall provide for the passengers from catchment area away from the existing Western Rail line, thus filling up gap for public transport. It is evident that any satisfactory provision of BRT system will attract high number of passengers. Based on diversions observed for various similar projects it is assumed that at least 10% of passengers will divert to BRT system requiring daily ridership of 0

City	Istanbul	Bogota	Ahmadabad
Number of lines	1	12	12
Number of stations	45	144	131
Daily ridership	800,000	1,400,000	130,000
Began operation	2007	2000	2009
Operator(s)	IETT	TRANSMILENIO	AJL
Number of vehicles	334	1265	560
Average Bus Capacity	200	220	60
Passenger per direction in peak hour	19500	40,000	
System length	50 km	87km	87km

ngers with 32,000 passengers during peak hour.

Reference is drawn from various existing successful bus services around the world

In order to ensure successful BRT system following provisions are proposed:

- Considering that Coastal Road is being built to expressway standards with no at grade crossings, it is essential to accommodate bus lanes on outer side of the carriageway to access intermediate stations.
- One lane each on either side shall be in red colour to indicate bus only usage. Lanes shall be assisted by CCTV system connected to SCADA for detection of violation and incident response;
- Offline boarding points are recommended to ensure speed of bus lane. Each stopping point shall be provided with minimum three platforms with provision for future platforms considering average stopping time of one minute with frequency of 20seconds for station;
- High capacity (190 to 250 passengers) articulated buses shall be used for plying on coastal road with minimum four wide doors. The buses shall be equipped with low floor and GPS for real-time tracking;
- Enclosed transparent bus stop shelters shall be provided at each platform with CCTV monitoring, direct pedestrian access, real time information on next bus on each route
- Various routes shall be derived based on operational demand
- A fleet size of 600 high capacity buses is estimated.
- Each bus station shall be provided with multi-level car park to enable park and ride facility. Each bus stop shall also provide for public toilets, 24x7 security, Auto Rickshaw stand or Taxy stand or both as per permits of the station area.
- To provide equal accessibility to all, elevators/ ramps shall be used at all locations for grade separated crossings

15. Conclusions and Recommendations

15.1 General

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

15.2 Traffic Analysis

From the traffic survey analysis indicated earlier in Chapter 5, the following conclusions can be made:
From the Traffic analysis we found out that lane requirement for the project are as under

- At the end of construction period (Yr 2019) 4 lanes are required
- Four lane roads will be saturated in year 2029
- Six lane roads will be saturated in year 2043

Road is required to be constructed as 4+4 lanes from priyadarshani park to Kandivali and 2+2lanes from Nariman Point to Priyadarshini Park. However, the length of road planned as 2+2 lane shall be constructed to accommodate future 2+2 lanes.
Assuming a balanced directional distribution it may be concluded that a 8-lane road will be able to cater to the traffic needs satisfactorily till the horizon year.
A median of 11m shall be provided to accommodate 1+1 lanes for future widening in median or for provision of Mass Rapid Transit Rail system.
A dedicated BRT lane shall be provided on outer most lane with offline bus stations.
The formation of additional east-west links will result in significant increase in traffic volume along the proposed coastal road.

15.3 Project Constraints and Project Sections

Various Project Constraints have been presented in Chapte 6
Based on traffic pattern and various Engineering and Environmental constraints following broad sections were identified for construction phasing:

Part 1: South (Jagannath Bhosale Road to Worli end of Sea Link)

- Section 1: Jagannath Bhosale Road to Priya Darshini Park
- Section 2: Priya Darshini Park to Mahalaxmi
- Section 3: Mahalaxmi to Baroda Palace
- Section 4: Baroda Palace to Worli End of Sea Link

Part 2: North (Bandra end of Sea Link to Kandivali Junction)

- Section 5: Bandra End of Sea Link to Juhu Sea Side Garden
- Section 6: Juhu Sea Side Garden to Ritumbhara College
- Section7: Ritumbhara College to Kandivali Junction and Central Institute of Fisheries, Versova to Madh Island

15.4 Option Analysis

Six Alignment options are analysed considering factors such as engineering standards, cost of project, social impact and environmental impact.

15.5 Alignment Proposals

Chapter 6 presents comparison of various options on the basis of construction, engineering standards, safety, environment and social impact of project. Comparing pros & cons of all the six Alignment options as explained in Chapter 6, we recommend Alignment Option 7 for kind approval.

15.6 Conclusions & Recommendations for Environmental Impact Assessment

The present CRZ notification issued in January 2011does not allow coastal roads on reclamation .The MoEF, Central Government of India, is constantly instrumental for strengthening existing policies for protecting and improving the quality of the coastal environment. The legal system of coastal zone management in India came into force in 1991. The Coastal Regulation Zone (CRZ) notification, under the environment Act, is one of the major norms limiting the activities in the coastal zone. It includes various laws for regulation of anthropogenic interferences by permitting environmental friendly developments. The Notification was later amendment in January 2001.
Coastal stretches of seas bays, estuaries, creeks, rivers and backwaters influenced by tidal action up to 500 m from High Tide Line (HTL) and the area between HTL and low tide line (LTL) is classified as CRZ Distance from HTL applied to both sides in rivers, creeks, backwaters and distance shall not be less than 100 m or width of water bodies whichever is less
CRZ I Zone consists of ecologically sensitive and important areas, and includes mangrove wetlands, national parks, sanctuaries, and wild life habitats, places of outstanding natural beauty or historical heritage. Areas close to breeding and spawning grounds of fish, those likely to be inundated due to sea level rise (consequent upon global warming), and the area between LTL and HTL are covered under this category. New construction are not permitted within 500 meters of the HTL of CRZ-I.
Land reclamation, bunding or disturbing the natural course of seawater is not allowed in CRZ I area so appropriate amendments be made in the current CRZ notification (which does not allow reclamation) for the proposed coastal road system in Mumbai. For this purpose, the state government

needs to move a proposal to the MOEF, GOI for the limited purpose of the proposed reclamation Most of the road passes through coastal area; hence CRZ notification 6th January 2011 is applicable.

The EIA notification September 14, 2006, states that prior environmental clearance from the concerned authority is required only for National, State Highways and Expressways. The coastal road is yet to be notified; depending on the type of the proposed road the EIA Notification 2006 will be applicable.

But an Environment Impact assessment study should be conducted and an Environmental Management plan is to be prepared to get CRZ Clearance and to minimize the environmental impact during construction and operation of the project.

The project area falls within 10 km of critically polluted area of Thane Belapur Industrial belt. Therefore, General condition as per "The Environmental Impact Assessment Notification 2006"applied to the project

Forest clearance from Forest Department/MoEF is required as construction in mangrove area is involved. NOC from High court is also required in reference to PIL 87 of 2006

The project falls within 10sq.km of Sanjay Gandhi National Park (Borivali National Park) hence SBWL and NBWL clearances are necessary.

Management plan for reclamation area, coastal protection and mangrove are to be formulated.

15.7 Facilities

Provision of following facilities are considered

BRTS as one of the dedicated lane of both carriageways to attract commuters to reduce private vehicles.

At each bus stop proper entry/exit and connectivity on both carriageway through subway or aesthetically pleasing foot over bridges to be proposed.

The toilet and drinking water facilities should be made available at suitable distances along the promenade.

The garden and promenade spaces being very important recreational space, suitable design landscapes, illumination and street furniture is provided.

The coastal erosion protection measures by providing tetra pods/sea walls at the end of sea side promenade.

Connectivity to madh island shall provide significant economic benefits, hence shall be undertaken at earliest.

15.8 Protection Wall (Break water wall)

Considering the storm surge impacts a well designed Break water wall on sea word side of proposed coastal road is planned with an elevation of about 3.5 m above HHTL

Road level is planned in such a way that it will not impact aesthetic and sea side view of commuters

15.9 Conclusion from Economic analysis and Financial analysis

From the economic analysis results it may be concluded that, the construction of the proposed Coastal road may be considered as **economically viable.**

From the Financial analysis results it may be concluded that, the construction of the proposed Coastal road financially not viable on BOT Basis.