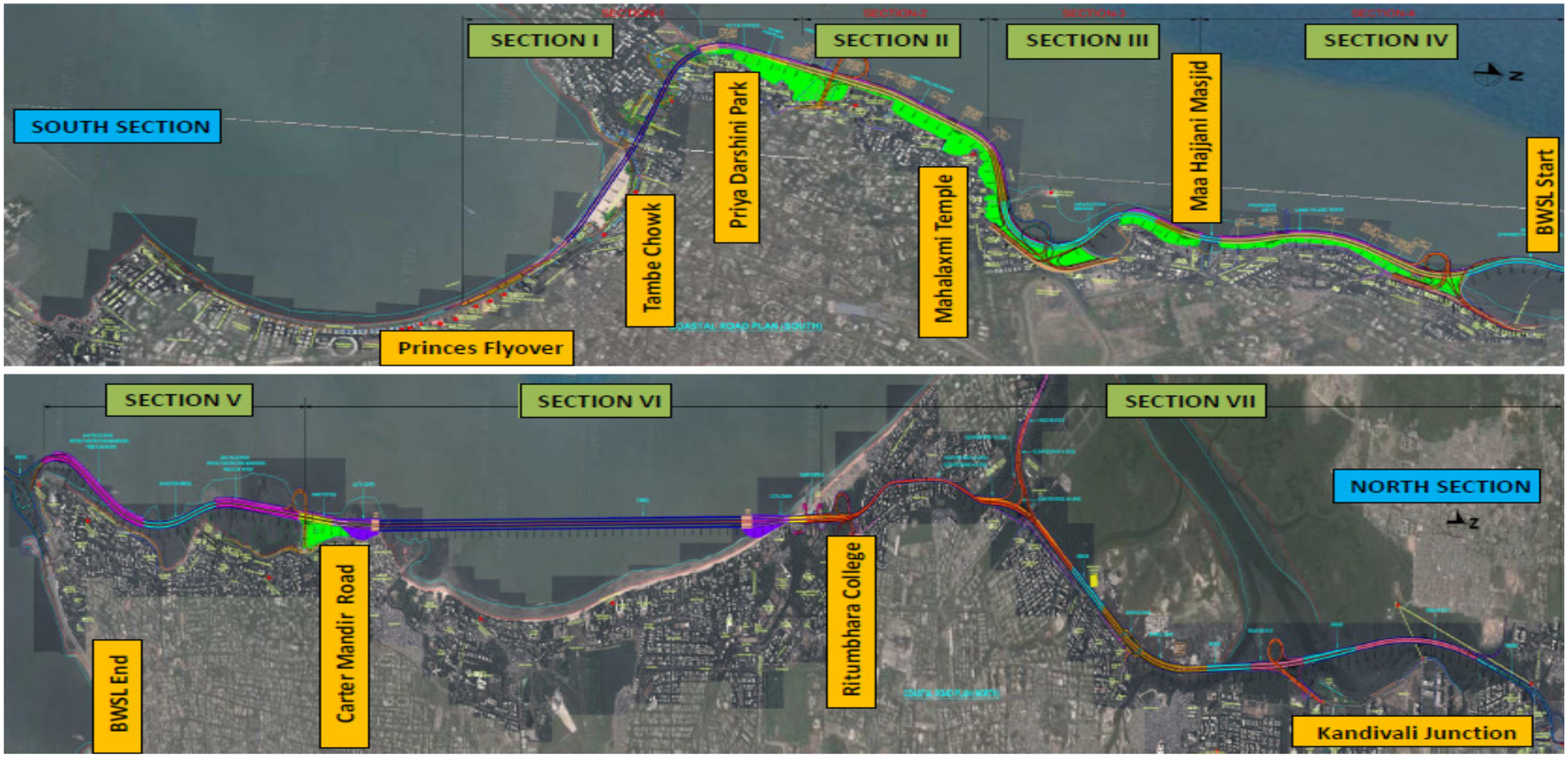
Municipal Corporation of Greater Mumbai

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



FINAL DETAILED PROJECT REPORT (DPR)

Vol – I Main Report

April 2016

STUP Consultants Pvt. Ltd.

Ernst& Young Pvt Ltd

STUP Consultants Pvt. Ltd

Plot No.22A, Sector 19C, Palm Beach Road
Vashi, Navi Mumbai 400 705
Phone: 40887777. Fax: [91-22] 2783 62 40
e-mail : navimumbai@stupmail.com

OFFICE OF ORIGIN

STUP, VASHI

OWNER

MUNICIPAL CORPORATION OF GREATER MUMBAI

CONTRACTOR CLIENT

PROJECT

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

TITLE

DETAIL PROJECT REPORT

DATE	Rev. No.	MODIFICATIONS/ PURPOSE OF ISSUE	PREPARED		CHECKED		APPROVED	
			Nam	Signat	Nam	Signat	Nam	Signat
18.02.15	R0	For Approval	SP		AGA		ADJ	
13.04.16	R1	For Approval	SP		AGA		ADJ	

DATE 13.04.16

PAGES 5+160

NOTE No. 8098/E/DN-21

REV.No. R1

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 and is 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 a new arterial road along the Western Coast as part of the transportation networks, as shown in Figure 1.1. Therefore, The Municipal Corporation of Greater Mumbai (MCGM) has proposed to construct a Coastal Road on the 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, Mazagaon, 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.

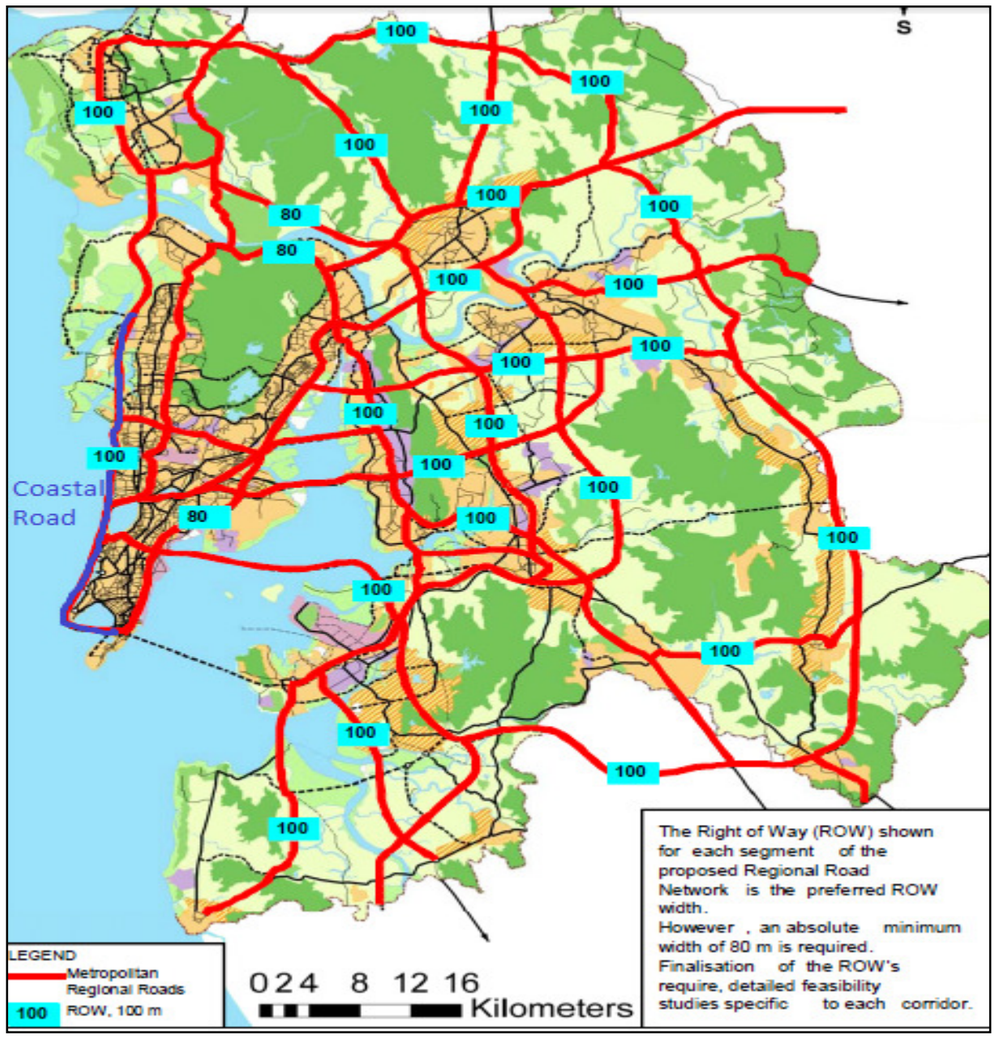


Figure 1.1: Highway Network Proposed by CTS

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.

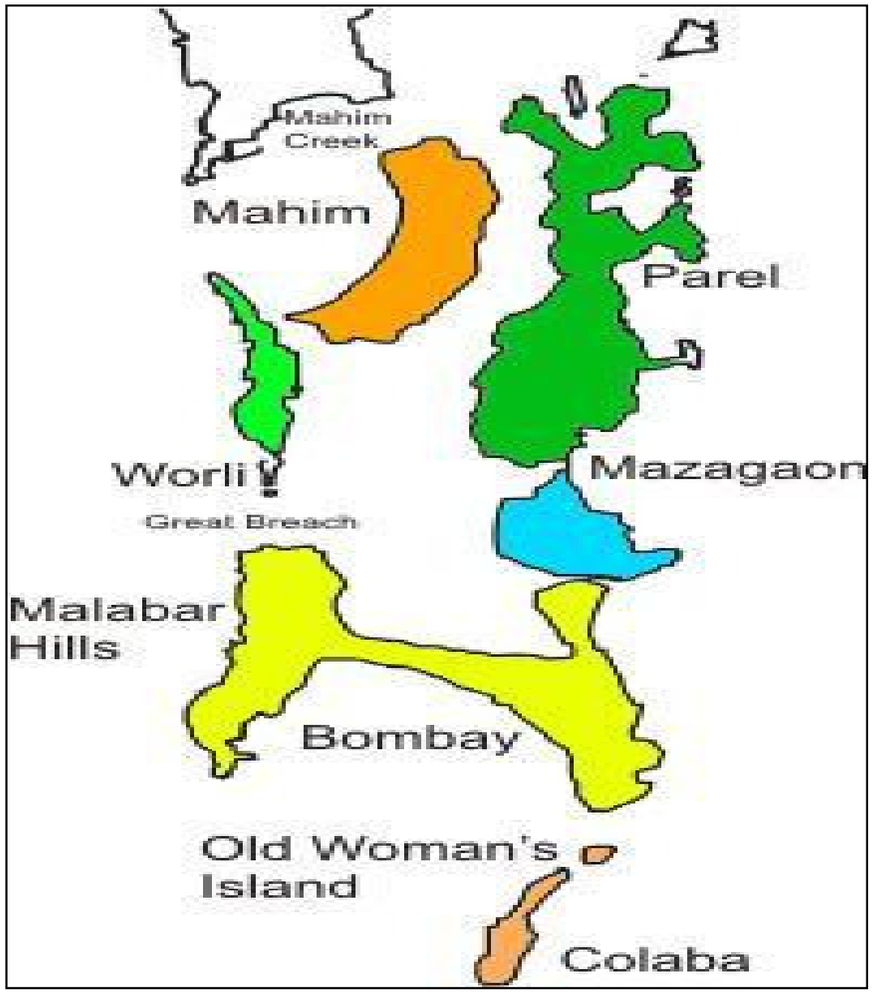


Figure 1.2: Seven Islands of Mumbai

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, 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 an 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 a 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 presents the studies carried out under guidance of Hon'ble Additional Municipal Commissioner to verify feasibility of the proposed coastal road, and recommendations for detailed design stage of the project.

1.5 Report Structure

The Detailed Project Report contains the following documents:

- **Volume I: Main Report**
- **Volume II: Design Report**
- **Volume III: Materials Report**
- **Volume IV: Engineering Report**
- **Volume V: Cost Estimate & Rate Analysis**
- **Volume VI: Drainage Design Report**
- **Volume VII: Drawings**
- **Volume VIII: Environmental Assessment Report**
- **Volume IX: Resettlement Action Plan Report**
- **Volume IV: Economic & Financial Analysis Report**

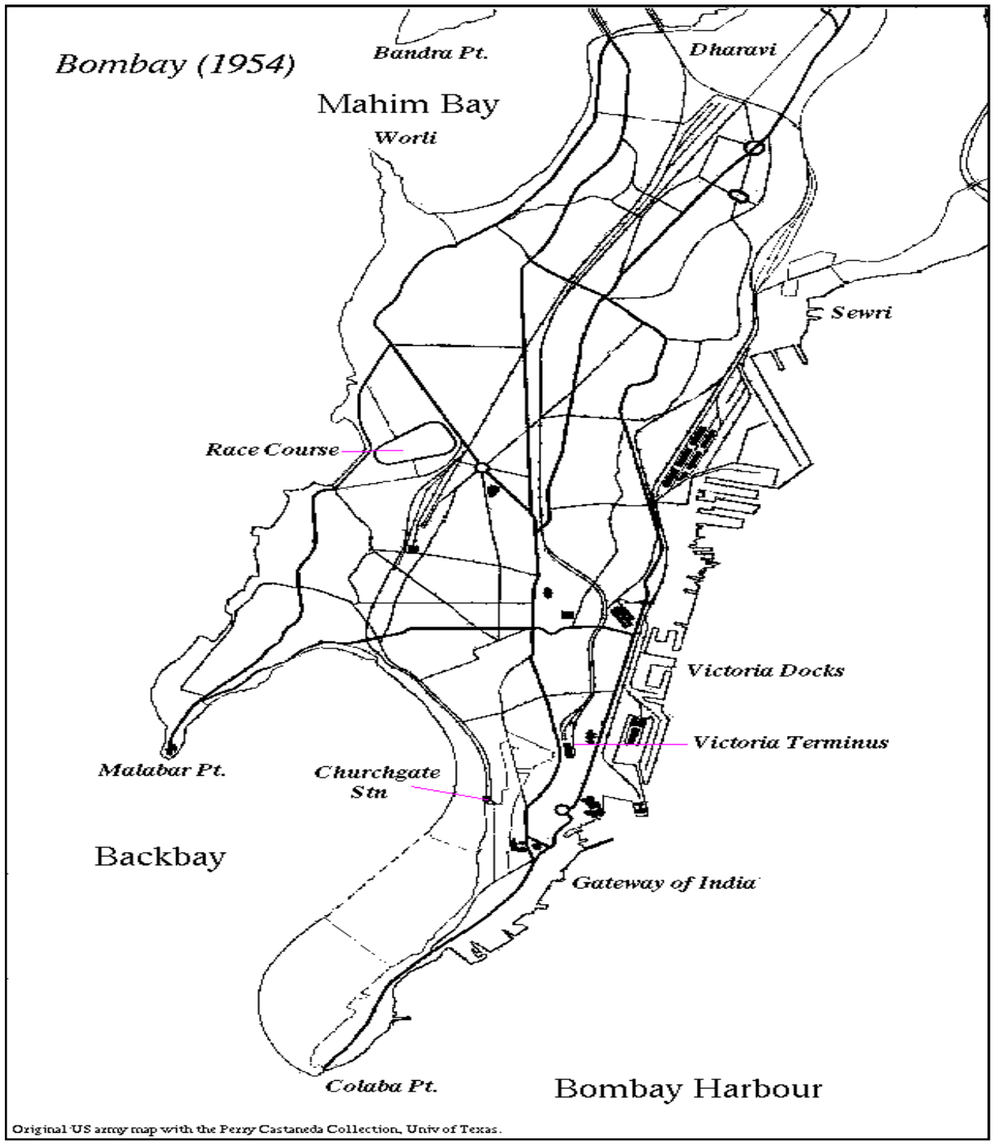


Figure 1.3: Backbay Reclamation

2. Regional/State Socio-economic profile

2.1 General

Mumbai is the capital of Maharashtra state. This chapter presents socio-economic profile of 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 northern 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 Rs.7, 01,550 crore during 2009-10, as against Rs.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 Rs 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

Year	Per Capita Income (Rs in Crores)	
	Current Prices	Constant Prices
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 reform measures in various sectors to liberalise the economy and make it conducive to rapid growth. As a result of liberalisation, the economy is on a 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, the 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 is 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 gauge, 510 km meter gauge and 915 km is narrow gauge. 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 is 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).

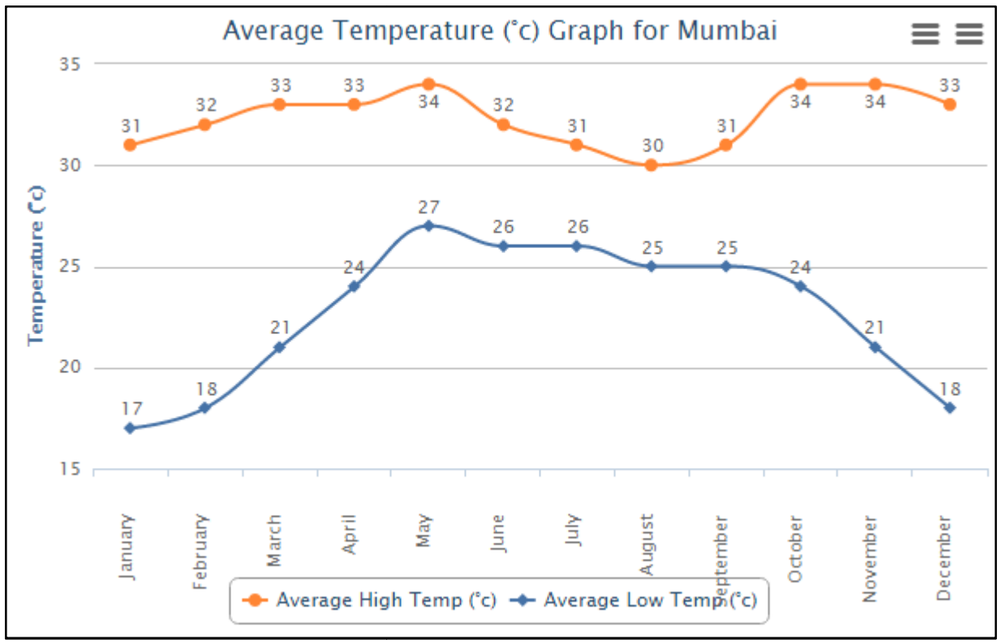


Figure 3.1: Average High/Low Temperature for Mumbai

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.

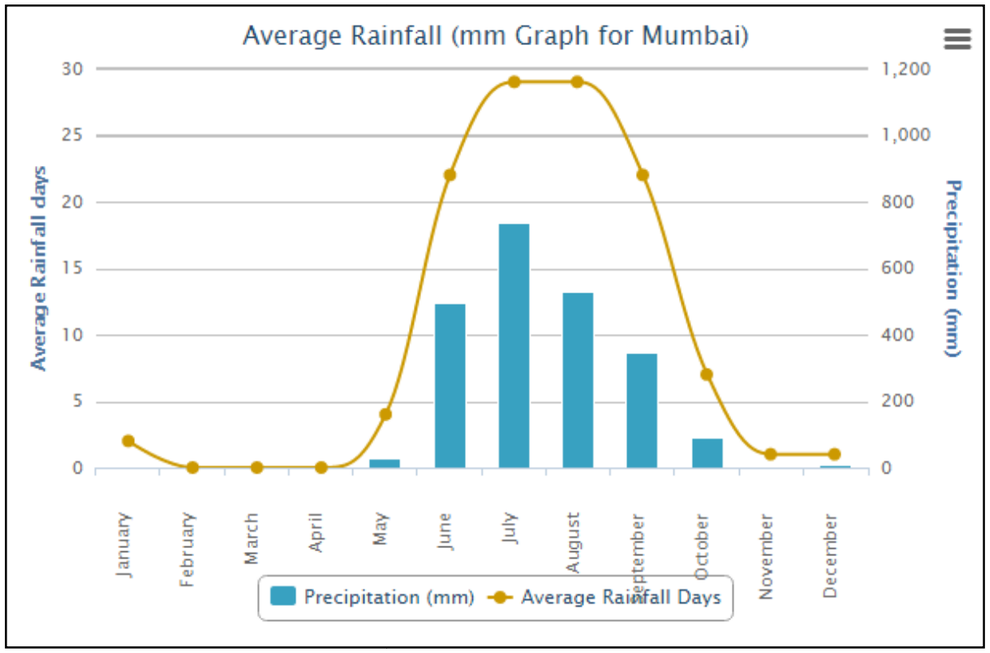


Figure 3.2: Average Rainfall for Mumbai

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.

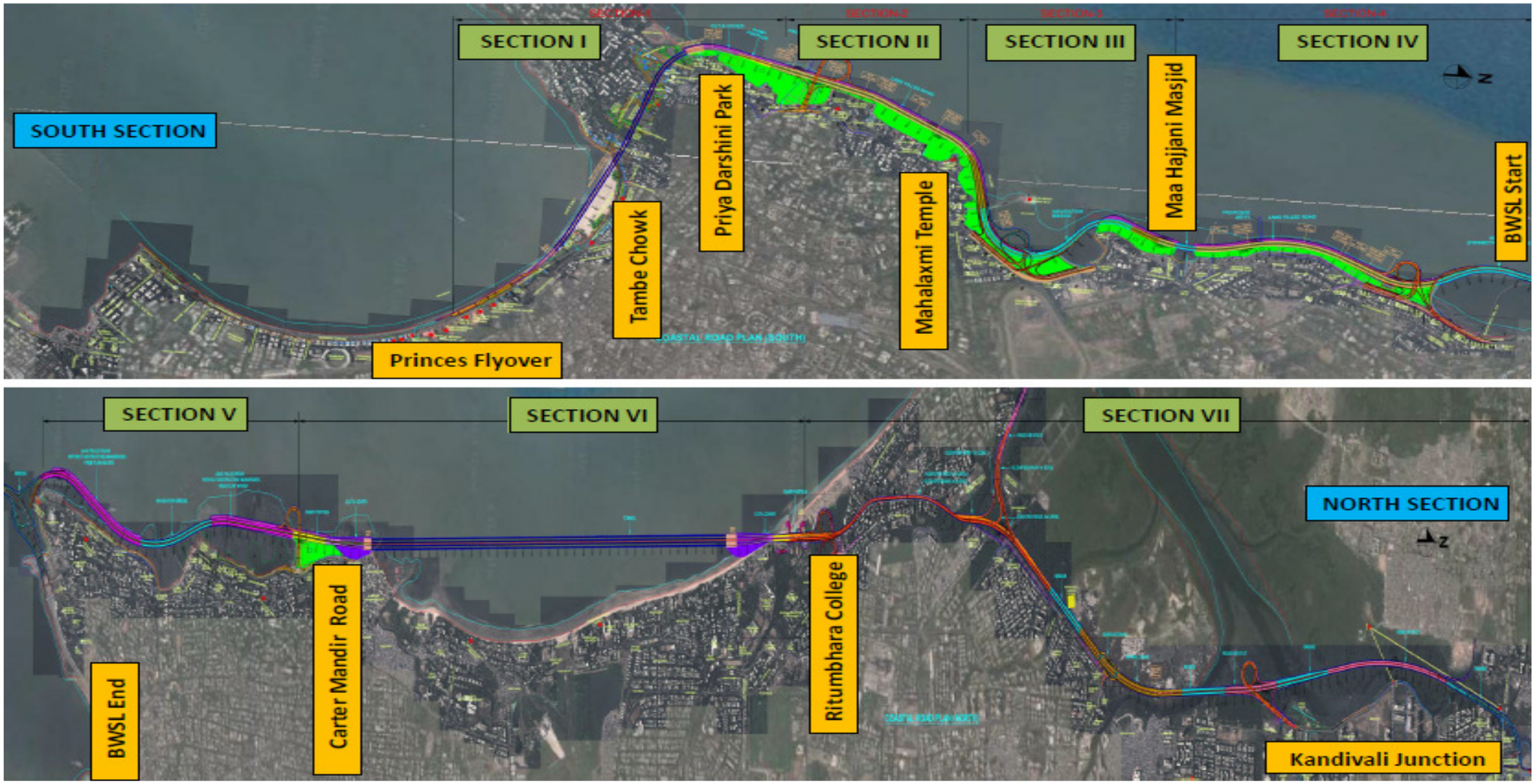


Figure 3.3: Alignment of Mumbai Coastal Road Project

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 Radar 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: Completed
- GPS survey: Completed
- Total Station Survey: Completed
- Bathymetry: Completed
- Geotechnical Studies: Completed (Except Tunnels)
- Material Investigation: Completed
- Pavement Investigation: Completed
- Inventory of Structures: Completed
- Hydrological Survey: Completed
- Utilities Survey: Ongoing
- Environmental Monitoring: Completed
- Social Survey: Completed

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

5.1.1 General

Traffic studies are essential for any road project, as it forms the basis for design of the project. MMR has seen rapid geographic and economic growth over past two decades. The increased vehicle population which causes traffic congestions during peak hours. Comprehensive Transport Study (CTS) was carried out in 2006 by MMRDA to establish transportation network necessary to cater for sustainable growth. Traffic studies for the project were conducted to relate the findings with CTS and conclusions were drawn.

5.1.2 Objective

The consultancy services concentrates on evolving an economical and financially viable alignment to connect Nariman Point to Kandivali Junction of the proposed Coastal Road Project. As part of activity number 2.4 Part 1 of Terms of Reference (ToR), STUP has prepared this report to provide Traffic and transportation planning studies for assessment of traffic on the project corridor for the period up to 2033/2043.

The chapter presents, findings of traffic survey and its analysis.

5.1.3 Scope

- Conduct seven days traffic volume count manually.
- Conduct One day Origin - Destination Survey.
- Speed and Delay Survey.

Projected traffic based on estimated traffic growth rate of costal road for the next 30 years.

5.2 Traffic Surveys

5.2.1 Project Description

Mumbai isthe financial capital of India and has been a growth centre providing opportunities for all. The city has seen migration from all parts of the country for work and better life. Mumbai Island and its surrounding districts of Thane and Raigad have also seen development of new employment and residential area. The Municipal Corporation of Greater Mumbai (MCGM) has been in forefront of creating a world class city driven by its vision. A Comprehensive Transport Study (CTS) was undertaken to identify transportation network for the growth horizon up to year 2044.

As part of this study, a methodology as per IRC guidelines have been followed to assess the characteristics of the traffic on the proposed Coastal road. The details pertaining to the data collection, primary as well as secondary, and results from its analysis are presented in the following sections.

5.2.2 Traffic Surveys: 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 and communicated to the MCGM for approval.

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, increase of scope of work; video surveys were carried out at all locations for a minimum three days out of seven days traffic count surveys. The data was then tabulated and analysed as per IRC-102. The 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 of the 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 of the Origin & Destination (OD) data.

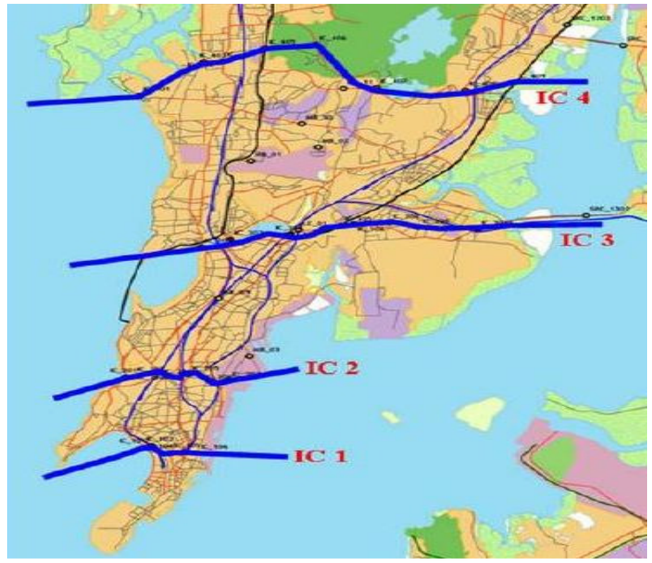


Figure 5-1: Inner Cordon lines from CTS Report

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

Figure 5-2: Traffic Survey Locations

5.2.2.1 Classified Traffic Volume Count at Mid-Block

Traffic surveys at Mid-Blocks were conducted at Seventeen locations presented in Table 5-1.

Table 5-1: Traffic Survey Locations

1	Kurar near Foot over bridge on NH 8
2	Shankarwadi on NH 8
3	Airport on NH 8
4	Santacruz Flyover on NH 8
5	Nanawathi Hospital on SV Road
6	Amboli on SV Road
7	Malad west on SV Road
8	Infinity mall on Link Road
9	Sea link
10	Worli dairy
11	Napean sea road
12	Peddar road
13	Marine drive
14	Dadabhai Naoroji Road
15	P D Mellow Road
16	Gokhale road
17	Mahim on SV Road

Classification of vehicles as per IRC: SP: 19-2001 "Manual for Survey, Investigation and Preparation of Road Projects (Second Revision)" was adopted for counts and presented in Table 5-2.

Table 5-2: Vehicle Classification Systems Adopted

Category	Type of Vehicles	
Fast Moving Vehicles	Two Wheeler	
	Three Wheeler	
	Car/Jeep	
	Bus	Bus
		Mini Bus
	LCV	
	Truck	2-Axle
		3-Axle
		Multi Axle
	Agricultural Tractor	With Trailer
		Without Trailer
Slow Moving Vehicles	Cycle	
	Cycle Rickshaw	
	Animal Drawn Vehicles	
	Others	

The Passenger Car Unit (PCU) recommended by IRC-106 "Guidelines for Capacity of Urban Roads in plain Areas" which are presented inTable 5-3.

Table 5-3: Equivalent PCU's

Sr. No	Vehicle Type	Equivalent PCU Factors	
		Percentage composition of Vehicle type in traffic stream	
		5%	10% and above
Fast Vehicles			
1	Two wheelers, Motor cycle or scooter etc.	0.5	0.75
2	Passenger car, pick-up van	1	1

Sr. No	Vehicle Type	Equivalent PCU Factors	
		Percentage composition of Vehicle type in traffic stream	
		5%	10% and above
3	Auto-rickshaw	1.2	2
4	Light commercial vehicle	1.4	2
5	Truck or Bus	2.2	3.7
6	Agricultural Tractor Trailer	4	5
Slow Vehicles			
7	Cycle	0.4	0.5
8	Cycle rickshaw	1.5	2
9	Tonga (Horse drawn vehicle)	1.5	2
10	Hand cart	2	3

Recording was done in a prescribed standard format as per IRC: SP: 19-2001 "Manual for survey, Investigation and Preparation of Road Projects (Second Revision)".

Daily traffic summary for all locations are provided in the appendix 'C'. Information in these sheets has been compiled from the field data for both the directions in separate forms.

5.2.2.2 Origin Destination (O-D) Survey

Analysis was carried out to determine composition of traffic. The Origin–Destination surveys were carried out at the same locations, where classified TVC were conducted. O-D surveys were conducted to determine the travel characteristics by different modes of vehicles within the project area. The expected traffic on any new bypass road is estimated as per IRC 102. Origin-Destination studies have been conducted at the same place of volume count as per IRC guidelines. The different types of vehicles were broadly divided into two categories as Passenger Vehicles and Goods Vehicles. Passenger vehicles constitute mainly of two wheelers, three-wheelers, cars, jeeps, vans, buses & cycles. Goods vehicles constitute light commercial vehicles, 2 - axle, 3-axle, multi – axle & tractor data was recorded based on the above-mentioned categories as per IRC SP 19.

The O-D survey was carried out on a weekday (one day-24 hours) at each location, by roadside interview method as described in IRC: 102-1988. Both passenger and commercial vehicles plying on the project road were stopped on a random sampling basis and interviewed.

The information pertaining to origin and destination of trips collected during roadside interviews was analysed to obtain the trip distribution based on a zoning system suitably designed for the present study.

The analysis of O-D data starts with coding of zones, i.e. categorising of the traffic with respect to its origin and destination. These Origins and Destinations depending on their distance from the project road are assigned to a region in terms of local, district and state. These regions are designated with unique code. These codes are termed as Traffic Analysis Zones (TAZ). All important areas of traffic generating points were assigned as local zones, immediate influence areas of the project road and districts were designated with district level zones, and state beyond the project influence areas were assigned broadly into state level zones. Total 26 zones were identified for the O-D survey analysis for the project road. The list of traffic analysis zones and respective codes are provided in Table 5-4.

Table 5-4: Zoning System

Local Code	Place
1	CST, Churchgate
2	Mumbai Central, Grant Road, Charni Road
3	Marine Lines
4	Masjid, Sandhust Road
5	Elphiston Road, Lower Parel, Mahalaxmi
6	Byculla, Chinchpokli, Reay Road, Dockyard
7	Mahim, Sion, Matunga road, Dadar
8	Parel, Sewri, Curry Road, Cotton Green
9	Santacruz, Khar, Bandra
10	Chunabhatti, GTB Nagar, King Circle, Matunga, Wadala
11	Jogeshwari, Andheri, Vile Parle
12	Ghatkopar, Vidhyavihar, Chembur, Kurla, Govandi, Mankhurd
13	Malad, Goregaon
14	Mulund, Bhandup, Kanjur Marg, Vikhroli
15	Dahisar, Borivali, Kandivali
District Code	
16	Navi Mumbai Region
17	Panvel-Uran Region, Pen-Alibagh Region, Neral-Karjat Region
18	Thane(Part of Thane Dist), North Eastern Region
19	Mira Bayander, North Western Region

Local Code	Place
20	Rest of Thane District, Ahmedpur, Nashik, Dhule, Jalgaon, Nandurbar
21	Raigad, Ratnagiri, Sindhudurg, Kolhapur, Sangli, Solapur, satara, Pune
22	Rest of Maharastra
23	Gujarat, MP, Rajasthan
24	AP, TN, Kerala, Karnataka
25	UP, Haryana, Himachal Pradesh, Punjab, Jammu & Kashmir, Uttaranchal
26	Eastern States, Rest of India

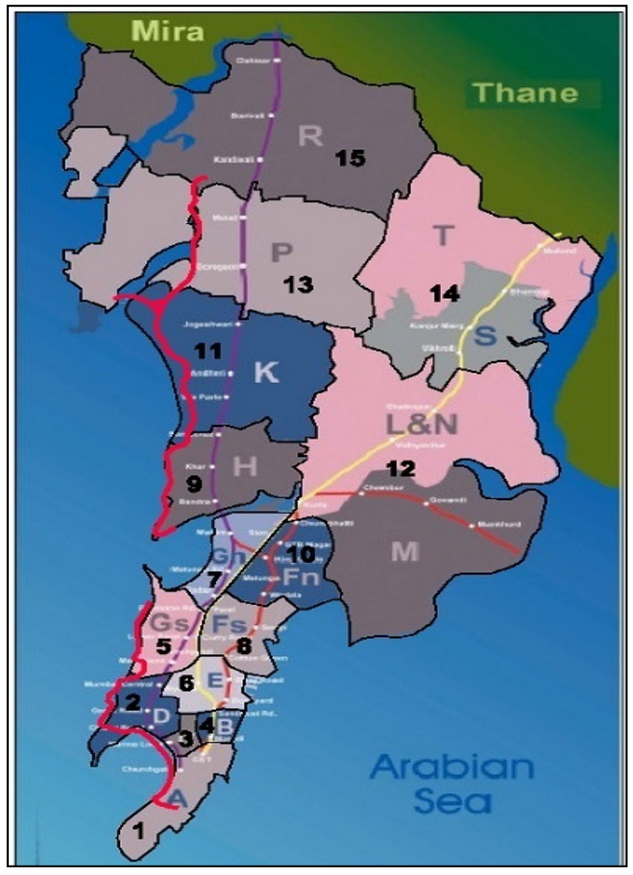
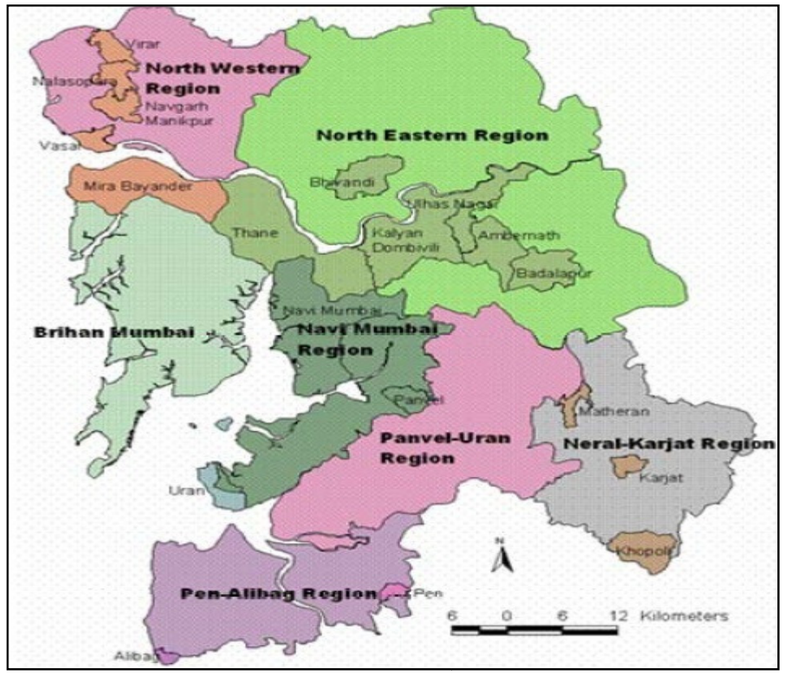


Figure 5-3: Traffic Zones - Internal

15 internal zones were been selected considering the Ward boundaries of Greater Mumbai along the proposed road.



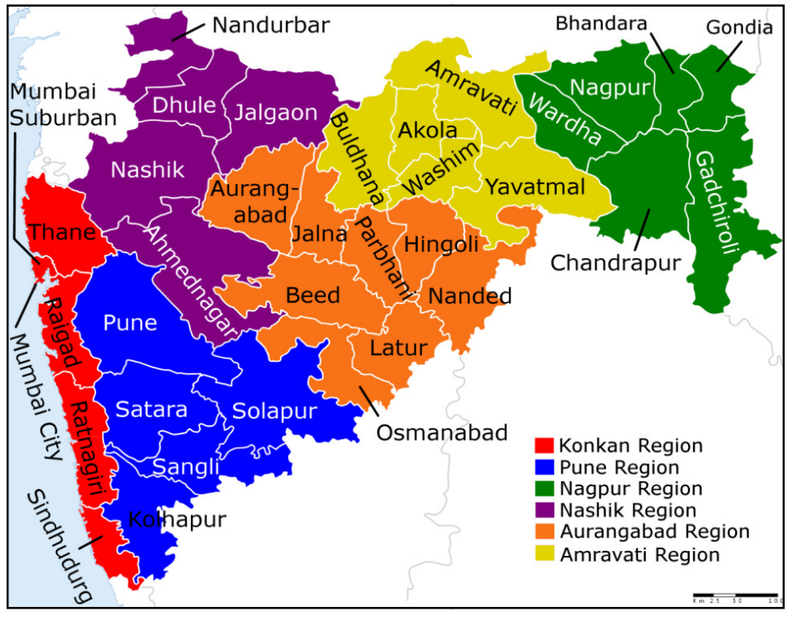


Figure 5-4: Traffic Zones - External

The travel characteristics obtained by O-D survey facilitate the classification of O-D travel pattern on the project road.

Trained enumerators under the supervision of transport planners collected the trip characteristics using the survey forms designed for this purpose. The travel characteristics obtained from O-D surveys identified were analysed to obtain the trip distribution based on the zoning The Origin and Destination Matrix for all the locations are given in Appendix-A.

5.2.3 Traffic Surveys Data Analysis & Results

Summary of traffic survey data, its analysis and recommendations are presented in subsequent paragraphs.

5.2.3.1 Classified Traffic Volume Count at Mid-Blocks

Average Daily Traffic

Annual Average Daily Traffic

Average Daily Traffic (ADT) at all 17 locations is provided in **Error! Reference source not found.**. Directional average daily traffic is presented in **Error! Reference source not found.**.

Table 5-5: Average Daily Traffic (ADT)

Location	ADT (In Nos)	ADT (In PCUs)
Kurar	184727	245648
Shankarwadi	216624	273544
Airport	270864	352508
Santacruz Flyover	222426	307166
Nanawati Hospital	66078	97955
Amboli	75026	104041
Malad west	38647	53464
Infinity mall	120235	164117
Sea link	49009	51544
Worli dairy	48699	49326
Napean sea road	30349	32161
Peddar road	81943	83947
Marine drive	53466	53354
Dadabhai Naoroji Road	59704	64882
P D Mellow Road	46008	49220
Gokhale road	37814	40252
Mahim	213769	220612

Table 5-6: Directional Average Daily Traffic (ADT)

Location	Direction	ADT (In Nos)	ADT (In PCUs)
Kurar	Borivali - Goregaon	94257	121564
	Goregaon - Borivali	90471	124084
Shankarwadi	Andheri - Goregaon East	101064	128314
	Goregaon East - Andheri	115560	145230
Airport	Chakala - Bandra	135970	177495
	Bandra - Chakala	134894	175013
Santacruz Flyover	CST Airport - Bandra	110893	152955
	Bandra - CST Airport	111532	154211
Nanawathi Hospital	Santa Cruz - Andheri	33583	50314
	Andheri - Santa Cruz	32495	47640
Amboli	Goregaon - Amboli	37546	51464
	Amboli - Goregaon	37480	52578
Malad west	Malad Station - Goregaon	20192	28245
	Goregaon - Malad Station	18456	25219
Infinity mall	Borivali - Goregaon (Infinity)	60195	81860
	Goregaon - Borivali (Infinity)	60040	82257
Sea link	Worli - Bandra	24206	25320
	Bandra - Worli	24803	26223
Worli dairy	Haji Ali - Worli	23708	23720
	Worli - Haji Ali	24991	25606
Napean Sea Road	Haji Ali - MSRDC	15306	16204
	MSRDC - Haji Ali	15043	15957

Location	Direction	ADT (In Nos)	ADT (In PCUs)
Peddar road	Mahalakshmi - Nepean Sea Road	42727	43662
	Napean Sea Road - Mahalakshmi	39216	40285
Marine drive	Haji Ali - Church Gate	26697	26412
	Church Gate - Haji Ali	26769	26942
Dadabhai Naoroji Rd	VT Station - Dadar	30773	33466
P D Mellow Road	NH3 Highway - VT Station	20980	22616
	VT Station - NH3 Highway	25028	26604
Gokhale road	BMC School Wadala - Mahim	21198	22581
	Mahim - BMC School Wadala	16616	17671
Mahim	Dadar - Bandra	96233	97926
	Bandra - Dadar	117536	122686

The ADT Summary for all the locations are given in Appendix – A.

5.2.3.2 Composition of Traffic

The compositions of traffic at the traffic count locations are indicated in Figure -5.5,5.6,5.7,5.8.

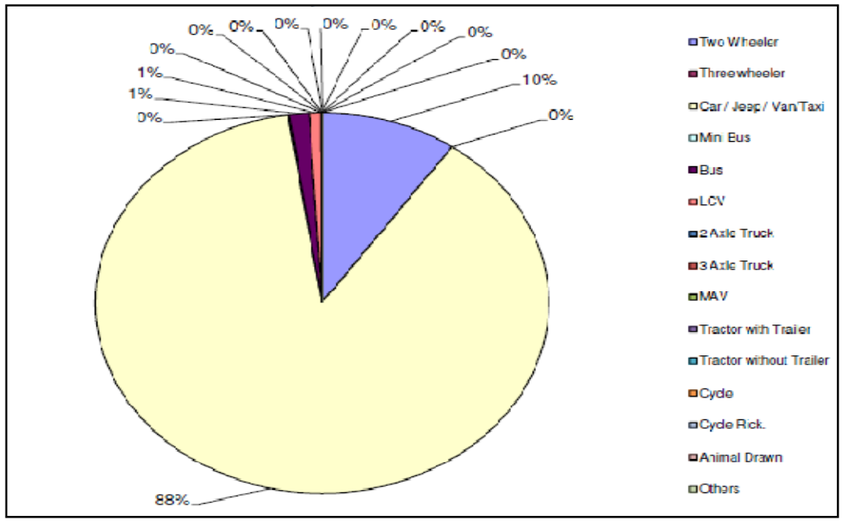


Figure 5-5: Traffic Composition at Peddar Road – South Stretch

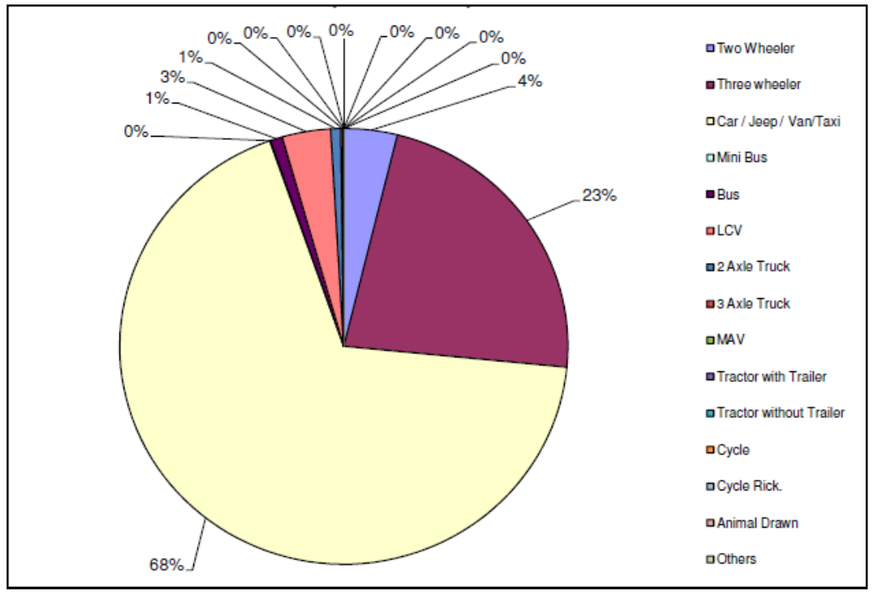


Figure 5-6: Traffic Composition at Airport – North Stretch

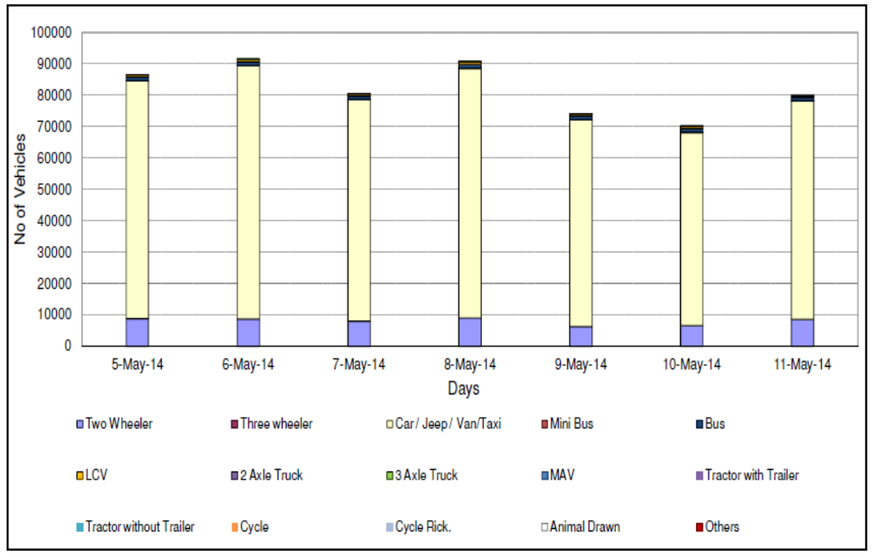


Figure 5-7: Annual Daily Traffic Variation at Peddar Road – South Stretch

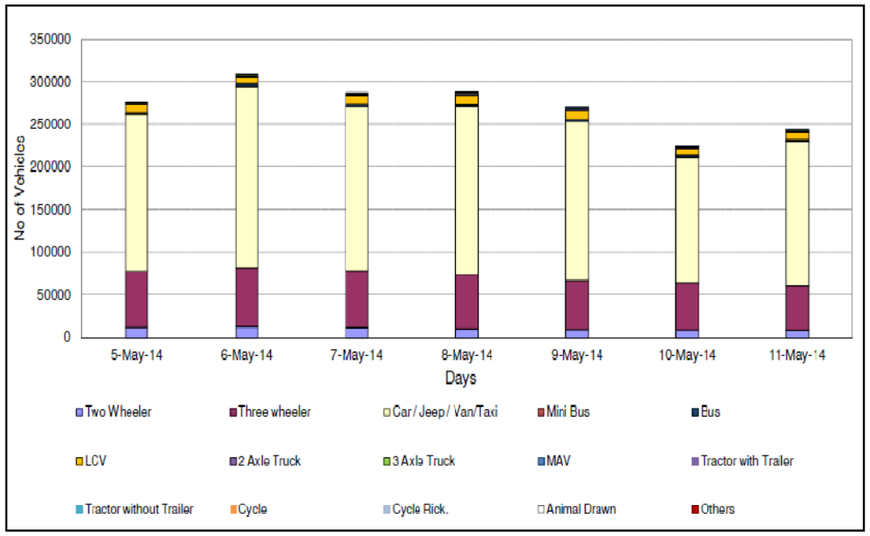


Figure 5-8: Annual Daily Traffic Variation at Airport – North Stretch

For almost all the locations the composition shows predominance of light fast vehicles.

The share for light vehicles at various locations ranges from 88% at Santacruz Flyover to 99% at Worli Dairy.

The composition of traffic for all the locations is pictorially indicated in Appendix-A.

5.2.3.3 Peak Hour Traffic volumes at Mid-Blocks

From the table showing Classified Average hourly traffic volumes for both the directions, the peak hour traffic observed at surveyed locations are provided in table 5-7. Peak hours were observed; one as morning peak hour and evening peak hour.

Table 5-7: Peak Hour traffic

Sr. No.	Location	Type of Peak Hour	Duration	Peak Hour Volume		Peak Hour Percentage	
				No's	PCU's	No's (%)	PCU's (%)
1	Kurar	Morning	09:00 - 10:00	8798	11756	4.76	4.79
		Evening	15:00 - 16:00	11907	15445	6.45	6.29
2	Shankarwadi	Morning	11:00 - 12:00	11972	15387	5.53	5.62
		Evening	18:00 - 19:00	14744	17560	6.81	6.42
3	Airport	Morning	09:00 - 10:00	14861	19363	5.49	5.49
		Evening	14:00 - 15:00	15685	20277	5.79	5.75
4	Santacruz Flyover	Morning	09:00 - 10:00	11081	15339	4.98	4.99
		Evening	15:00 - 16:00	11992	16096	5.39	5.24
5	Nanawathi Hospital	Morning	12:00 - 13:00	4095	6014	6.20	6.14
		Evening	20:00 - 21:00	3932	5482	5.95	5.60
6	Amboli	Morning	09:00 - 10:00	2232	3024	2.98	2.91
		Evening	16:00 - 17:00	6251	8699	8.33	8.36
7	Malad west	Morning	12:00 - 13:00	2119	2955	5.48	5.53
		Evening	20:00 - 21:00	2547	3544	6.59	6.63
8	Infinity mall	Morning	08:00 - 09:00	6918	9364	5.75	5.71
		Evening	20:00 - 21:00	6021	8186	5.01	4.99
9	Sea link	Morning	12:00 - 13:00	2625	2759	5.36	5.35
		Evening	19:00 - 20:00	3174	3295	6.48	6.39
10	Worli dairy	Morning	10:00 - 11:00	3531	3584	7.25	7.27
		Evening	19:00 - 20:00	3578	3573	7.35	7.24
11	Napean sea road	Morning	12:00 - 13:00	1938	2029	6.39	6.31
		Evening	19:00 - 20:00	2260	2468	7.45	7.67
12	Peddar road	Morning	11:00 - 12:00	5515	5650	6.73	6.73
		Evening	17:00 - 18:00	5150	5237	6.28	6.24
13	Marine drive	Morning	09:00 - 10:00	3594	3644	6.72	6.83
		Evening	16:00 - 17:00	3877	3859	7.25	7.23
14	Dadabhai Naoroji Rd	Morning	12:00 - 13:00	3149	3360	5.27	5.18
		Evening	18:00 - 19:00	3913	4298	6.55	6.62
15	P D Mellow Road	Morning	11:00 - 12:00	3019	3248	6.56	6.60
		Evening	16:00 - 17:00	2733	2937	5.94	5.97
16	Gokhale road	Morning	08:00 - 09:00	2759	2902	7.30	7.21
		Evening	14:00 - 15:00	2580	2738	6.82	6.80
17	Mahim	Morning	06:00 - 07:00	15231	14966	7.12	6.78
		Evening	16:00 - 17:00	14261	14737	6.67	6.68

From the above table it is observed that peak hour traffic varies from 2.98% to 8.33% in Nos and 2.91% to 8.36% in PCUs.

For calculation 10% of AADT was considered for calculation of capacity of proposed road and interchange arms.

The Hourly variation of traffic for all the locations is pictorially indicated in Appendix B1.

5.2.4 Speed and Delay Surveys

Speed and delay surveys were carried out from Kandivali to Nariman Point corridor taking in to consideration existing fastest corridor for movement during peak and off-peak hours. This is to establish current average speed and time delays. Benefit cost analysis as per IRC SP 30 based on Vehicle Operating Costs (VOC) and time delays are basis for decision by a user to make use of the Project Road. Fuel prices have been varying in Mumbai over past two year period, therefore Petrol price has been taken as Rs. 65/litre and Diesel Price as Rs 55/litre (Current Rates April 2016). Based on user survey, mileage for petrol car has been taken as 12kmpl on congested road and 17kmpl on expressway and for diesel car 8Kmpl for congested road and 11kmpl for an expressway respectively.

Therefore fuel cost savings per km travel on project road for petrol cars= (65/12)-(65/17) = Rs 1.61

Therefore fuel cost savings per km travel on project road for Diesel cars= (55/8)-(55/11) = Rs 1.875

Time savings may be monetised by as per IRC SP 30 at 2009 price base = Rs. 62.5 per hour

WPI for 2009=124.50

WPI for 2013=168.80

Therefore, time savings= (62.5x168.80)/124.50 =84.58, say Rs. 84/ per hour at 2013 price level.

Time Savings were calculated with consideration of time necessary to reach Project Road using existing network. Bandra Worli Link being a tolled road, with construction of the Project Road to similar standards as an extension, traffic on the Sea Link may only increase slightly due to impact of project road. Percentage diversion for each location of survey for each Origin and Destination was considered.

5.2.4.1 Existing Road Speed Delay Analysis

3 trips from Kandivali to Nariman Point were carried out to establish the speed and delay data. During the survey, noted down the travel time including actual running time and stopped delays. Zone wise travel time matrix and distance travelled in both Southward Journey and Northward journey is presented in Table 5 8, Table 5 9, Table 5 10 and Table 5 12.

Table 5-8: Time of travel- Southward Journey Peak Hour (in Hour)

		DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	0:44:00	0:57:00	1:29:00	1:48:00	2:06:00	2:19:00	2:23:00	2:50:00
	13	-	-	0:13:00	0:45:00	1:04:00	1:22:00	1:35:00	1:39:00	2:06:00
	11	-	-	-	0:32:00	0:51:00	1:09:00	1:22:00	1:26:00	1:53:00
	9	-	-	-	-	0:19:00	0:37:00	0:50:00	0:54:00	1:21:00
	7	-	-	-	-	-	0:18:00	0:31:00	0:35:00	1:02:00
	5	-	-	-	-	-	-	0:13:00	0:17:00	0:44:00
	2	-	-	-	-	-	-	-	0:04:00	0:31:00
	3	-	-	-	-	-	-	-	-	0:27:00
	1	-	-	-	-	-	-	-	-	-

Table 5-9: Distance of travel- Southward Journey Peak Hour (in Km)

		DESTINATION ZONES								
ORIGIN ZONES	**Zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	5.59	9.36	17.43	29.04	32.49	36.09	37.19	43.19
	13	-	-	3.77	11.84	23.45	26.90	30.50	31.60	37.60
	11	-	-	-	8.07	19.68	23.13	26.73	27.83	33.83
	9	-	-	-	-	11.61	15.06	18.66	19.76	25.76
	7	-	-	-	-	-	3.45	7.05	8.15	14.15
	5	-	-	-	-	-	-	3.60	4.70	10.70
	2	-	-	-	-	-	-	-	1.10	7.10
	3	-	-	-	-	-	-	-	-	6.00
	1	-	-	-	-	-	-	-	-	-

Table 5-10: Time of travel- Northward Journey Peak Hour (in Hour)

		DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	-	-	-	-	-	-	-	-
	13	0:15:00	-	-	-	-	-	-	-	-
	11	0:23:00	0:08:00	-	-	-	-	-	-	-
	9	0:44:00	0:29:00	0:21:00	-	-	-	-	-	-
	7	0:54:00	0:39:00	0:31:00	0:10:00	-	-	-	-	-
	5	1:18:00	1:03:00	0:55:00	0:34:00	0:24:00	-	-	-	-
	2	1:26:00	1:11:00	1:03:00	0:42:00	0:32:00	0:08:00	-	-	-
	3	1:34:00	1:19:00	1:11:00	0:50:00	0:40:00	0:16:00	0:08:00	-	-
	1	1:44:00	1:29:00	1:21:00	1:00:00	0:50:00	0:26:00	0:18:00	0:10:00	-

Table 5-11: Distance of travel- Northward Journey Peak Hour (in Km)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	-	-	-	-	-	-	-	-
	13	5.59	-	-	-	-	-	-	-	-
	11	9.36	3.77	-	-	-	-	-	-	-
	9	17.43	11.84	8.07	-	-	-	-	-	-
	7	29.04	23.45	19.68	11.61	-	-	-	-	-
	5	32.49	26.90	23.13	15.06	3.45	-	-	-	--
	2	36.09	30.50	26.73	18.66	7.05	3.60	-	-	-
	3	37.19	31.60	27.83	19.76	8.15	4.70	1.10	-	-
	1	43.19	37.60	33.83	25.76	14.15	10.70	7.10	6.00	-

5.2.4.2 Proposed Coastal Road Estimation

Table 5-12: Time of travel- Southward Journey Peak Hour (in Hour)

		DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	0:04:18	0:08:17	0:19:30	0:23:12	0:26:28	0:32:17	0:33:24	0:38:30
	13	-	-	0:04:00	0:15:11	0:18:54	0:22:12	0:28:00	0:29:06	0:34:12
	11	-	-	-	0:11:12	0:14:53	0:18:11	0:24:00	0:25:05	0:30:11
	9	-	-	-	-	0:03:42	0:07:00	0:12:47	0:13:54	0:19:00
	7	-	-	-	-	-	0:03:18	0:09:06	0:10:12	0:15:18
	5	-	-	-	-	-	-	0:05:48	0:06:54	0:12:00
	2	-	-	-	-	-	-	-	0:01:05	0:06:11
	3	-	-	-	-	-	-	-	-	0:05:06
	1	-	-	-	-	-	-	-	-	-

Table 5-13: Distance of travel- Southward Journey Peak Hour (in Km)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	4.30	8.30	19.50	23.20	26.50	32.30	33.40	38.50
	13	-	-	4.00	15.20	18.90	22.20	28.00	29.10	34.20
	11	-	-	-	11.20	14.90	18.20	24.00	25.10	30.20
	9	-	-	-	-	3.70	7.00	12.80	13.90	19.00
	7	-	-	-	-	-	3.30	9.10	10.20	15.30
	5	-	-	-	-	-	-	5.80	6.90	12.00
	2	-	-	-	-	-	-	-	1.10	6.20
	3	-	-	-	-	-	-	-	-	5.10
	1	-	-	-	-	-	-	-	-	-

Table 5-14: Time of travel- Northward Journey Peak Hour (in Hour)

	DESTINATION ZONES								
ORIGIN ZONES	zone	15	13	11	9	7	5	2	3	1
	15	-	-	-	-	-	-	-	-	-
	13	0:04:18	-	-	-	-	-	-	-	-
	11	0:08:17	0:04:00	-	-	-	-	-	-	-
	9	0:19:30	0:15:11	0:11:12	-	-	-	-	-	-
	7	0:23:12	0:18:54	0:14:53	0:03:42	-	-	-	-	-
	5	0:26:28	0:22:12	0:18:11	0:07:00	0:03:18	-	-	-	-
	2	0:32:17	0:28:00	0:24:00	0:12:47	0:09:06	0:05:48	-	-	-
	3	0:33:24	0:29:06	0:25:05	0:13:54	0:10:12	0:06:54	0:01:05	-	-
	1	0:38:30	0:34:12	0:30:11	0:19:00	0:15:18	0:12:00	0:06:11	0:05:06	-

Table 5-15: Distance of travel- Northward Journey Peak Hour (in Km)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	-	-	-	-	-	-	-	-
	13	4.30	-	-	-	-	-	-	-	-
	11	8.30	4.00	-	-	-	-	-	-	-
	9	19.50	15.20	11.20	-	-	-	-	-	-
	7	23.20	18.90	14.90	3.70	-	-	-	-	-
	5	26.50	22.20	18.20	7.00	3.30	-	-	-	-
	2	32.30	28.00	24.00	12.80	9.10	5.80	-	-	-
	3	33.40	29.10	25.10	13.90	10.20	6.90	1.10	-	-
	1	38.50	34.20	30.20	19.00	15.30	12.00	6.20	5.10	-

5.2.4.3 Time and Distance Savings for Diverted traffic to Coastal Road

Table 5-16: Savings in Time of travel- Southward Journey Peak Hour (in Hour)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	0:35:22	0:38:43	0:47:30	0:57:28	1:09:12	1:20:23	1:22:16	1:38:30
	13	-	-	0:03:20	0:12:09	0:22:06	0:33:48	0:45:00	0:46:54	1:03:08
	11	-	-	-	0:08:48	0:18:47	0:30:29	0:41:40	0:43:35	0:59:49
	9	-	-	-	-	0:09:58	0:21:40	0:32:53	0:34:46	0:51:00
	7	-	-	-	-	-	0:11:42	0:22:54	0:24:48	0:41:02
	5	-	-	-	-	-	-	0:11:12	0:13:06	0:29:20
	2	-	-	-	-	-	-	-	0:01:55	0:14:49
	3	-	-	-	-	-	-	-	-	0:16:14
	1	-	-	-	-	-	-	-	-	-

Table 5-17: Savings in Distance of travel- Southward Journey Peak Hour (in Km)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	13	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	1.29	1.06	-2.07	5.84	5.99	3.79	3.79	4.69
	13	-	-	-0.23	-3.36	4.55	4.7	2.5	2.5	3.4
	11	-	-	-	-3.13	4.78	4.93	2.73	2.73	3.63
	9	-	-	-	-	7.91	8.06	5.86	5.86	6.76
	7	-	-	-	-	-	0.15	-2.05	-2.05	-1.15
	5	-	-	-	-	-	-	-2.2	-2.2	-1.3
	2	-	-	-	-	-	-	-	-	0.9
	3	-	-	-	-	-	-	-	-	0.9
	1	-	-	-	-	-	-	-	-	-

Table 5-18: Savings in Time of travel- Northward Journey Peak Hour (in Hour)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	-	-	-	-	-	-	-	-
	13	0:07:42	-	-	-	-	-	-	-	-
	11	0:30:03	0:22:20	-	-	-	-	-	-	-
	9	0:31:10	0:23:29	0:01:08	-	-	-	-	-	-
	7	0:40:48	0:33:06	0:10:47	0:09:38	-	-	-	-	-
	5	0:54:52	0:47:08	0:24:49	0:23:40	0:14:02	-	-	-	-
	2	0:57:23	0:49:40	0:27:20	0:26:13	0:16:34	0:02:32	-	-	-
	3	1:06:16	0:58:34	0:36:15	0:35:06	0:25:28	0:11:26	0:08:55	-	-
	1	1:13:10	1:05:28	0:43:09	0:42:00	0:32:22	0:18:20	0:15:49	0:06:54	-

Table 5-19: Savings in Distance of travel- Northward Journey Peak Hour (in Km)

	DESTINATION ZONES								
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	-	-	-	-	-	-	-	-
	13	1.29	-	-	-	-	-	-	-	-
	11	1.06	-0.23	-	-	-	-	-	-	-
	9	-2.07	-3.36	-3.13	-	-	-	-	-	-
	7	5.84	4.55	4.78	7.91	-	-	-	-	-
	5	5.99	4.7	4.93	8.06	0.15	-	-	-	-
	2	3.79	2.5	2.73	5.86	-2.05	-2.2	-	-	-
	3	3.79	2.5	2.73	5.86	-2.05	-2.2	0	-	-
	1	4.69	3.4	3.63	6.76	-1.15	-1.3	0.9	0.9	-

5.2.4.4 Cost Savings for Diverted traffic to Coastal Road

Estimated Total Cost Savings inclusive of Time savings (Monetised), Distance Savings (Monetised) and Vehicle Operating Cost Savings

Total Cost Savings = Cost of travel time savings + Cost of distance saved + Cost of savings in vehicle operation cost

Table 5-20: Cost savings in Rupees - Southward Direction Travel (Peak Hour)

	DESTINATION ZONES									
ORIGIN ZONES	**Zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	55.61	63.35	61.42	150.82	160.37	170.21	173.96	207.00
	13	-	-	7.72	5.82	95.17	114.00	114.38	118.31	151.67
	11	-	-	-	-1.88	87.47	106.30	106.86	110.61	143.96
	9	-	-	-	-	89.37	108.23	108.79	112.54	145.89
	7	-	-	-	-	-	18.83	19.44	23.14	56.49
	5	-	-	-	-	-	-	0.61	4.31	37.66
	2	-	-	-	-	-	-	-	3.75	33.63
	3	-	-	-	-	-	-	-	-	33.35
	1	-	-	-	-	-	-	-	-	-

Table 5-21: Cost savings in Rupees - Northward Direction Travel (Peak Hour)

	DESTINATION ZONES									
ORIGIN ZONES	**zone**	**15**	**13**	**11**	**9**	**7**	**5**	**2**	**3**	**1**
	15	-	-	-	-	-	-	-	-	-
	13	26.79	-	-	-	-	-	-	-	-
	11	54.32	27.51	-	-	-	-	-	-	-
	9	44.40	17.63	-9.86	-	-	-	-	-	-
	7	133.46	106.63	79.14	89.02	-	-	-	-	-
	5	154.72	127.89	100.40	110.32	21.26	-	-	-	-
	2	146.25	119.24	91.93	101.85	12.85	-8.41	-	-	-
	3	157.29	130.47	102.97	112.89	23.84	2.57	11.04	-	-
	1	180.61	154.10	126.60	136.52	47.46	26.20	34.67	23.63	-

5.2.5 Origin Destination (O-D) Survey

One day O-D Survey was conducted at the locations of TVC surveys. The surveys are essential to estimate likely traffic volumes on new links.

The influencing traffic corridors related to the project road is shown below:

- **Influencing Traffic Corridors**

Figure 5-9: Traffic Influencing Corridors

Northern side – Diverted traffic mainly from

- Link Road
- S V Road
- Western Express Highway (NH 8)

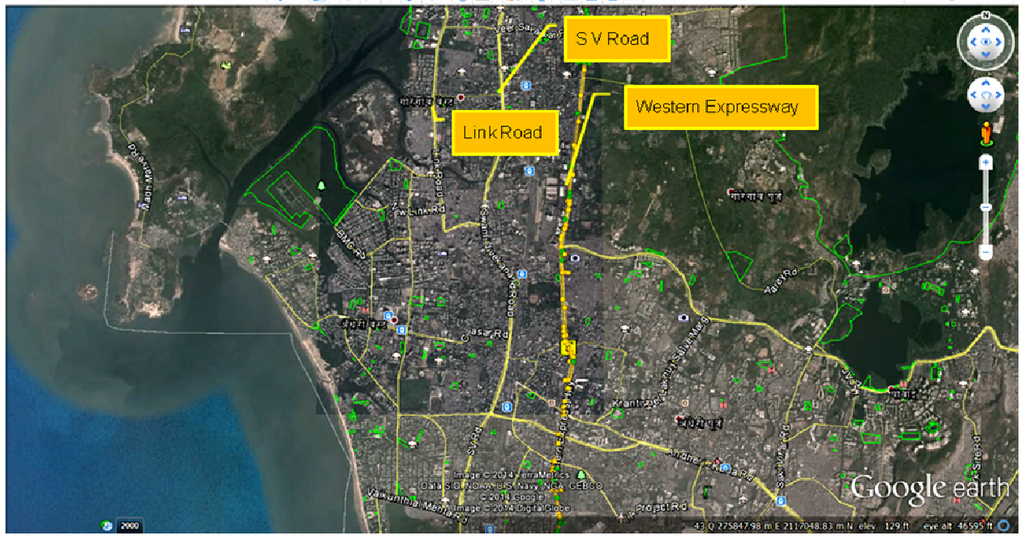


Figure 5-10: Influencing Traffic Corridor – North End

Central part – Diverted traffic mainly from

- Santacruz Flyover
- Bandra -Worli Sea Link

Southern side – Diverted traffic mainly from

- Marine Drive
- Dadabhai Naoroji Road
- P D Mellow Road
- Khan Abdul Gaffar Khan Road
- Napean Sea Road
- Peddar road
- Gokhale Road

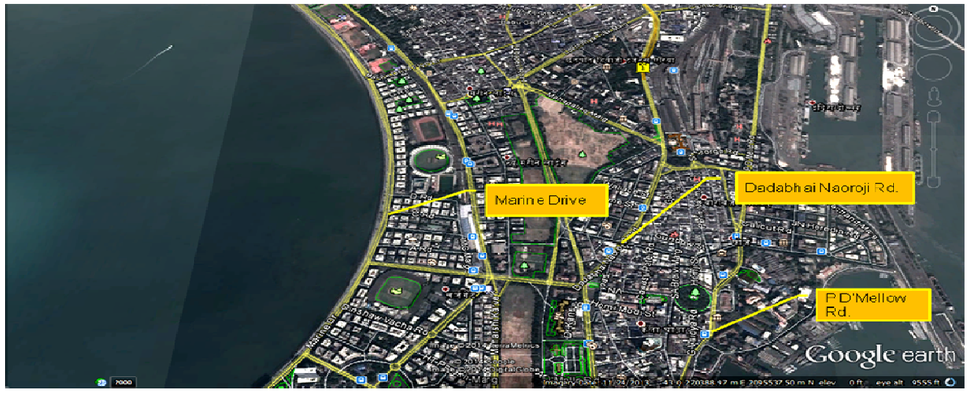


Figure 5-11: Influencing Traffic Corridor – South End

5.2.5.1 O-D Analysis

From O-D matrix was derived for each of the 17 traffic survey locations. Based on Speed and Delay analysis percentage diversion was assigned to each O-D in the matrix to derive the actual percentage of traffic getting diverted at the survey location. Percentage diverted traffic for each survey location is presented in Table. The diverted traffic shall reach the project road through proposed interchanges. Therefore, this traffic has been assigned to each of the proposed interchange location based on O-D.

From both the ends it is observed that major generating / attracting zones are - Wards A, C, GS, H, K, D, Gh, P and R. These wards account for more than 70% of movement pattern.

Except for Wards A, C, P & R, which are located at northern and southern ends, rest of the wards are located in the middle with significant movement.

Table 5-22: Total Diversions to Coastal Road at each Traffic Survey Location based on O-D related Cost Savings

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

Location	AADT All Vehicles		AADT Divertible Vehicles	Zone ID	Productions %	Attractions %	Productions AADT	Attractions AADT	Total Diverted Traffic Both Directions
	IN PCU	64882	58556				0	0	0
P D Mellow Road	In No's	46008	36641	1A	15%	61%	0	0	0
	IN PCU	49220	38516				0	0	0
Gokhula road	In No's	37814	27077	7B	15%	14%	573	244	817
	IN PCU	40252	32200				682	290	971
Mahim	In No's	213769	143830	7A	8%	8%	1515	1582	3097
	IN PCU	220612	168148				1771	1850	3621

5.2.6 Traffic Demand Forecast

5.2.6.1 Growth Factor

Traffic Growth on a road facility is generally estimated on the basis of historical trends. Demand changes are usually because of shifts in the pattern of economic activities in the surrounding regions. The proposed coastal road is from Princes Flyover to Kandivali Junction link road. Hence, future traffic estimation necessitates a preview, however imprecise, of the probable pattern of future growth of the economy of the country and particularly Greater Mumbai. CTS was carried out for the MMR in 2008 to establish various parameters. The study concentrates in updating the findings of the CTS related to the impact of the Coastal Road and extend the horizon period from 2031 to 2043.

It may be noted that the Coastal Road will be mainly used by city traffic particularly by cars and taxis between southern end at Princes Flyover and northern end at Kandivali. The access points are provided through 12 interchanges, four along southern stretch between Princes Flyover and BWSL and eight along northern stretch between BWSL and Kandivali. However it is expected that with another proposed link between NH 348 near Gavan Phata extended to coastal road by Worli Sewri link, some amount of traffic from / to Navi Mumbai and Raigad will be loaded on the Coastal Road. Moreover, the development potential along the study corridor is quite restricted. In that situation, the growth of registered vehicles, especially cars and taxis, will be the guiding factor for traffic projection. The analysis of the secondary data indicates that;

The number of total registered vehicles in Maharashtra (2008-2012) is growing at 11.46% per annum (Table 5.22).

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 5.23).

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:

Table 5-23: Growth of Registered Vehicles in Maharashtra

(In Numbers)

Sr. No.	Category	As on 31 st March 2008	2009	2010	2011	2012	Percentage increase or decreas over previous year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Two Wheelers	9394869	10212360	11181762	12429011	13921763	12.01
2	Cars / Jeeps & Station Wagons.	1822458	1979191	2182969	2440404	2750167	12.69
3	Taxi Cabs	149526	157916	168307	168496	175797	4.33
4	Auto - Rickshaws	574625	598013	626332	640700	640040	-0.10
5	Stage Carriages/Contract Carriages	55281	57353	60387	64549	62308	-3.47
6	School Buses	4154	4698	5222	7415	17781	139.80
7	Private Service Vehicles.	10154	8762	9103	8326	9451	13.51
8	Ambulances	7453	8260	9104	9571	10557	10.30
9	Arti./Multi.vehicles,Trucks & Lorries, Tankers & Delivery vans	780992	845617	896397	973788	1067825	9.66
10	Tractors	276438	302249	331694	371075	419291	12.99
11	Trailers	238080	252409	270078	293576	324824	10.64
12	Others	21331	24080	27066	27188	32557	19.75
	Total	**13335361**	**14450908**	**15768421**	**17434099**	**19432361**	**11.46**

Table 5-24: Growth of Registered Vehicles in Greater Mumbai and Thane Region

Year	Total Registered Cars and Taxis as on31st March	
	Greater Mumbai	Thane
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:

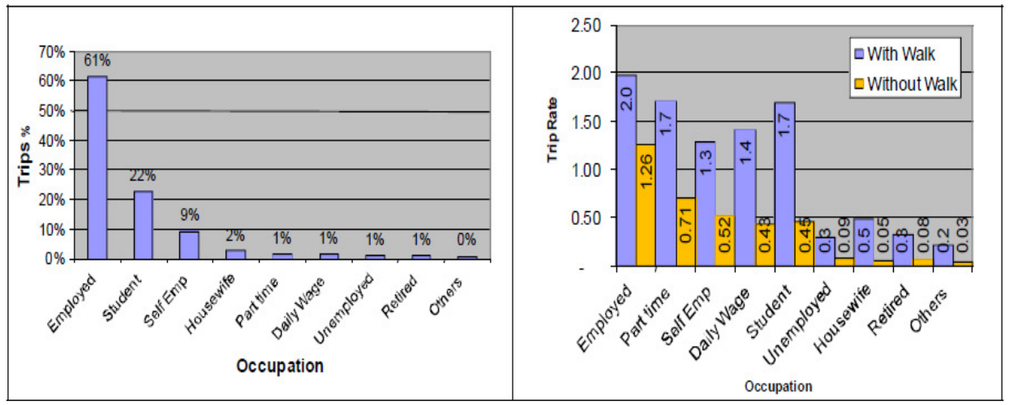


Figure 5-12: Trip Rates from CTS Report

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,

Year	Growth
2014 to 2024	20.86%
2024 to 2034	18.13%
2034 to 2043	03.00%

The same has adopted for projection of traffic growth over Horizon period up to 2043.

Table 5-25: Growth Rates in Different Scenarios

Year	Growth Scenario – Per Annum (%)
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.

The projected traffic is shown in Appendix.

5.2.7 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 manoeuvre 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 5-13: Interchange Locations

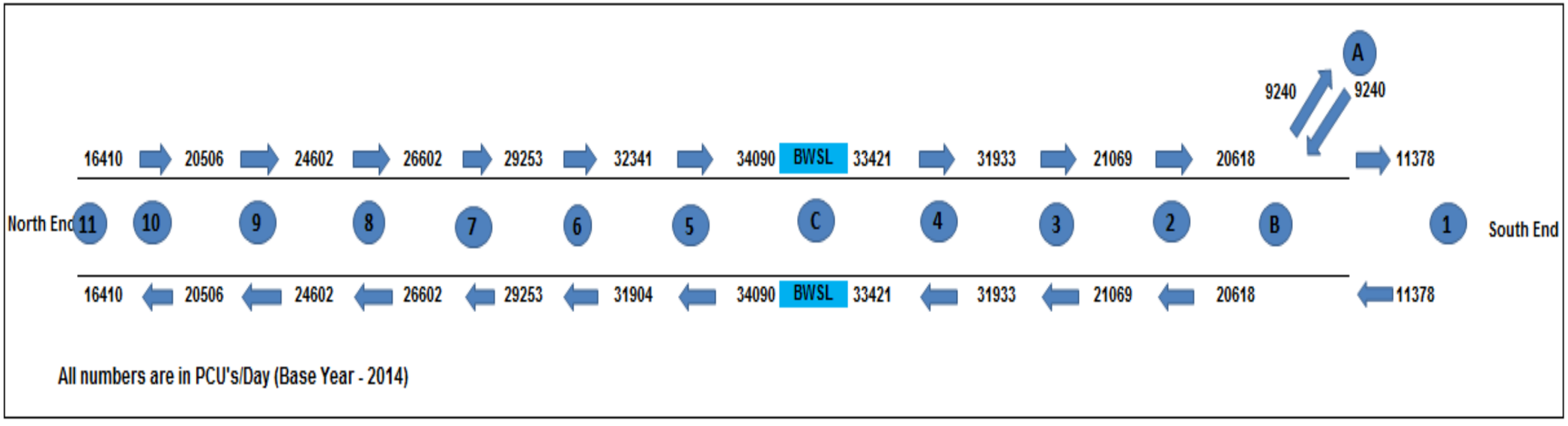
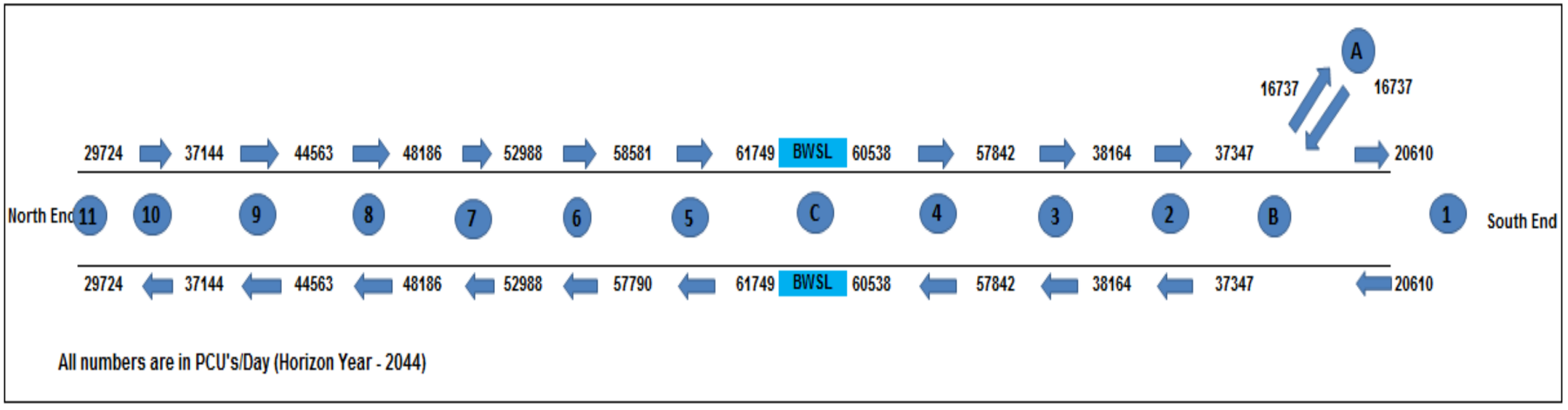


Figure 5-14: Link Traffic between Interchanges – Base Year 2014

Figure 5-15: Interchange Locations



F

igure 5-16: Link Traffic between Interchanges – Horizon Year 2044

Table 5-26: Lane Capacity – North Bound Carriageway

Year	11 - 10	Lane Configurat	10 - 9	Lane Configurat	9 - 8	Lane Configurat	8 - 7	Lane Configurat	7 - 6	Lane Configurat	6 - 5	Lane Configurat	5-C	Lane Configurat	C-4	Lane Configurat	4 - 3	Lane Configurat	3 - 2	Lane Configurat	2 - B	Lane Configurat	B - A	Lane Configurat	B - 1	Lane Configurat
2014 (ADT)	1313	2 Lane	1640	2 Lane	1968	2 Lane	2674	3 Lane	2340	2 Lane	2587	3 Lane	2727	3 Lane	2674	3 Lane	2555	3 Lane	1686	2 Lane	1643	2 Lane	739	2 Lane	910	2 Lane
2015	1333	2 Lane	1673	2 Lane	2008	2 Lane	2727	3 Lane	2387	2 Lane	2639	3 Lane	2782	3 Lane	2727	3 Lane	2606	3 Lane	1719	2 Lane	1643	2 Lane	754	2 Lane	928	2 Lane
2016	1366	2 Lane	1707	2 Lane	2048	2 Lane	2782	3 Lane	2435	3 Lane	2632	3 Lane	2837	3 Lane	2782	3 Lane	2658	3 Lane	1754	2 Lane	1682	2 Lane	769	2 Lane	947	2 Lane
2017	1393	2 Lane	1741	2 Lane	2089	2 Lane	2837	3 Lane	2483	3 Lane	2746	3 Lane	2894	3 Lane	2837	3 Lane	2711	3 Lane	1789	2 Lane	1716	2 Lane	784	2 Lane	966	2 Lane
2018	1421	2 Lane	1776	2 Lane	2130	2 Lane	2894	3 Lane	2533	3 Lane	2801	3 Lane	2952	3 Lane	2894	3 Lane	2765	3 Lane	1824	2 Lane	1750	2 Lane	800	2 Lane	985	2 Lane
2019	1449	2 Lane	1811	2 Lane	2173	2 Lane	2952	3 Lane	2584	3 Lane	2857	3 Lane	3011	3 Lane	2952	3 Lane	2821	3 Lane	1861	2 Lane	1785	2 Lane	816	2 Lane	1005	2 Lane
2020	1478	2 Lane	1847	2 Lane	2216	2 Lane	3011	3 Lane	2635	3 Lane	2914	3 Lane	3071	3 Lane	3011	3 Lane	2877	3 Lane	1898	2 Lane	1821	2 Lane	832	2 Lane	1025	2 Lane
2021	1508	2 Lane	1884	2 Lane	2261	2 Lane	3071	3 Lane	2688	3 Lane	2972	3 Lane	3133	3 Lane	3071	3 Lane	2934	3 Lane	1936	2 Lane	1858	2 Lane	849	2 Lane	1046	2 Lane
2022	1538	2 Lane	1922	2 Lane	2306	2 Lane	3133	3 Lane	2742	3 Lane	3031	3 Lane	3195	3 Lane	3133	3 Lane	2993	3 Lane	1975	2 Lane	1895	2 Lane	866	2 Lane	1066	2 Lane
2023	1569	2 Lane	1961	2 Lane	2352	2 Lane	3195	3 Lane	2797	3 Lane	3092	3 Lane	3259	3 Lane	3195	3 Lane	3053	3 Lane	2014	2 Lane	1933	2 Lane	883	2 Lane	1088	2 Lane
2024	1600	2 Lane	2000	2 Lane	2399	2 Lane	3259	3 Lane	2853	3 Lane	3154	3 Lane	3324	3 Lane	3259	3 Lane	3114	3 Lane	2055	2 Lane	1971	2 Lane	901	2 Lane	1110	2 Lane
2025	1632	2 Lane	2040	2 Lane	2447	3 Lane	3324	3 Lane	2910	3 Lane	3217	3 Lane	3391	3 Lane	3324	3 Lane	3176	3 Lane	2096	2 Lane	2011	2 Lane	919	2 Lane	1132	2 Lane
2026	1665	2 Lane	2081	2 Lane	2496	3 Lane	3391	3 Lane	2968	3 Lane	3281	3 Lane	3459	3 Lane	3391	3 Lane	3240	3 Lane	2138	2 Lane	2051	2 Lane	937	2 Lane	1154	2 Lane
2027	1698	2 Lane	2122	2 Lane	2546	3 Lane	3459	3 Lane	3027	3 Lane	3347	3 Lane	3528	3 Lane	3459	3 Lane	3305	3 Lane	2180	2 Lane	2092	2 Lane	956	2 Lane	1177	2 Lane
2028	1732	2 Lane	2165	2 Lane	2597	3 Lane	3528	3 Lane	3088	3 Lane	3414	3 Lane	3598	3 Lane	3528	3 Lane	3371	3 Lane	2224	2 Lane	2134	2 Lane	975	2 Lane	1201	2 Lane
2029	1767	2 Lane	2208	2 Lane	2649	3 Lane	3598	3 Lane	3150	3 Lane	3482	3 Lane	3670	4 Lane	3598	3 Lane	3438	3 Lane	2268	2 Lane	2176	2 Lane	995	2 Lane	1225	2 Lane
2030	1802	2 Lane	2252	2 Lane	2702	3 Lane	3670	4 Lane	3213	3 Lane	3552	3 Lane	3744	4 Lane	3670	4 Lane	3507	3 Lane	2314	2 Lane	2220	2 Lane	1015	2 Lane	1250	2 Lane
2031	1838	2 Lane	2297	2 Lane	2756	3 Lane	3744	4 Lane	3277	3 Lane	3623	4 Lane	3819	4 Lane	3744	4 Lane	3577	3 Lane	2360	2 Lane	2264	2 Lane	1035	2 Lane	1275	2 Lane
2032	1875	2 Lane	2343	2 Lane	2811	3 Lane	3819	4 Lane	3342	3 Lane	3695	4 Lane	3895	4 Lane	3819	4 Lane	3649	4 Lane	2407	3 Lane	2310	2 Lane	1056	2 Lane	1300	2 Lane
2033	1913	2 Lane	2390	2 Lane	2867	3 Lane	3895	4 Lane	3409	3 Lane	3769	4 Lane	3973	4 Lane	3895	4 Lane	3722	4 Lane	2455	3 Lane	2356	2 Lane	1077	2 Lane	1326	2 Lane
2034	1951	2 Lane	2438	3 Lane	2925	3 Lane	3973	4 Lane	3477	3 Lane	3845	4 Lane	4052	4 Lane	3973	4 Lane	3796	4 Lane	2505	3 Lane	2403	3 Lane	1098	2 Lane	1353	2 Lane
2035	1990	2 Lane	2486	3 Lane	2983	3 Lane	4052	4 Lane	3547	3 Lane	3921	4 Lane	4134	4 Lane	4052	4 Lane	3872	4 Lane	2555	3 Lane	2451	3 Lane	1120	2 Lane	1380	2 Lane
2036	2030	2 Lane	2536	3 Lane	3043	3 Lane	4133	4 Lane	3618	4 Lane	4000	4 Lane	4216	4 Lane	4133	4 Lane	3949	4 Lane	2606	3 Lane	2500	3 Lane	1143	2 Lane	1407	2 Lane
2037	2070	2 Lane	2587	3 Lane	3104	3 Lane	4216	4 Lane	3690	4 Lane	4080	4 Lane	4301	4 Lane	4216	4 Lane	4028	4 Lane	2658	3 Lane	2550	3 Lane	1166	2 Lane	1435	2 Lane
2038	2112	2 Lane	2639	3 Lane	3166	3 Lane	4300	4 Lane	3764	4 Lane	4161	4 Lane	4387	4 Lane	4300	4 Lane	4109	4 Lane	2711	3 Lane	2601	3 Lane	1189	2 Lane	1464	2 Lane
2039	2154	2 Lane	2691	3 Lane	3229	3 Lane	4386	4 Lane	3839	4 Lane	4245	4 Lane	4474	4 Lane	4386	4 Lane	4191	4 Lane	2765	3 Lane	2653	3 Lane	1213	2 Lane	1493	2 Lane
2040	2197	2 Lane	2745	3 Lane	3294	3 Lane	4474	4 Lane	3916	4 Lane	4330	4 Lane	4564	4 Lane	4474	4 Lane	4275	4 Lane	2821	3 Lane	2706	3 Lane	1237	2 Lane	1523	2 Lane
2041	2241	2 Lane	2800	3 Lane	3359	3 Lane	4564	4 Lane	3995	4 Lane	4416	4 Lane	4655	4 Lane	4564	4 Lane	4360	4 Lane	2877	3 Lane	2760	3 Lane	1262	2 Lane	1554	2 Lane
2042	2286	2 Lane	2856	3 Lane	3427	3 Lane	4655	4 Lane	4074	4 Lane	4505	4 Lane	4748	4 Lane	4655	4 Lane	4448	4 Lane	2935	3 Lane	2815	3 Lane	1287	2 Lane	1585	2 Lane
2043	2331	2 Lane	2913	3 Lane	3495	3 Lane	4748	4 Lane	4156	4 Lane	4595	4 Lane	4843	5 Lane	4748	4 Lane	4537	4 Lane	2993	3 Lane	2872	3 Lane	1313	2 Lane	1616	2 Lane
2044	2378	2 Lane	2972	3 Lane	3565	3 Lane	4843	5 Lane	4239	4 Lane	4686	4 Lane	4940	5 Lane	4843	5 Lane	4627	4 Lane	3053	3 Lane	2929	3 Lane	1339	2 Lane	1649	2 Lane

Year	11 - 10	Lane Configurat	10 - 9	Lane Configurat	9 - 8	Lane Configurat	8 - 7	Lane Configurat	7 - 6	Lane Configurat	6 - 5	Lane Configurat	5-C	Lane Configurat	C-4	Lane Configurat	4 - 3	Lane Configurat	3 - 2	Lane Configurat	2 - B	Lane Configurat	B - A	Lane Configurat	B - 1	Lane Configurat
2014 (ADT)	1313	2 Lane	1640	2 Lane	1968	2 Lane	2674	3 Lane	2340	2 Lane	2587	3 Lane	2727	3 Lane	2674	3 Lane	2555	3 Lane	1686	2 Lane	1643	2 Lane	739	2 Lane	910	2 Lane
2015	1339	2 Lane	1673	2 Lane	2008	2 Lane	2727	3 Lane	2387	2 Lane	2639	3 Lane	2782	3 Lane	2727	3 Lane	2606	3 Lane	1719	2 Lane	1649	2 Lane	754	2 Lane	928	2 Lane
2016	1366	2 Lane	1707	2 Lane	2048	2 Lane	2782	3 Lane	2435	3 Lane	2632	3 Lane	2837	3 Lane	2782	3 Lane	2658	3 Lane	1754	2 Lane	1682	2 Lane	769	2 Lane	947	2 Lane
2017	1393	2 Lane	1741	2 Lane	2089	2 Lane	2837	3 Lane	2483	3 Lane	2746	3 Lane	2894	3 Lane	2837	3 Lane	2711	3 Lane	1789	2 Lane	1716	2 Lane	784	2 Lane	966	2 Lane
2018	1421	2 Lane	1776	2 Lane	2130	2 Lane	2894	3 Lane	2533	3 Lane	2801	3 Lane	2952	3 Lane	2894	3 Lane	2765	3 Lane	1824	2 Lane	1750	2 Lane	800	2 Lane	985	2 Lane
2019	1449	2 Lane	1811	2 Lane	2173	2 Lane	2952	3 Lane	2584	3 Lane	2857	3 Lane	3011	3 Lane	2952	3 Lane	2821	3 Lane	1861	2 Lane	1785	2 Lane	816	2 Lane	1005	2 Lane
2020	1478	2 Lane	1847	2 Lane	2216	2 Lane	3011	3 Lane	2635	3 Lane	2914	3 Lane	3071	3 Lane	3011	3 Lane	2877	3 Lane	1898	2 Lane	1821	2 Lane	832	2 Lane	1025	2 Lane
2021	1508	2 Lane	1884	2 Lane	2261	2 Lane	3071	3 Lane	2688	3 Lane	2972	3 Lane	3133	3 Lane	3071	3 Lane	2934	3 Lane	1936	2 Lane	1858	2 Lane	849	2 Lane	1046	2 Lane
2022	1538	2 Lane	1922	2 Lane	2306	2 Lane	3133	3 Lane	2742	3 Lane	3031	3 Lane	3195	3 Lane	3133	3 Lane	2993	3 Lane	1975	2 Lane	1895	2 Lane	866	2 Lane	1066	2 Lane
2023	1569	2 Lane	1961	2 Lane	2352	2 Lane	3195	3 Lane	2797	3 Lane	3092	3 Lane	3259	3 Lane	3195	3 Lane	3053	3 Lane	2014	2 Lane	1933	2 Lane	883	2 Lane	1088	2 Lane
2024	1600	2 Lane	2000	2 Lane	2399	2 Lane	3259	3 Lane	2853	3 Lane	3154	3 Lane	3324	3 Lane	3259	3 Lane	3114	3 Lane	2055	2 Lane	1971	2 Lane	901	2 Lane	1110	2 Lane
2025	1632	2 Lane	2040	2 Lane	2447	3 Lane	3324	3 Lane	2910	3 Lane	3217	3 Lane	3391	3 Lane	3324	3 Lane	3176	3 Lane	2096	2 Lane	2011	2 Lane	919	2 Lane	1132	2 Lane
2026	1665	2 Lane	2081	2 Lane	2496	3 Lane	3391	3 Lane	2968	3 Lane	3281	3 Lane	3459	3 Lane	3391	3 Lane	3240	3 Lane	2138	2 Lane	2051	2 Lane	937	2 Lane	1154	2 Lane
2027	1698	2 Lane	2122	2 Lane	2546	3 Lane	3459	3 Lane	3027	3 Lane	3347	3 Lane	3528	3 Lane	3459	3 Lane	3305	3 Lane	2180	2 Lane	2092	2 Lane	956	2 Lane	1177	2 Lane
2028	1732	2 Lane	2165	2 Lane	2597	3 Lane	3528	3 Lane	3088	3 Lane	3414	3 Lane	3598	3 Lane	3528	3 Lane	3371	3 Lane	2224	2 Lane	2134	2 Lane	975	2 Lane	1201	2 Lane
2029	1767	2 Lane	2208	2 Lane	2649	3 Lane	3598	3 Lane	3150	3 Lane	3482	3 Lane	3670	4 Lane	3598	3 Lane	3438	3 Lane	2268	2 Lane	2176	2 Lane	995	2 Lane	1225	2 Lane
2030	1802	2 Lane	2252	2 Lane	2702	3 Lane	3670	4 Lane	3213	3 Lane	3552	3 Lane	3744	4 Lane	3670	4 Lane	3507	3 Lane	2314	2 Lane	2220	2 Lane	1015	2 Lane	1250	2 Lane
2031	1838	2 Lane	2297	2 Lane	2756	3 Lane	3744	4 Lane	3277	3 Lane	3623	4 Lane	3819	4 Lane	3744	4 Lane	3577	3 Lane	2360	2 Lane	2264	2 Lane	1035	2 Lane	1275	2 Lane
2032	1875	2 Lane	2343	2 Lane	2811	3 Lane	3819	4 Lane	3342	3 Lane	3695	4 Lane	3895	4 Lane	3819	4 Lane	3649	4 Lane	2407	3 Lane	2310	2 Lane	1056	2 Lane	1300	2 Lane
2033	1913	2 Lane	2390	2 Lane	2867	3 Lane	3895	4 Lane	3409	3 Lane	3769	4 Lane	3973	4 Lane	3895	4 Lane	3722	4 Lane	2455	3 Lane	2356	2 Lane	1077	2 Lane	1326	2 Lane
2034	1951	2 Lane	2438	3 Lane	2925	3 Lane	3973	4 Lane	3477	3 Lane	3845	4 Lane	4052	4 Lane	3973	4 Lane	3796	4 Lane	2505	3 Lane	2403	3 Lane	1098	2 Lane	1353	2 Lane
2035	1990	2 Lane	2486	3 Lane	2983	3 Lane	4052	4 Lane	3547	3 Lane	3921	4 Lane	4134	4 Lane	4052	4 Lane	3872	4 Lane	2555	3 Lane	2451	3 Lane	1120	2 Lane	1380	2 Lane
2036	2030	2 Lane	2536	3 Lane	3043	3 Lane	4133	4 Lane	3618	4 Lane	4000	4 Lane	4216	4 Lane	4133	4 Lane	3949	4 Lane	2606	3 Lane	2500	3 Lane	1143	2 Lane	1407	2 Lane
2037	2070	2 Lane	2587	3 Lane	3104	3 Lane	4216	4 Lane	3690	4 Lane	4080	4 Lane	4301	4 Lane	4216	4 Lane	4028	4 Lane	2658	3 Lane	2550	3 Lane	1166	2 Lane	1435	2 Lane
2038	2112	2 Lane	2639	3 Lane	3166	3 Lane	4300	4 Lane	3764	4 Lane	4161	4 Lane	4387	4 Lane	4300	4 Lane	4109	4 Lane	2711	3 Lane	2601	3 Lane	1189	2 Lane	1464	2 Lane
2039	2154	2 Lane	2691	3 Lane	3229	3 Lane	4386	4 Lane	3839	4 Lane	4245	4 Lane	4474	4 Lane	4386	4 Lane	4191	4 Lane	2765	3 Lane	2653	3 Lane	1213	2 Lane	1493	2 Lane
2040	2197	2 Lane	2745	3 Lane	3294	3 Lane	4474	4 Lane	3916	4 Lane	4330	4 Lane	4564	4 Lane	4474	4 Lane	4275	4 Lane	2821	3 Lane	2706	3 Lane	1237	2 Lane	1523	2 Lane
2041	2241	2 Lane	2800	3 Lane	3359	3 Lane	4564	4 Lane	3995	4 Lane	4416	4 Lane	4655	4 Lane	4564	4 Lane	4360	4 Lane	2877	3 Lane	2760	3 Lane	1262	2 Lane	1554	2 Lane
2042	2286	2 Lane	2856	3 Lane	3427	3 Lane	4655	4 Lane	4074	4 Lane	4505	4 Lane	4748	4 Lane	4655	4 Lane	4448	4 Lane	2935	3 Lane	2815	3 Lane	1287	2 Lane	1585	2 Lane
2043	2331	2 Lane	2913	3 Lane	3495	3 Lane	4748	4 Lane	4156	4 Lane	4595	4 Lane	4843	5 Lane	4748	4 Lane	4537	4 Lane	2993	3 Lane	2872	3 Lane	1313	2 Lane	1616	2 Lane
2044	2378	2 Lane	2972	3 Lane	3565	3 Lane	4843	5 Lane	4239	4 Lane	4686	4 Lane	4940	5 Lane	4843	5 Lane	4627	4 Lane	3053	3 Lane	2929	3 Lane	1339	2 Lane	1649	2 Lane

Table 5-27: Lane Capacity – South Bound Carriageway

5.2.9 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.

5.2.9.1 Proposed Interchange Locations

The proposed Interchanges Locations for coastal road are listed below:

- Jagannath Bhosle Marg
- Exit on Marine Drive
- 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
- Kandivali Interchange

Figure 5-17: Proposed Interchange Locations

5.2.9.2 Directional Traffic Volumes

Directional traffic for proposed interchanges are given below:

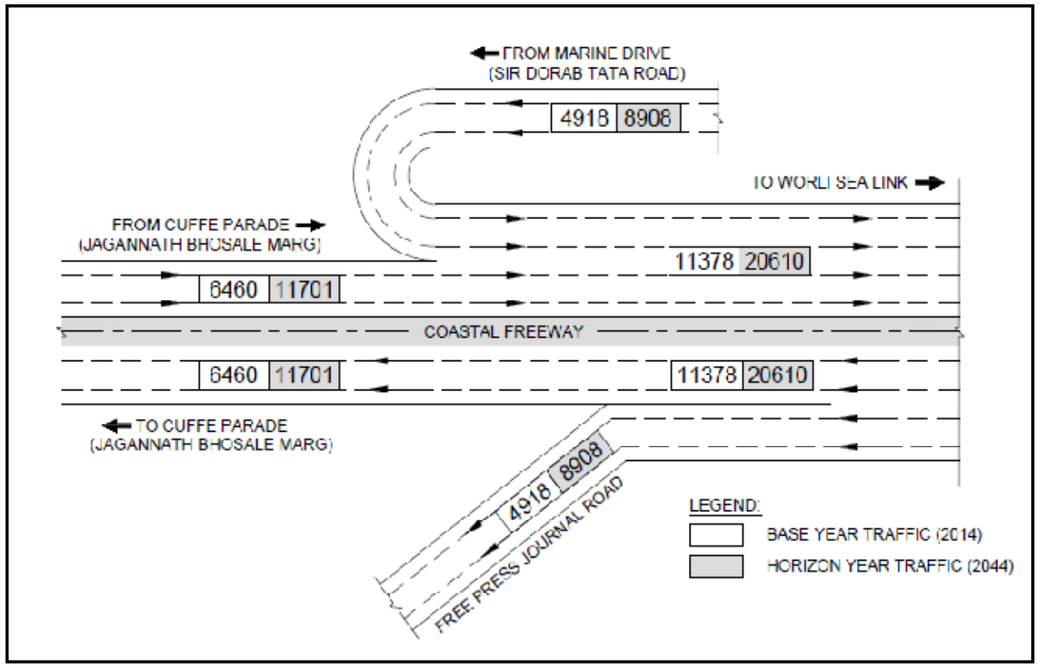


Figure 5-18: Jagannath Bhosale Marg Interchange (AADT in PCU's)

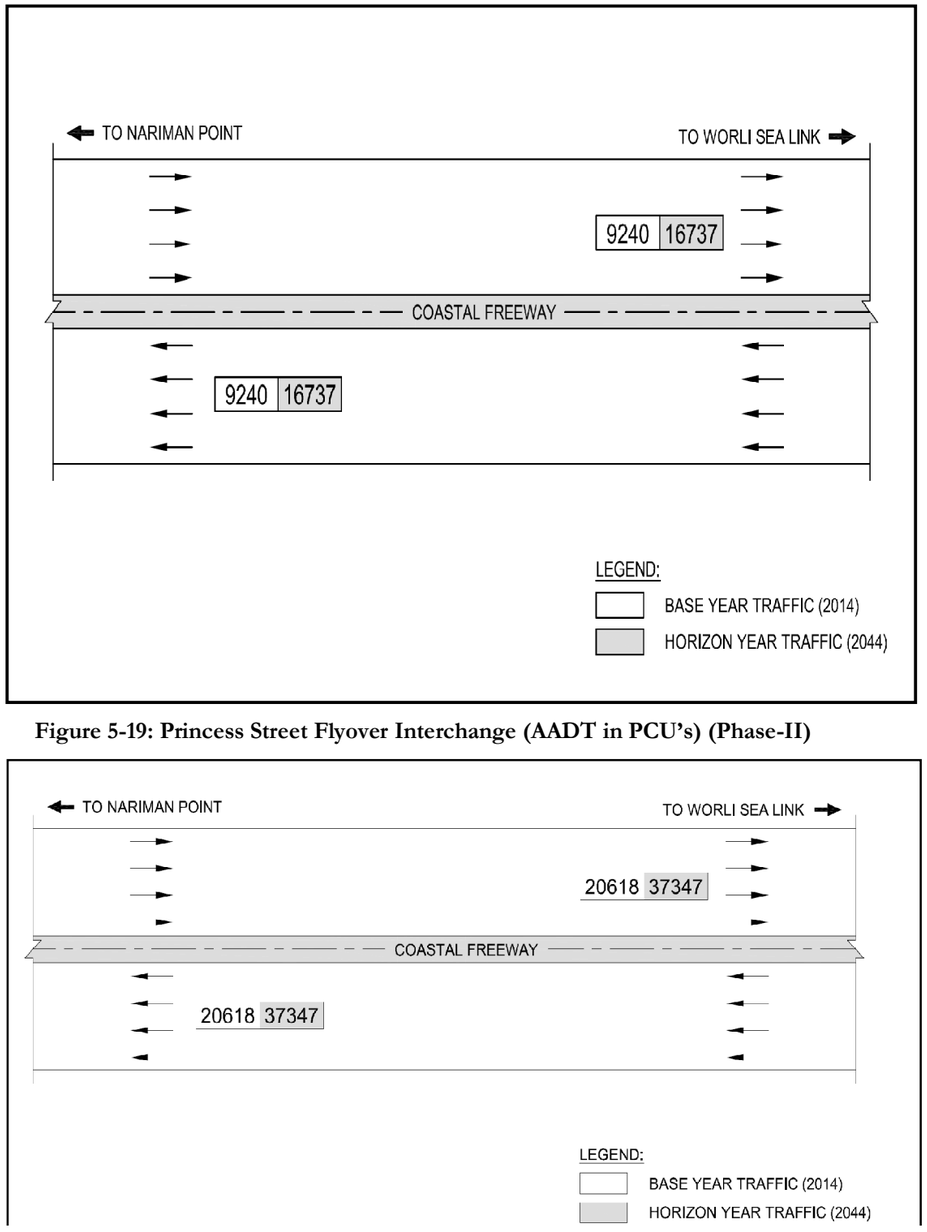


Figure 5-19: Princess Street Flyover Interchange (AADT in PCU's) (Phase-II)

Figure 5-20: Princess Street Flyover Interchange (AADT in PCU's) (Phase-I)

Note: If Phase-II does not occur, Capacity at Princess Street flyover will reach 5% growth rate by 2022 (Fig 5-20).

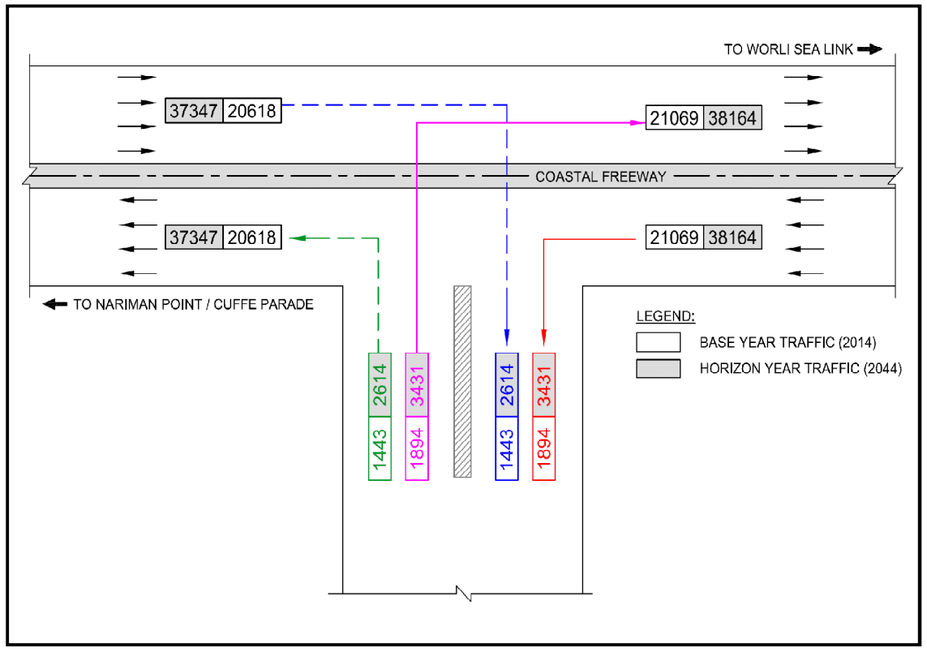


Figure 5-21: Amarsons Garden Interchange (AADT in PCU's) (Phase-II)

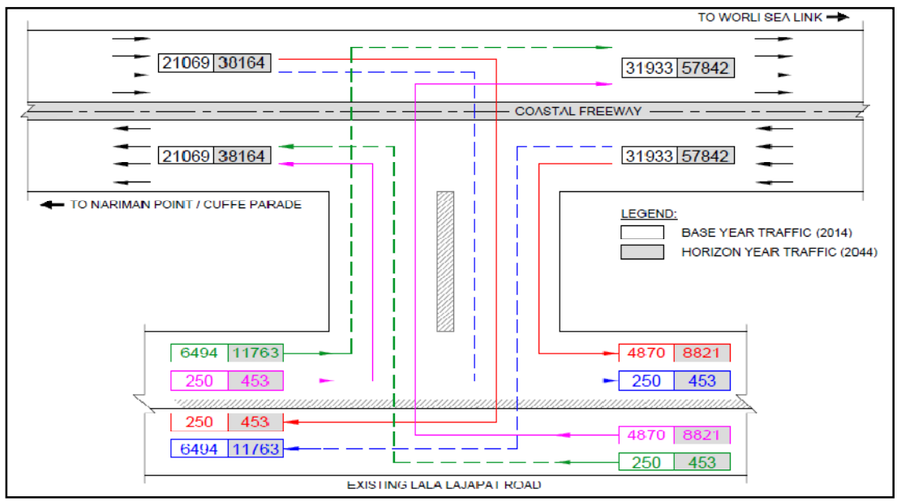


Figure 5-22: Haji Ali Interchange (AADT in PCU's)

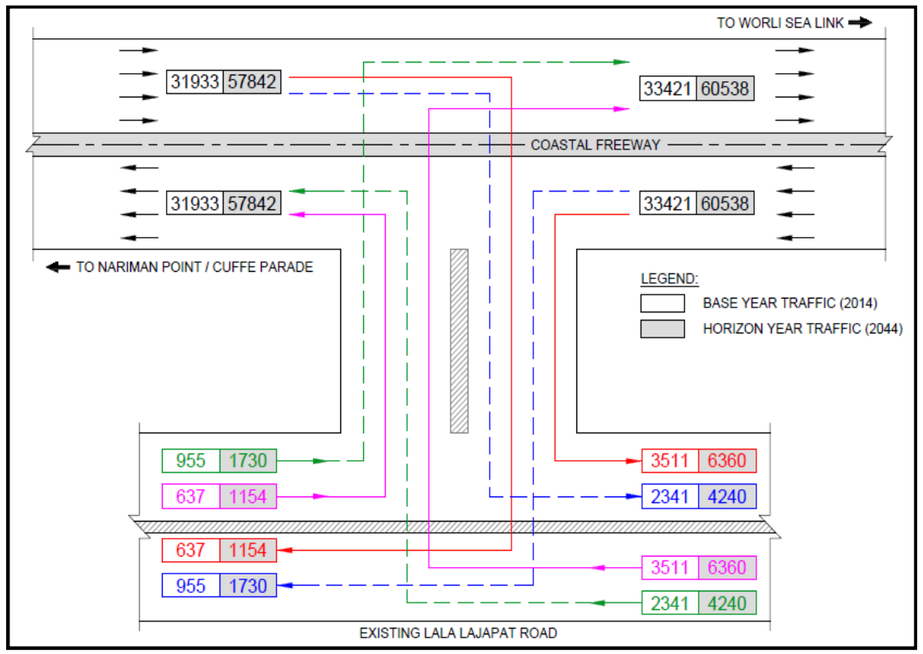


Figure 5-23: Bandra Worli Sea Link Interchange (Worli) (AADT in PCU's)

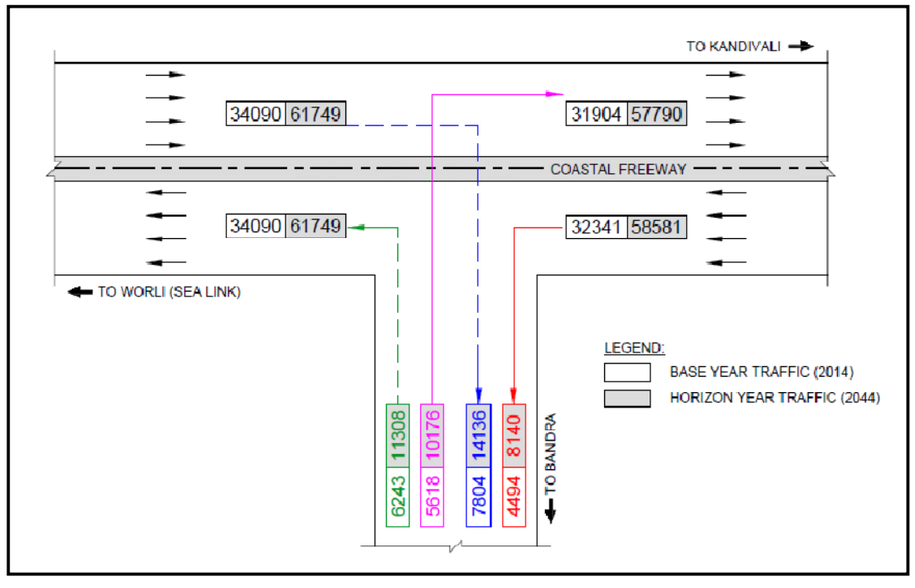


Figure 5-24: Bandra Worli Sea Link Interchange (Bandra) (AADT in PCU's)

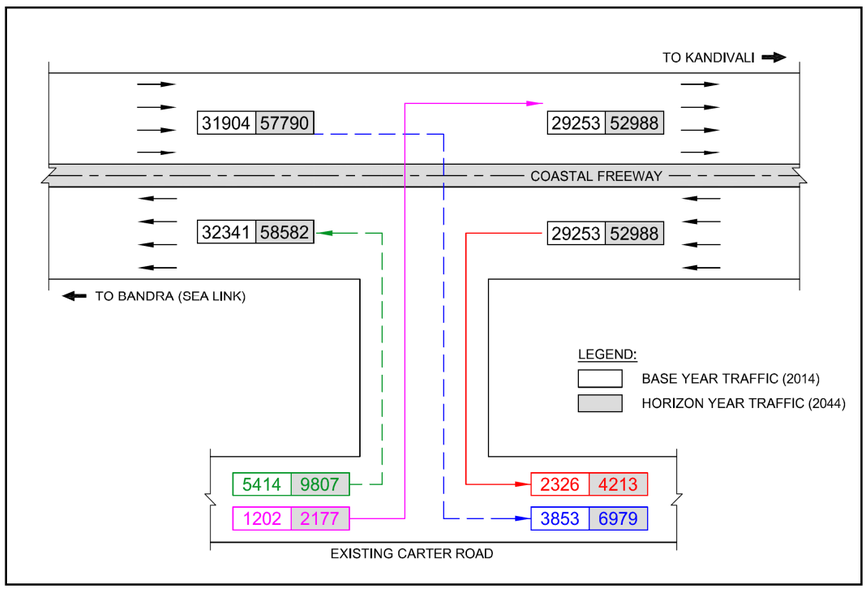


Figure 5-25: Carter Road Interchange (Danda Village) (AADT in PCU's)

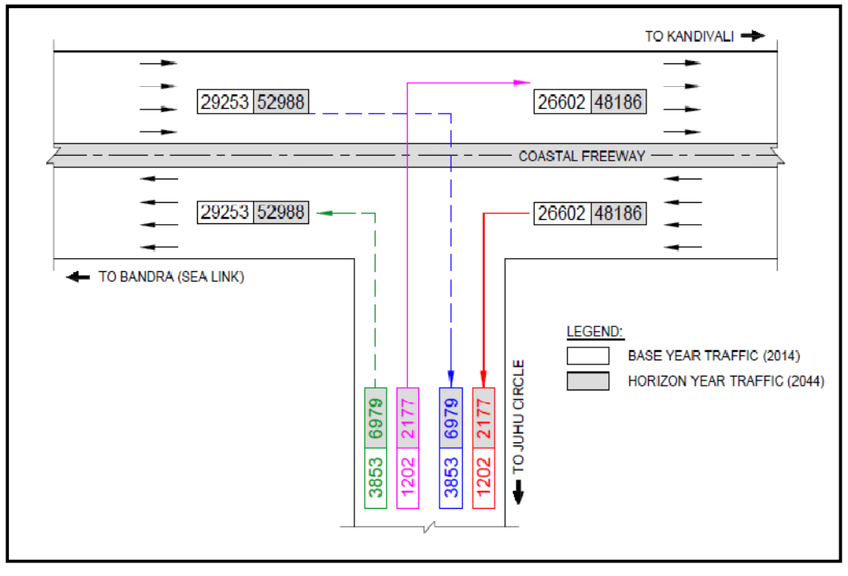


Figure 5-26: Ritumbhara College Interchange (AADT in PCU's)

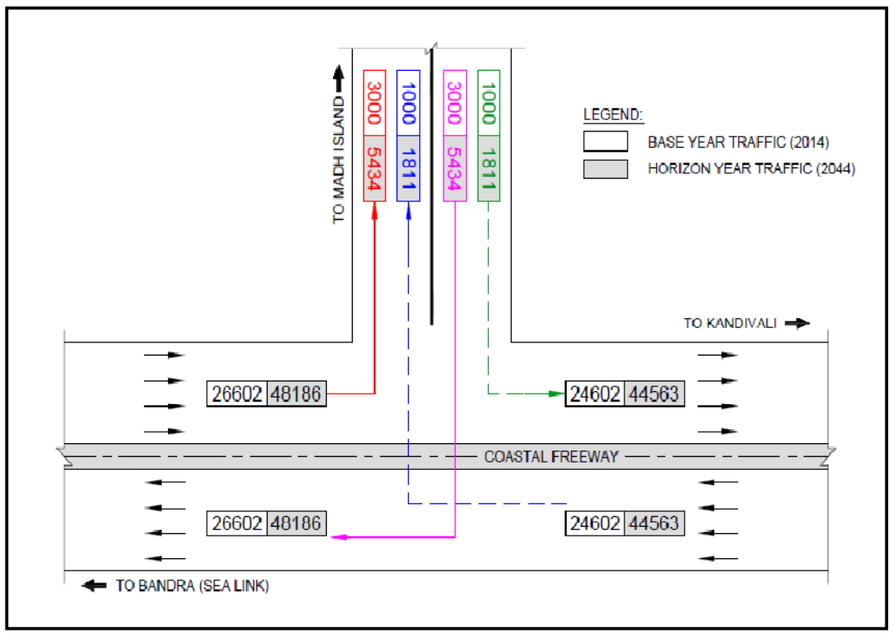


Figure 5-27: MADH island Interchange (Institute of Fisheries Education) (AADT in PCU's)

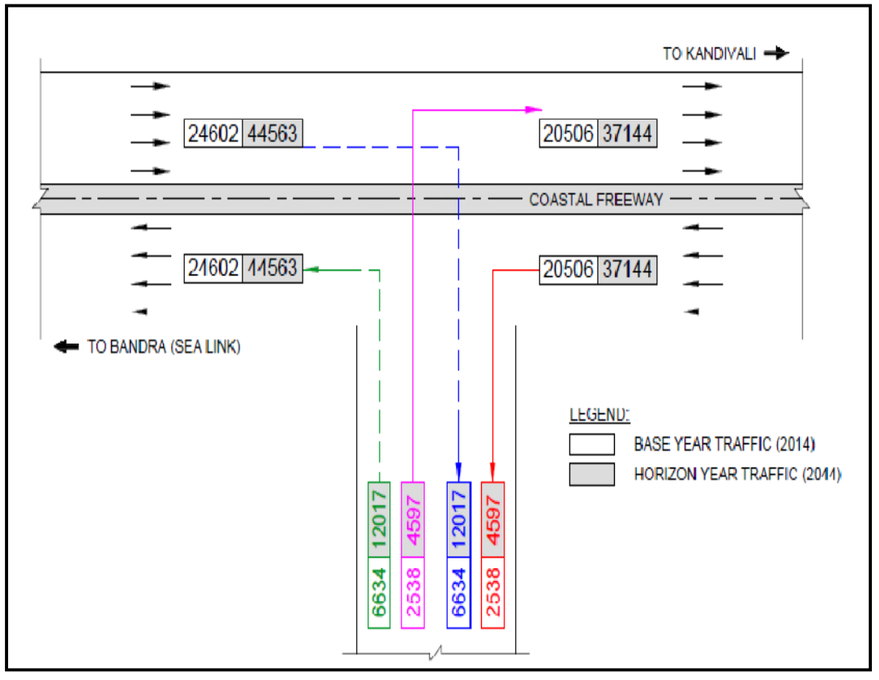


Figure 5-28: Oshiwara Interchange (AADT in PCU's)

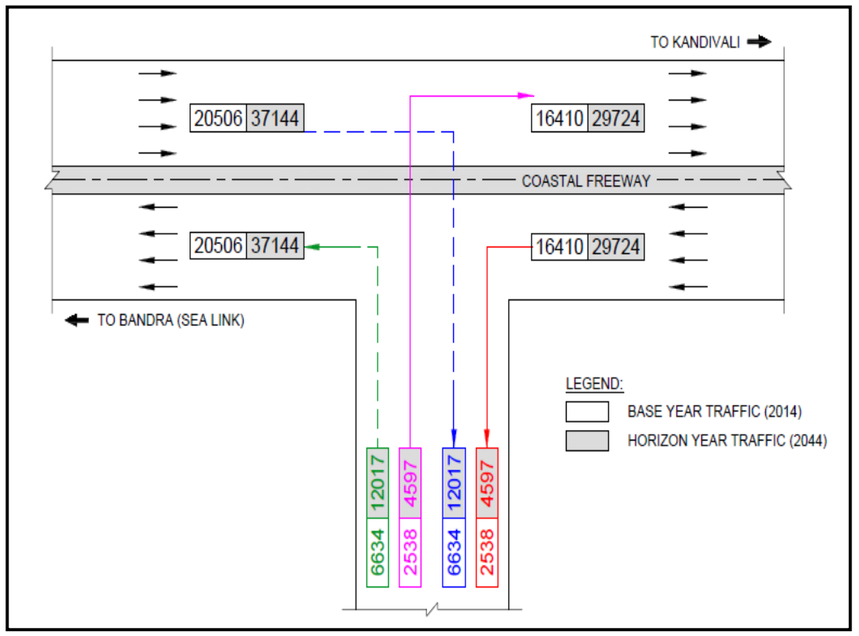


Figure 5-29: Malad Interchange (AADT in PCU's)

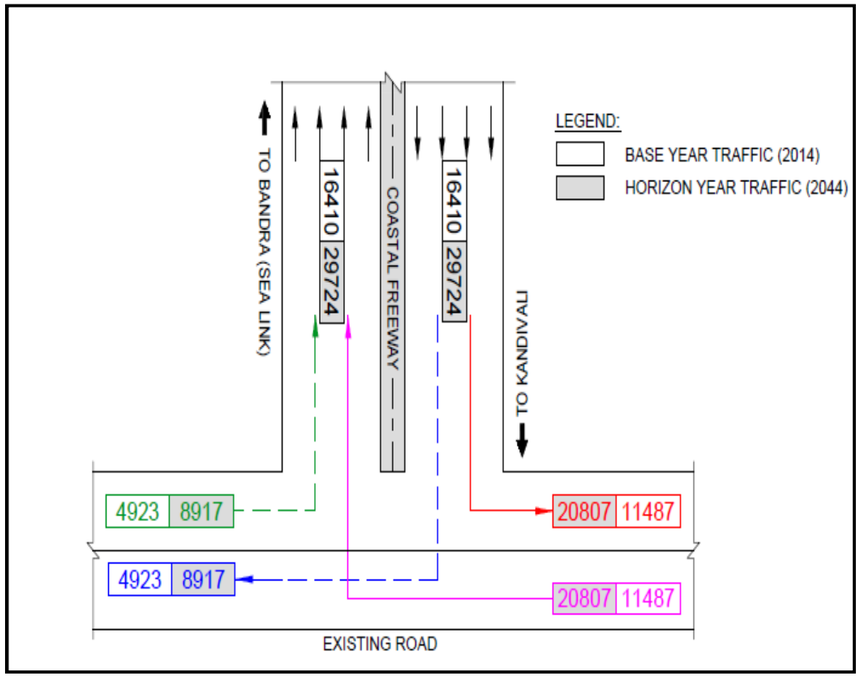


Figure 5-30: Kandivali Interchange (AADT in PCU's)

Table 5-28: Peak Hour Link Traffic/Hr/Lane (Towards South)

Link	2014	2019	2024	2029	2034	2039	2044
11-10	1313	1449	1600	1767	1951	2154	2378
10-9	1640	1811	2000	2208	2438	2691	2972
9-8	1968	2173	2399	2649	2925	3229	3565
8-7	2674	2952	3259	3598	3973	4386	4843
7-6	2340	2584	2853	3150	3477	3839	4239
6 - 5	2587	2857	3154	3482	3845	4245	4686
5 - C	2727	3011	3324	3670	4052	4474	4940
C - 4	2674	2952	3259	3598	3973	4386	4843
4 - 3	2555	2821	3114	3438	3796	4191	4627
3 - 2	1686	1861	2055	2268	2505	2765	3053
2 - B	1649	1785	1971	2176	2403	2653	2929
B - A	739	816	901	995	1098	1213	1339
B -1	910	1005	1110	1225	1353	1493	1649

Table 5-29: Peak Hour Link Traffic/Hr/Lane (Towards North)

Link	2014	2019	2024	2029	2034	2039	2044
1 - B	910	1005	1110	1225	1353	1493	1649
A - B	739	816	901	995	1098	1213	1339
B - 2	1649	1821	2011	2220	2451	2706	2988
2 - 3	1686	1861	2055	2268	2505	2765	3053
3 - 4	2555	2821	3114	3438	3796	4191	4627
4 - C	2674	2952	3259	3598	3973	4386	4843
C -5	2727	3011	3324	3670	4052	4474	4940
5 - 6	2552	2818	3111	3435	3793	4187	4623
6 - 7	2340	2584	2853	3150	3477	3839	4239
7 - 8	2128	2350	2594	2864	3162	3491	3855
8 - 9	1968	2173	2399	2649	2925	3229	3565
9 - 10	1640	1811	2000	2208	2438	2691	2972
10 -11	1313	1449	1600	1767	1951	2154	2378

The projected link traffic is shown in Appendix.

5.3 Traffic Dispersal Scheme of Existing Network

Traffic diversions calculated in the report are based on minimum improvement to the current roads through which traffic dispersal is likely to take place. However, some improvement will be necessary to cater for changes to the traffic flow directions. Existing road network influenced by the proposed road at each interchange is described in subsequent paragraphs along with proposed improvements.

5.3.1 Amarson Garden

The proposed interchange connects exiting road at Amarson Garden to proposed alignment. This trumped interchange will connect the traffic on Bhulabhai 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 Bhulabhai Desai Road. This interchange has 4 free flow movement of traffic between existing road and proposed costal road without any traffic conflict. Figure 5-31 shows the connectivity and traffic movement between existing road and proposed road networks. Figure 5-32 shows the traffic dispersal scheme for the interchange.

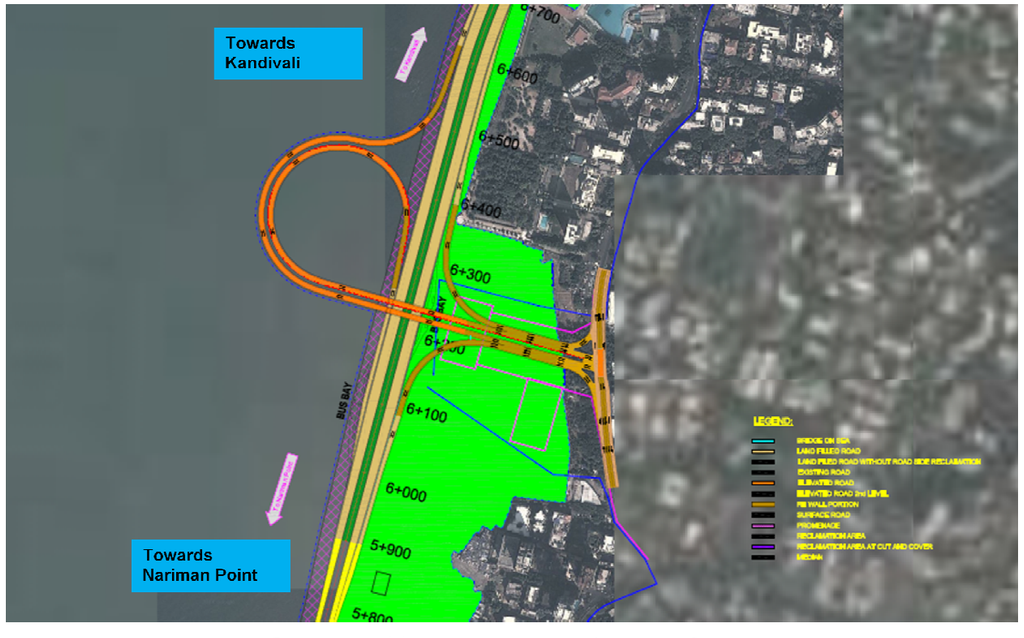


Figure 5-31: Directional Traffic Movement –Amarson Garden Interchange

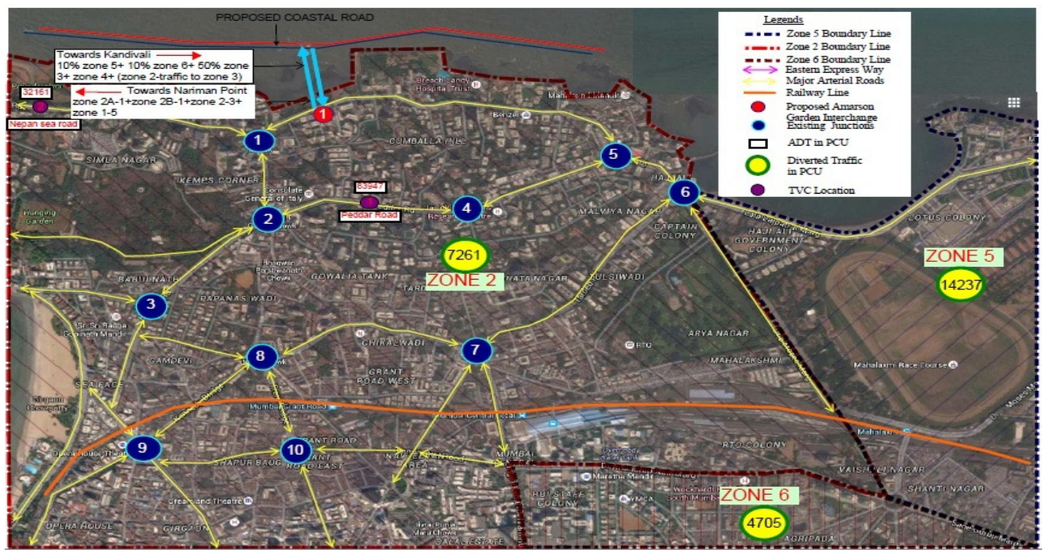


Figure 5-32: Traffic Dispersal Scheme – Amarson Garden Interchange

Proposed network development scheme for the catchment of Amarson Garden Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5-33. Summary of the development scheme is appended in Table 5-30.

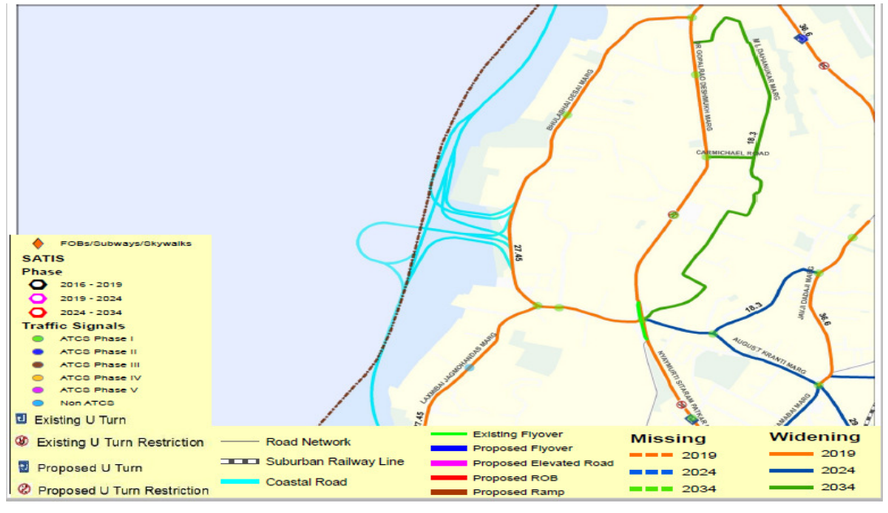


Figure 5-33 : Network Development Scheme – Amarson Garden Interchange

Table 5-30: Summary of Network Development Scheme

Name of Interchange		Amarson Garden Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Bhulabhai Desai Marg	27.45m
	Laxmibai Jagmohandas Marg	27.45m
	August Kranti Marg	27.45m
	Javji Dadaji Marg	36.6m
2024 Widening Scheme		
2	August Kranti Marg Extension	18.30m
2034 Widening Scheme		
3	M L Dhanukar Marg	18.30m

- **Junction Development Scheme-**

Junctions need to be developed are:

Mukesh Chowk (Bhulabhai Desai Marg –Neapean Sea Road – August Kranti Marg)

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Bhulabhai Desai Marg	Arterial Road	14m	4 lane divided	1054	3600	0.29	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1054	3600	0.29	B - Above Average	-
Neapean Sea Road	Arterial Road	14m	4 lane divided	1054	3600	0.29	B - Above Average		1054	3600	0.29	B - Above Average	-
August Kranti Marg	Arterial Road	14m	4 lane divided	1054	3600	0.29	B - Above Average		1054	3600	0.29	B - Above Average	-

i.

Junction Name	Mukesh Chowk (Bhulabhai Desai Marg –Neapean Sea Road – August Kranti Marg)												
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Bhulabhai Desai Marg	Arterial Road	14m	4 lane divided	1221	3600	0.34	B - Above Average	Proposes 6 lane divided road	1221	5400	0.23	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Neapean Sea Road	Arterial Road	14m	4 lane divided	1221	3600	0.34	B - Above Average		1221	5400	0.23	B - Above Average	

August Kranti Marg	Arterial Road	14m	4 lane divided	1221	3600	0.34	B - Above Average		1221	5400	0.23	B - Above Average	

Junction Name				Mukesh Chowk (Bhulabhai Desai Marg –Neapean Sea Road – August Kranti Marg)									
Road Details				**LOS (2024)**					**LOS (2034)**				
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	**Proposed development Scheme (2024)**	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	**Proposed development Scheme (2034)**
Bhulabhai Desai Marg	Arterial Road	14m	4 lane divided	1415	5400	0.26	B - Above Average	Minor improvements like installation of proper road Signages & Markings	1903	5400	0.26	B - Above Average	Minor improvements like installation of proper road Signages & Markings
Neapean Sea Road	Arterial Road	14m	4 lane divided	1415	5400	0.26	B - Above Average		1903	5400	0.26	B - Above Average	
August Kranti Marg	Arterial Road	14m	4 lane divided	1415	5400	0.26	B - Above Average		1903	5400	0.26	B - Above Average	

Junction Name					Mukesh Chowk (Bhulabhai Desai Marg –Neapean Sea Road – August Kranti Marg)					
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Bhulabhai Desai Marg	2557	5400	0.47	C - Average	Proposes 8 lane divided road	2557	7200	0.36	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Neapean Sea Road	2557	5400	0.47	C - Average	Proposes 8 lane divided road	2557	7200	0.36	B - Above Average	
August Kranti Marg	2557	5400	0.471	C - Average	Proposes 8 lane divided road	2557	7200	0.36	B - Above Average	

ii.

- **Adeshir B Godrej Chowk**

Junction Name	Adeshir B Godrej Chowk												
Road Details				**LOS (2024)**				**Proposed development Scheme (2024)**	**LOS (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
August Kranti Marg	Arterial Road	14m	4 lane divided	1221	5400	0.23	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1903	5400	0.35	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).
Peddar Road	Arterial Road	15m	4 lane divided	1221	5400	0.23	B - Above Average		1903	5400	0.35	B - Above Average	
Ridges Road (Service Road)	Arterial Road	7m	two lane	1221	3600	0.34	B - Above Average		1903	3600	0.53	C - Average	

Junction Name	Adeshir B Godrej Chowk								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
August Kranti Marg	2557	5400	0.47	C - Average	Proposes 8 lane divided road	2557	7200	0.36	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Peddar Road	2557	5400	0.47	C - Average	Proposes 8 lane divided road	2557	7200	0.36	B - Above Average	
Ridges Road (Service Road)	2557	3600	0.71	D - Below Average	Proposes 6 lane divided road	2557	5400	0.47	B - Above Average	

- **Warden Road- Peddar Road Chowk**

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Warden Road	Arterial Road	14m	4 lane divided	204	3600	0.06	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	204	3600	0.06	A - Excellent	-
Peddar Road	Arterial Road	15m	4 lane divided	204	3600	0.06	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	204	3600	0.06	A - Excellent	-

Junction Name	**Warden Road- Peddar Road Chowk**												
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Warden Road	Arterial Road	14m	4 lane divided	236	3600	0.07	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	236	3600	0.07	A - Excellent	-
Peddar Road	Arterial Road	15m	4 lane divided	236	3600	0.07	A - Excellent		236	3600	0.07	A - Excellent	-
Road Details				**LOS (2024)**				**Proposed development Scheme (2024)**	**LOS (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Warden Road	Arterial Road	14m	4 lane divided	274	3600	0.08	A - Excellent	.	368	3600	0.10	A - Excellent	-
Peddar Road	Arterial Road	15m	4 lane divided	274	3600	0.08	A - Excellent		368	3600	0.10	A - Excellent	

Junction Name	**Warden Road- Peddar Road Chowk**									
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Warden Road	496	3600	0.14	A - Excellent	No improvement necessary	-	-	-	-	-
Peddar Road	496	3600	0.14	A - Excellent	No improvement necessary	-	-	-	-	

5.3.2 Haji Ali Chowk

This Junction is most important interchange to provide connection for religious place and business area. Interchange connects to existing Lala Lajpatrai Marg. 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, Tardeo, Tulsiwadi, Agripada, Mahalaxmi Race Course, Peddar Road, Pandit Madan Mohan Malviya Marg and Clarke Road area. This interchange has 7 free flow movement of traffic between existing road and proposed costal road without any traffic conflict. Figure 5-34 shows the connectivity and directional traffic movement between existing and proposed roads network. Figure 5-35 shows the traffic dispersal road network diagram.

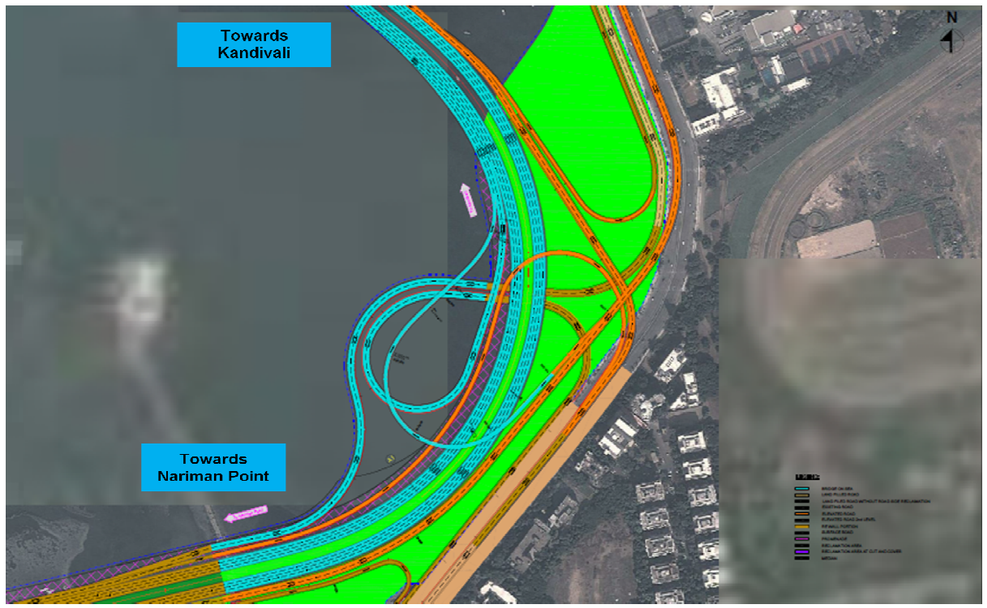


Figure 5-34: Directional Traffic Movement – Haji Ali Interchange

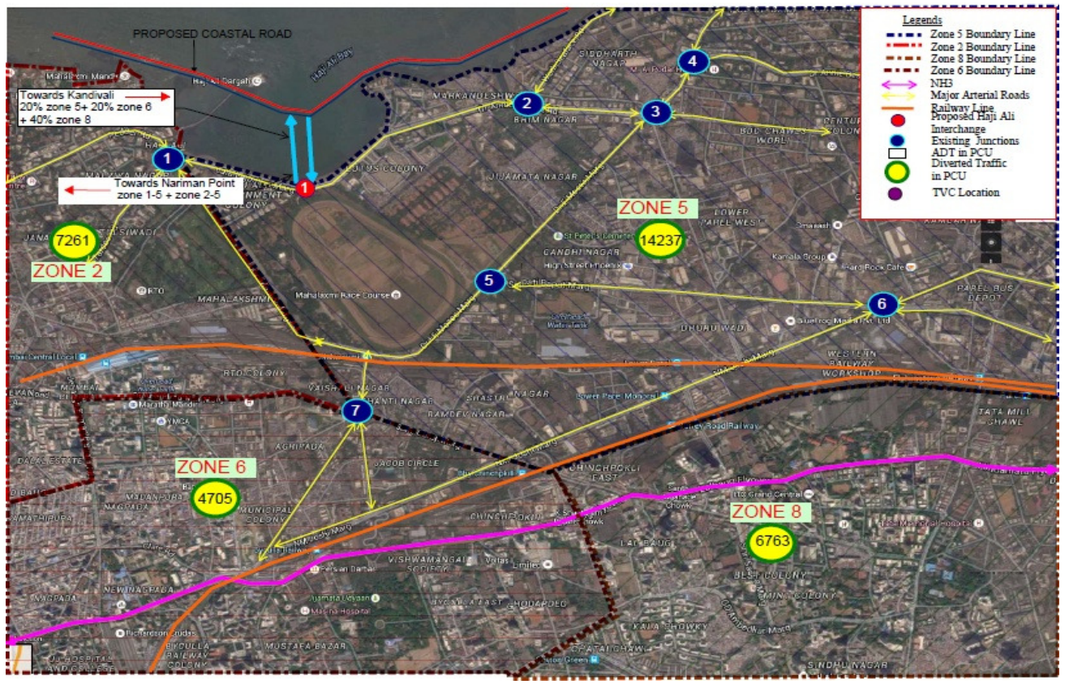


Figure 5-35: Traffic Dispersal Scheme – Haji Ali Chowk

Proposed network development scheme for the catchment of Haji Ali Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5-36. Network development scheme summary is presented in Table 5 31.

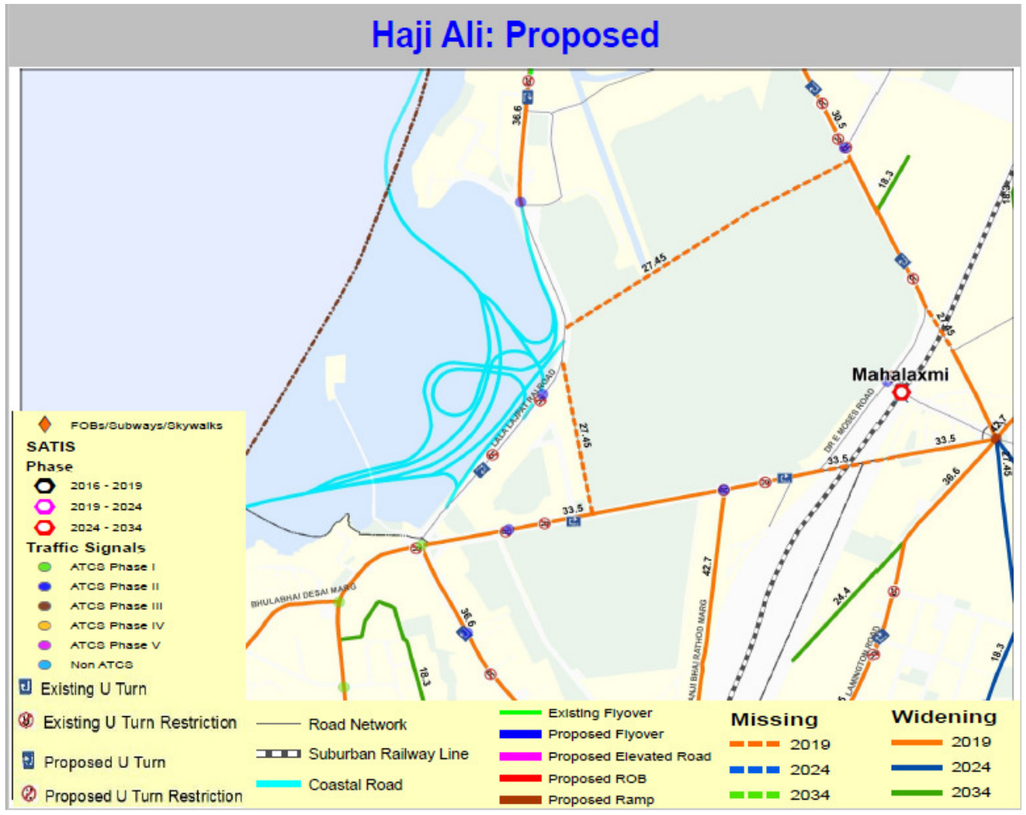


Figure 5-36 : Network Development Scheme – Haji Ali Chowk

Table 5-31: summary of Network Development Scheme

Name of Interchange		Haji Ali Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Tardeo Road	36.6m
	Dr E Moses Marg	33.5m
	Samanth Bhai Rathod Marg	42.7m
	Lala Lajpatrai Marg	36.6m
	Sane Guruji Marg	36.6m
	Sakpal Marg -Dr E Moses Marg	27.45m
	Sane Guruji Marg	42.7m
	Dr East Moses Marg	30.5m
2024 Widening Scheme		
2	Ripon Road	18.30m
	Bapurao Jagtap Road	27.45m
2034 Widening Scheme		
3	Ghas Galli Road	24.4m
	Deshmukh Lane	18.30m
	Kishav Ravkhadhi Road	18.30m

iii. Junction Development Scheme

iv. Junctions which need to be developed are:

v. Haji Ali Chowk

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lala Lajpatrai Marg	Arterial Road	30m	6 lane divided	674	5400	0.12	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	674	5400	0.12	A - Excellent	-
Tardeo Road	Arterial Road	27m	4 lane divided	674	3600	0.19	A - Excellent		674	3600	0.19	A - Excellent	-
Dr. E Moses Road	Arterial Road	14m	4 lane divided	674	3600	0.19	A - Excellent		674	3600	0.19	A - Excellent	-
Dr. Gopalrao Deshmukh Marg	Arterial Road	24m	4 lane divided	674	3600	0.19	A - Excellent		674	3600	0.19	A - Excellent	-

Junction Name	Haji Ali Chowk												
Road Details				LOS - Existing road (2019)				Proposed development Scheme (2019)	LOS - After improvement (2019)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lala Lajpatrai Marg	Arterial Road	30m	6 lane divided	781	5400	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	781	5400	0.14	A - Excellent	-
Tardeo Road	Arterial Road	27m	4 lane divided	781	3600	0.22	B - Above Average		781	3600	0.22	B - Above Average	-
Dr. E Moses Road	Arterial Road	14m	4 lane divided	781	3600	0.22	B - Above Average		781	3600	0.22	B - Above Average	-
Dr. Gopalrao Deshmukh Marg	Arterial Road	24m	4 lane divided	781	3600	0.22	B - Above Average		781	3600	0.22	B - Above Average	-

Junction Name				Haji Ali Chowk									
Road Details				**LOS (2024)**				**Proposed development Scheme (2024)**	**LOS (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lala Lajpatrai Marg	Arterial Road	30m	6 lane divided	906	5400	0.17	A - Excellent	-	1218	5400	0.23	B - Above Average	
Tardeo Road	Arterial Road	27m	4 lane divided	906	3600	0.25	B - Above Average		1218	3600	0.34	B - Above Average	
Dr. E Moses Road	Arterial Road	14m	4 lane divided	906	3600	0.25	B - Above Average		1218	3600	0.34	B - Above Average	
Dr. Gopalrao Deshmukh Marg	Arterial Road	24m	4 lane divided	906	3600	0.25	B - Above Average		1218	3600	0.34	B - Above Average	

Road Segment	**Junction Name**				Haji Ali Chowk				
	LOS- Horizon Year (2043)				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**			**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lala Lajpatrai Marg	1637	5400	0.30	B - Above Average	8 lane divided	1637	7200	0.23	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Tardeo Road	1637	3600	0.45	C - Average	6 lane divided	1637	5400	0.30	B - Above Average	
Dr. E Moses Road	1637	3600	0.45	C - Average	6 lane divided	1637	5400	0.30	B - Above Average	
Dr. Gopalrao Deshmukh Marg	1637	3600	0.45	C - Average	6 lane divided	1637	5400	0.30	B - Above Average	

5.3.3 BWSL 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. Figure 5-37 show the connectivity and traffic movement between existing road and proposed coastal road network. Figure 5-38 shows the traffic dispersal scheme for the interchange.

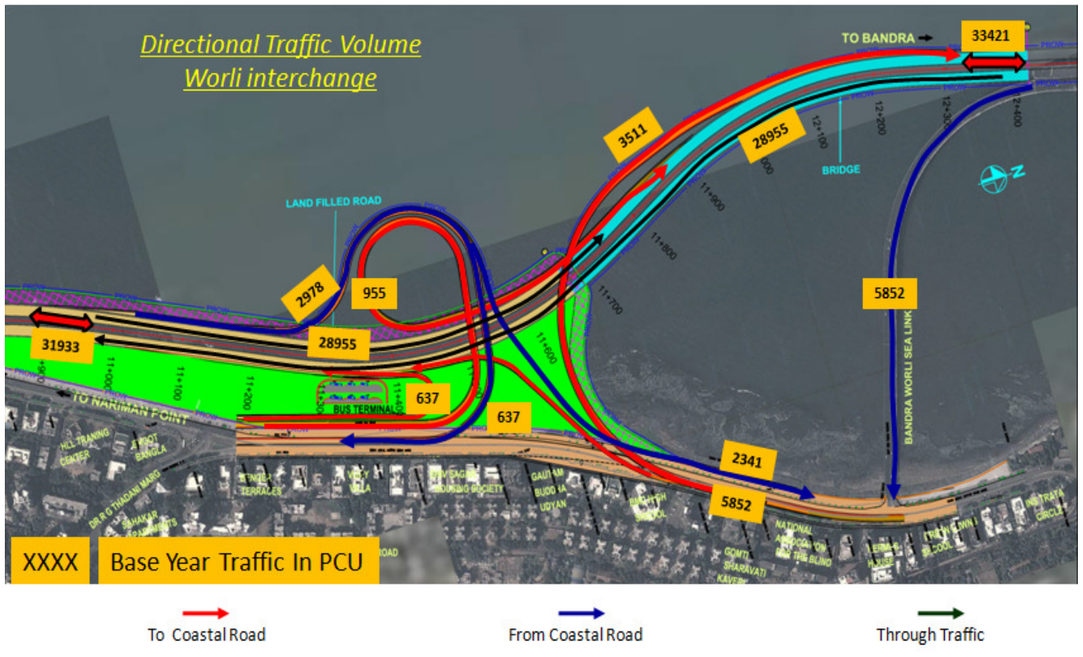


Figure 5-37: Directional Traffic Movement at Worli Interchange

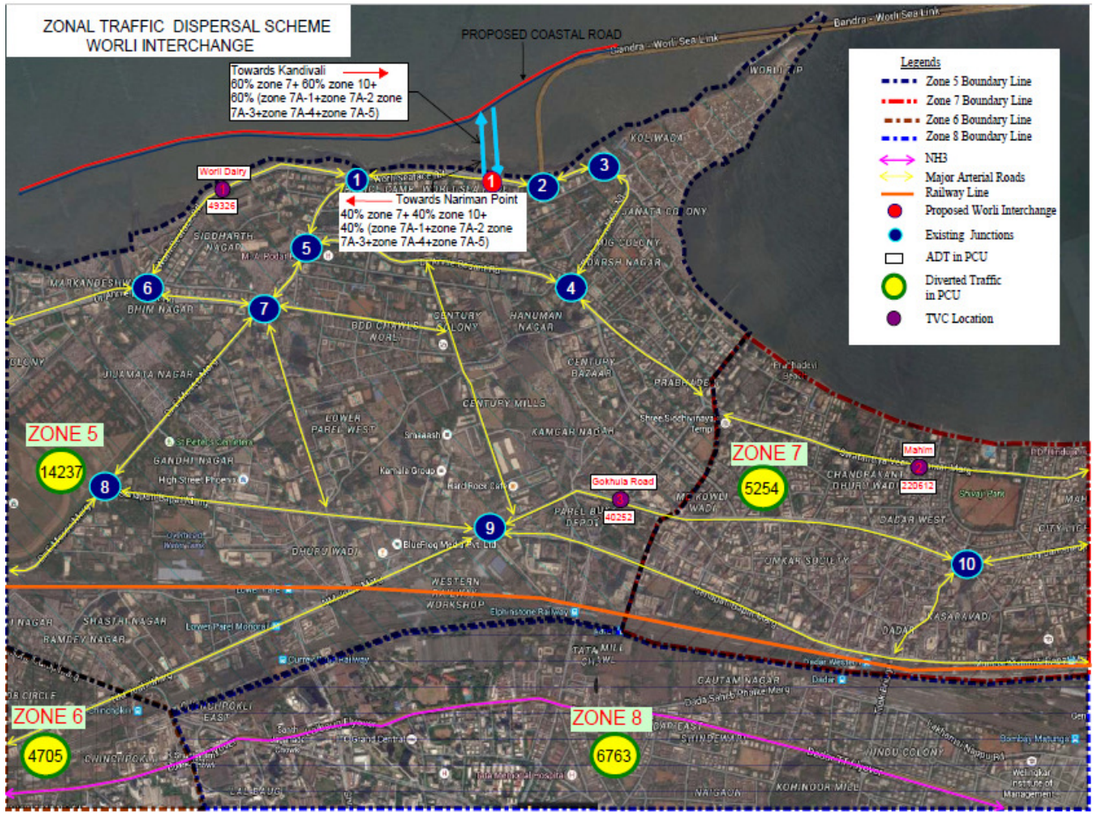


Figure 5-38: traffic Dispersal Scheme at Worli Interchange

Proposed network development scheme for the catchment of Worli Dairy Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5 39. Table 5 32 presents the summary of network development scheme.

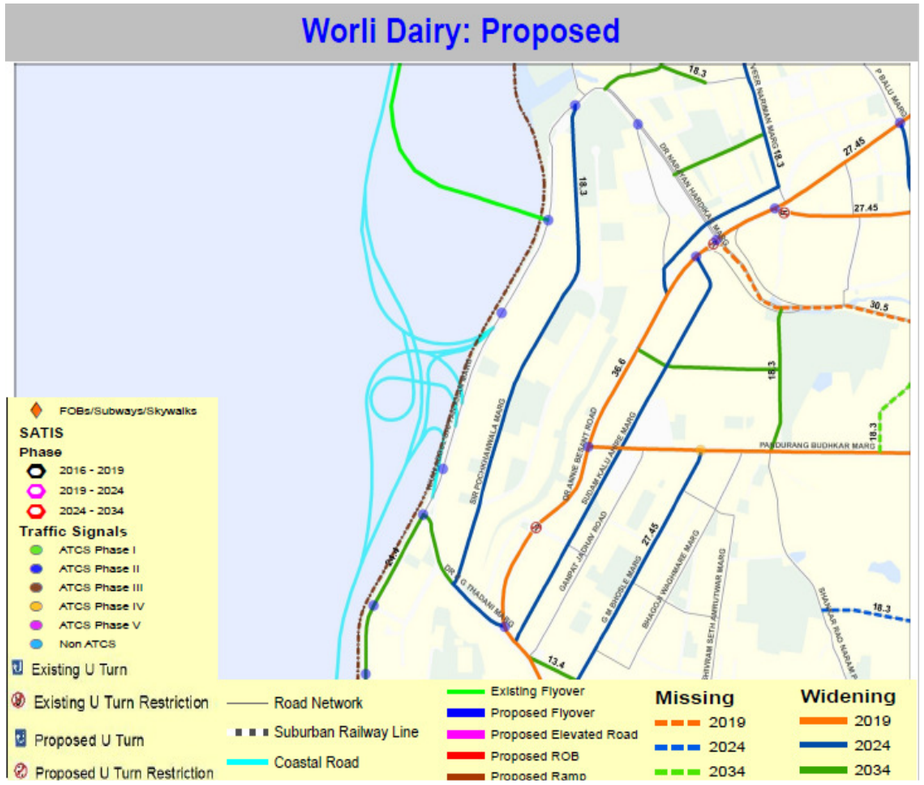


Figure 5-39 : Network Development Scheme – Worli Interchange

Table 5-32: Summary of Network Development Scheme

Name of Interchange		Worli Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Dr Annie Besant Road	36.60m
	Shankar Ghaenkar Road	27.45m
	Dr Annie Besant Road	27.45m
	Pandurang Budhkar Marg	-
2024 Widening Scheme		
2	Dr R G Thadani Marg	18.30m
	Sir Pochkhanawala Marg	18.30m
	G M Bhosle Marg	27.45m
	Veer Nariman Marg	18.30m
2034 Widening Scheme		
3	Worli Seaface Road	24.4m
	Chndarkant S Rane Marg	13.4m
	Hind Cycle Marg	18.30m
	Pandurang Budhkar Marg	18.30m
	V B Worlikar Marg	18.30m

Junction Development Scheme

vi. Junctions which need to be developed are:

vii. Worli Sea face road-Dr RG Tadani Marg junction

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Worli Sea face Road	Arterial Road	22m	6 lane divided	159	5400	0.03	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	159	5400	0.03	A - Excellent	-
Dr. R G Thadani Road	Arterial Road	17m	4 lane divided	159	3600	0.04	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	159	3600	0.04	A - Excellent	-

Junction Name	Worli Sea face road-Dr RG Tadani Marg junction												
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Worli Sea face Road	Arterial Road	22m	6 lane divided	184	5400	0.03	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	184	5400	0.03	A - Excellent	-
Dr. R G Thadani Road	Arterial Road	17m	4 lane divided	184	3600	0.05	A - Excellent		184	3600	0.05	A - Excellent	-

Road Details				**LOS (2024)**				**Proposed development Scheme (2024)**	**LOS (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Worli Sea face Road	Arterial Road	22m	6 lane divided	231	5400	0.04	A - Excellent	-	287	5400	0.04	A - Excellent	-
Dr. R G Thadani Road	Arterial Road	17m	6 lane divided	231	5400	0.05	A - Excellent	6 lane divided	287	5400	0.05	A - Excellent	

Junction Name	Worli Sea face road-Dr RG Tadani Marg junction									
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Worli Sea face Road	386	5400	0.07	A - Excellent	6 lane divided	386	5400	0.07	A - Excellent	-
Dr. R G Thadani Road	386	5400	0.07	A - Excellent	6 lane divided	386	5400	0.07	A - Excellent	-

viii. J K Kapur Chowk - Round About

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Khan Abdul Gaffar Khan Road /Worli Sea face Road	Arterial Road	24m	6 lane divided	585	5400	0.11	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	585	5400	0.11	A - Excellent	-
Sir Pochkhanawala Road	Sub Arterial Road	7m	2 lane 2 way	585	1200	0.49	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	585	1200	0.49	B - Above Average	-
Prabhadevi New Road	Arterial Road	22m	6 lane divided	585	3600	0.16	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	585	3600	0.16	A - Excellent	-

Junction Name	**J K Kapur Chowk - Round About**												
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Khan Abdul Gaffar Khan Road /Worli Sea face Road	Arterial Road	24m	6 lane divided	678	5400	0.13	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	678	5400	0.13	A - Excellent	-

Sir Pochkhanawala Road	Sub Arterial Road	7m	2 lane 2 way	678	1200	0.57	C - Average	Minor improvements like installation of road furniture's (Signages & Markings).	678	1200	0.57	C - Average	-
Prabhadevi New Road	Arterial Road	22m	6 lane divided	678	3600	0.19	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	678	3600	0.19	A - Excellent	-

Junction Name	**J K Kapur Chowk - Round About**												
Road Details				**LOS (2024)**				**Proposed Development (2024)**	**LOS (2034)**				**Proposed Development (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Khan Abdul Gaffar Khan Road /Worli Sea face Road	Arterial Road	24m	6 lane divided	786	5400	0.15	A - Excellent	-	1056	5400	0.20	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).
Sir Pochkhanawala Road	Sub Arterial Road	7m	2 lane 2 way	786	2900	0.27	B – Above Average	Proposes 4 lane divided	1056	2900	0.36	B – Above Average	
Prabhadevi New Road	Arterial Road	22m	6 lane divided	786	3600	0.22	B - Above Average	-	1056	3600	0.29	B - Above Average	

Junction Name	J K Kapur Chowk - Round About								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Khan Abdul Gaffar Khan Road /Worli Sea face Road	1420	7200	0.20	A - Excellent	-	1420	7200	0.20	A - Excellent	-
Sir Pochkhanawala Road	1420	2900	0.49	C - Average	4 lane divided to 6 lane divided	1420	4300	0.33	B - Above Average	-
Prabhadevi New Road	1420	3601	0.39	B - Above Average	5 lane divided to 8 lane divided	1420	7201	0.20	A - Excellent	-

5.3.4 BWSL Toll Plaza Interchange

Interchange will connect to existing road near the Toll Plaza location of BWSL. North face of Bandra Worli Sea Link (BWSL) at Bandra will connect to proposed alignment. 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 Bandra kurla complex, Kalanagar, Bandra Terminus, Bandra East, Bandra West, Mahim and Dharavi Area. This interchange has 6 conflict free traffic movement between proposed and existing road network.

Figure **5-40** shows the connectivity and directional traffic movement between existing road and proposed coastal road network. Figure 5-41 presents the traffic dispersal scheme for BWSL Toll Plaza interchange.

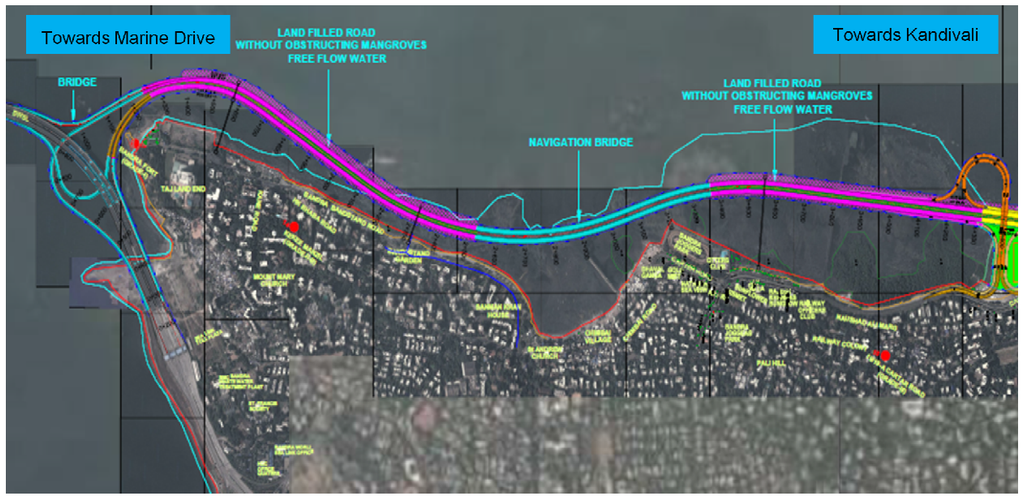


Figure 5-40: Directional Traffic Movement at BWSL Toll Plaza Interchange

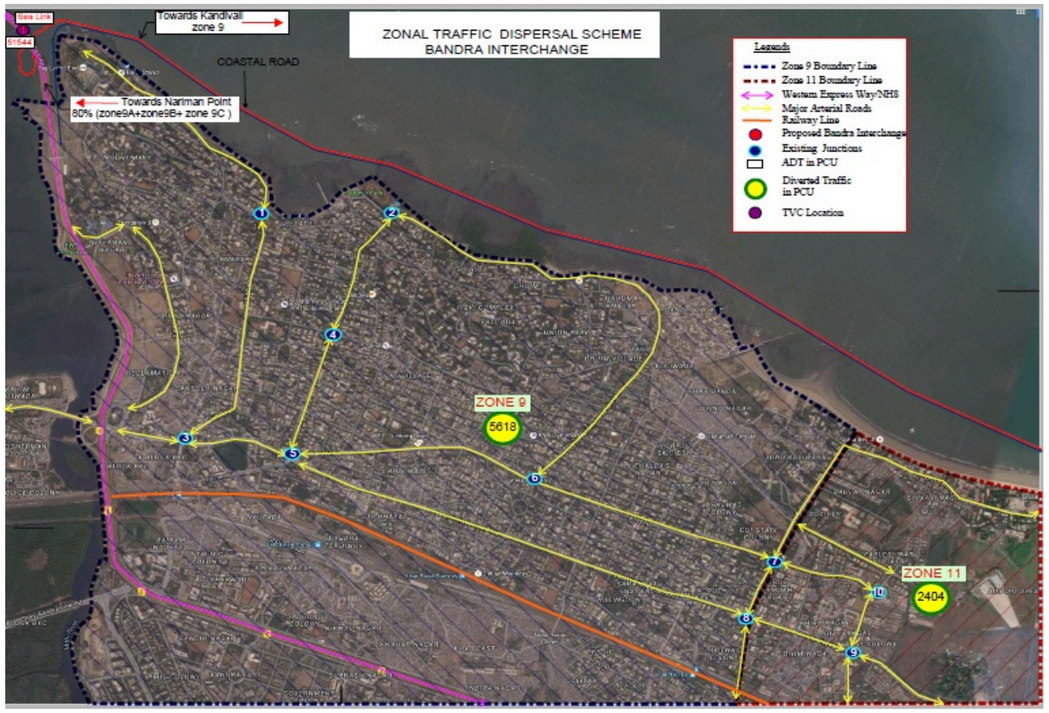


Figure 5-41: Traffic Dispersal Scheme – BWSL Toll Plaza Interchange

Table 5 33 presents the summary of network development scheme.

Table 5-33: Summary of Network Development Scheme

Name of Interchange		BWSL Toll Plaza Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Mori Road	18.30m
	Swatantrya Veer Savarkar Marg	27.45m
	Swami Vivekananda Road	30.5m
2024 Widening Scheme		
2	Raheja Hospital Marg	27.45m
2034 Widening Scheme		
3	Byramji Jeejeebhoy Road	18.30m
	Kane Road	18.30m
	Krishna Chandra Road	27.45m
	T M Mandi Road	18.30m
	Byramji Jeejeebhoy Road	18.30m

Junction Development Scheme

ix. Junctions which need to be developed are:

x. Mohammad Rafi Chowk

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Western Expressway	Arterial Road	22m	8 lane divided	1230	7200	0.17	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	1230	7200	0.17	A - Excellent	-
S V Road	Arterial Road	20m	6 lane divided	1230	5400	0.23	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1230	5400	0.23	B - Above Average	-

•

Junction Name	**Mohammad Rafi Chowk**												
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Western Expressway	Arterial Road	22m	8 lane divided	1425	7200	0.20	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1425	7200	0.20	B - Above Average	-
S V Road	Arterial Road	20m	6 lane divided	145	5400	0.26	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	145	5400	0.26	B - Above Average	-

•

Junction Name	**Mohammad Rafi Chowk**												
Road Details				**LOS (2024)**				**Proposed Development (2024)**	**LOS (2034)**				**Proposed Development (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Western Expressway	Arterial Road	22m	8 lane divided	1652	7200	0.23	B - Above	Minor improvements like	2221	5400	0.20	A - Excellent	Minor improvements like installation of

							Average	installation of road furniture's (Signages & Markings).					road furniture's (Signages & Markings).
S V Road	Arterial Road	20m	6 lane divided	1652	5400	0.31	B - Above Average		2221	5400	0.41	C - Average	

Junction Name					M M ohammad Rafi Chowk				
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**			**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Western Expressway	2813	7200	0.39	B - Above Average	8 lane divided	2813	7200	0.39	B - Above Average	-
S V Road	2813	5400	0.52	C - Average	6 lane divided to 8 lane divided	2813	7200	0.39	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

5.3.5 Carter Road

This interchange connects to existing Dattaram Lad Path near CCD corner. This provides connectivity to Khar east & west, Juhu, Santacruz east & west area. This interchange has 4 conflict free traffic movement between existing and proposed road. It collects traffic from Bandra west, Palli Village and ONGC Colony. Figure 5-42 shows the connectivity and directional traffic movement between existing road and proposed coastal road network. Figure 5 44 presents the traffic dispersal scheme for the interchange.

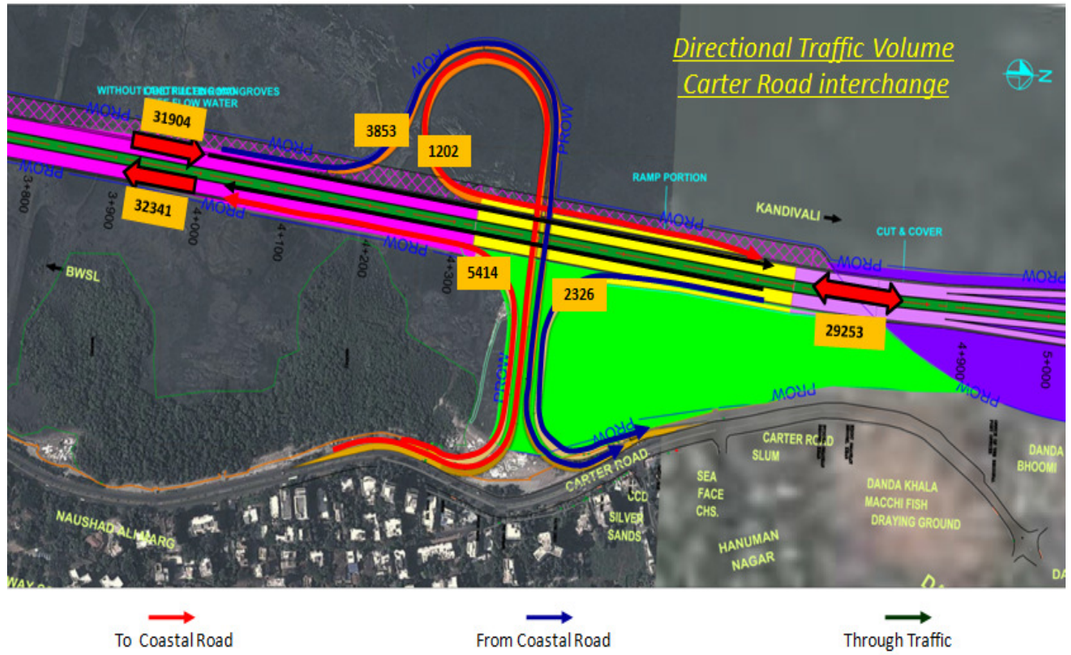


Figure 5-42: Directional Traffic Movement –Carter Road Interchange

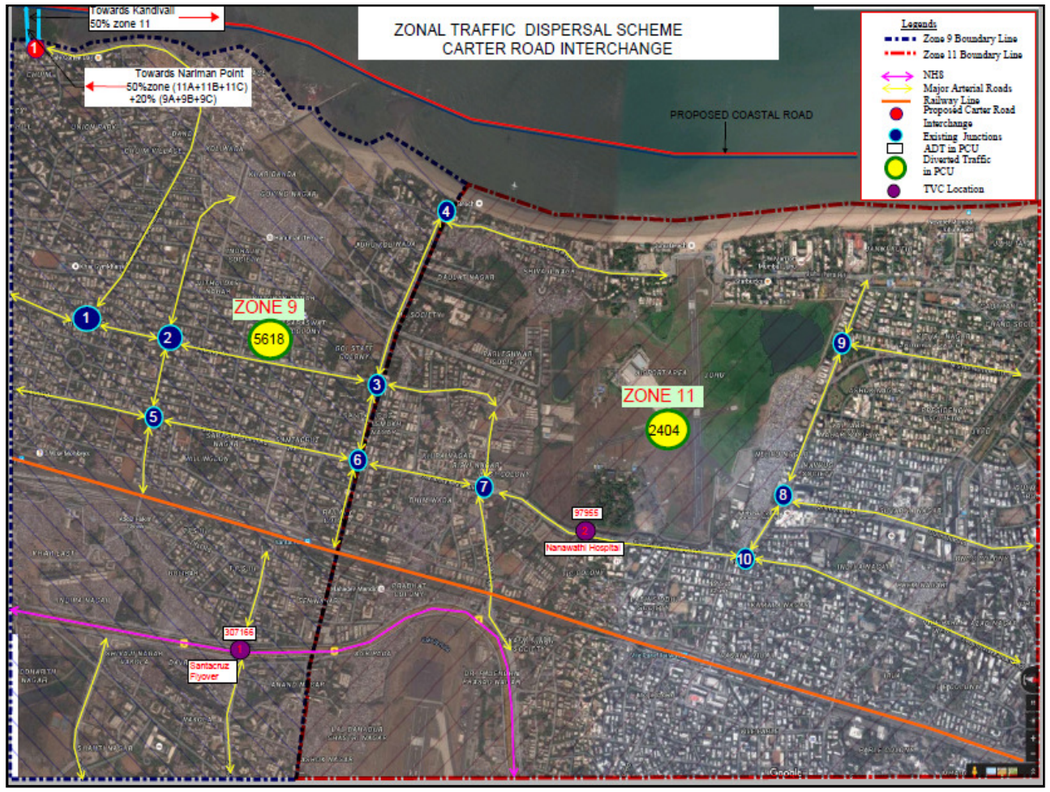


Figure 5-43: Traffic Dispersal Scheme – Carter Road Interchange

Proposed network development scheme for the catchment of Carter Road Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5 45. Summary of development scheme is appended in Table 5 34

.

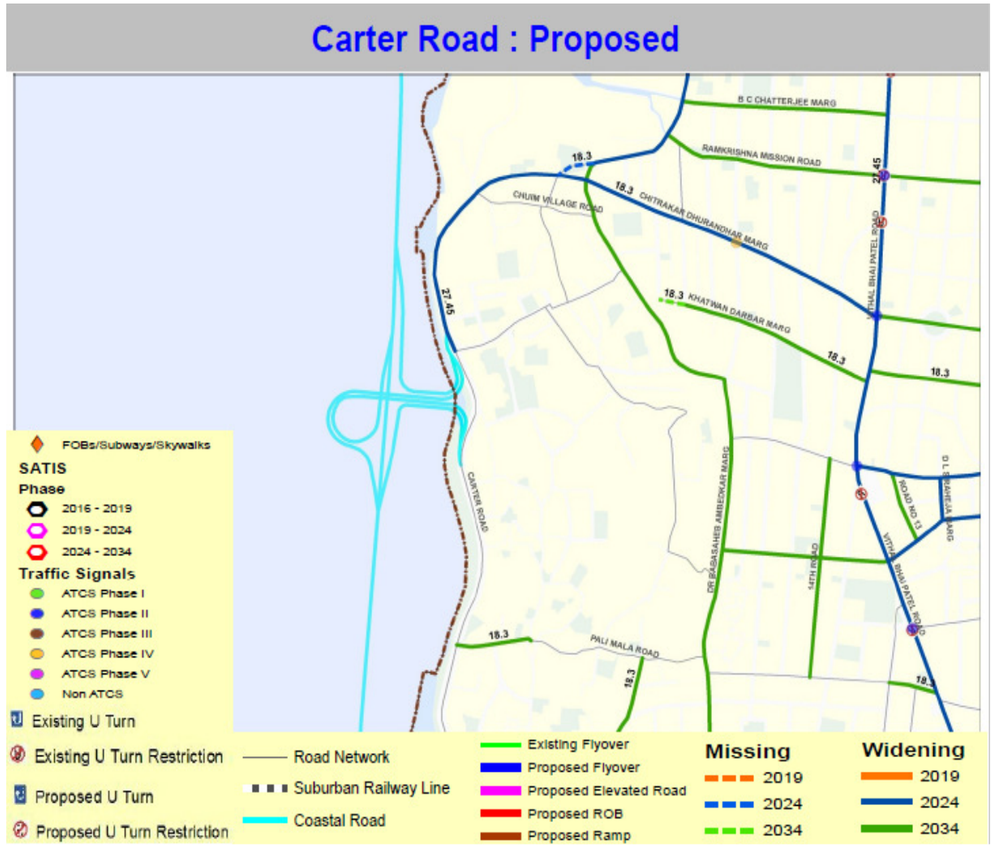


Figure 5-44: Network Development Scheme –Carter Road Interchange

Table 5-34: Summary of Network Development Scheme

	Name of Interchange	Carter Road Interchange
Sl No.	Name of Road	Proposed Road Width
2024 Widening Scheme		
1	Dattaram Lad Path Marg	27.45m
	Chitrakar Dhurandhar Marg	18.30m
	Vithal Bhai Patel Road	27.45
	S B Patil Road	18.30m
2034 Widening Scheme		
3	Pali Mala Road	18.30m
	Dr Babasheb Ambedkar Marg	18.30m
	St . Andrews Road	18.30m
	Khatwan Darbar Marg	18.30m
	7th Road	18.30m

Junction Development Scheme

xi. Junction which need to be developed :

xii. Linking Road- Chitrakar Durandhar Road Junction

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	Arterial Road	18m	4 lane divided	618	3600	0.17	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	618	3600	0.17	A - Excellent	-
Chitrakar Dhurandar Road	Arterial Road	12m	2 lane undivided	618	1500	0.41	C - Average	4 lane undivided	618	3000	0.2	A - Excellent	Need site visit to check the availability of land nearby

Junction Name				Linking Road- Chitrakar Dhurandar Road Junction									
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	Arterial Road	18m	4 lane divided	716	3600	0.20	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	716	3600	0.20	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).
Chitrakar Dhurandar Road	Arterial Road	12m	2 lane undivided	716	1500	0.48	C - Average		716	1500	0.48	C - Average	

Junction Name				Linking Road- Chitrakar Dhurandar Road Junction									
Road Details				**LOS - (2024)**				**Proposed development Scheme (2024)**	**LOS - (2034)**				**Proposed development Scheme (2034**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	Arterial Road	18m	4 lane divided	830	3600	0.23	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1150	3600	0.32	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).
Chitrakar Dhurandar Road	Arterial Road	12m	2 lane undivided	830	3600	0.23	B - Above Average	4 lane divided road	1150	3600	0.32	B - Above Average	

Junction Name	L Linking Road- Chitrakar Dhurandar Road Junction								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	1499	5400	0.28	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1499	5400	0.28	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Chitrakar Dhurandar Road	1499	3600	0.42	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1499	3600	0.42	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

xiii. Linking Road- Juhu Road Junction (Arya Samaj Chowk)

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	Arterial Road	18m	4 lane divided	618	3600	0.17	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	618	3600	0.17	A - Excellent	-
Juhu Road	Arterial Road	14m	4 lane divided	618	3600	0.17	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	618	3600	0.17	A - Excellent	-

Junction Name	xiv. Linking Road- Juhu Road Junction (Arya Samaj Chowk)												
Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	Arterial Road	18m	4 lane divided	716	3600	0.20	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	716	3600	0.20	A - Excellent	-
Juhu Road	Arterial Road	14m	4 lane divided	716	3600	0.20	A - Excellent		716	3600	0.20	A - Excellent	-

Junction Name	xv. Linking Road- Juhu Road Junction (Arya Samaj Chowk)												
Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	Arterial Road	18m	4 lane divided	830	5400	0.15	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	1115	5400	0.21	B - Above Average	-
Juhu Road	Arterial Road	14m	4 lane divided	830	3600	0.23	B - Above Average		1115	3600	0.31	B - Above Average	-

Junction Name					xvi. Linking Road- Juhu Road Junction (Arya Samaj Chowk)				
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Linking Road	1499	5400	0.28	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1499	5400	0.28	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Juhu Road	1499	3600	0.42	D - Below Average	4 lane divided to 6 lane divided	1499	5400	0.28	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

5.4.1 Ritumbara College Interchange

Interchange passing near to Moragaon Juhu and merging to the road in front of Ritumbara 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. This interchange has 4 conflict free traffic movement between exiting road and proposed alignment. Figure 5-45 shows the connectivity and directional traffic movement between existing road and proposed coastal road network. Figure 5-46 presents the traffic dispersal scheme for the interchange.

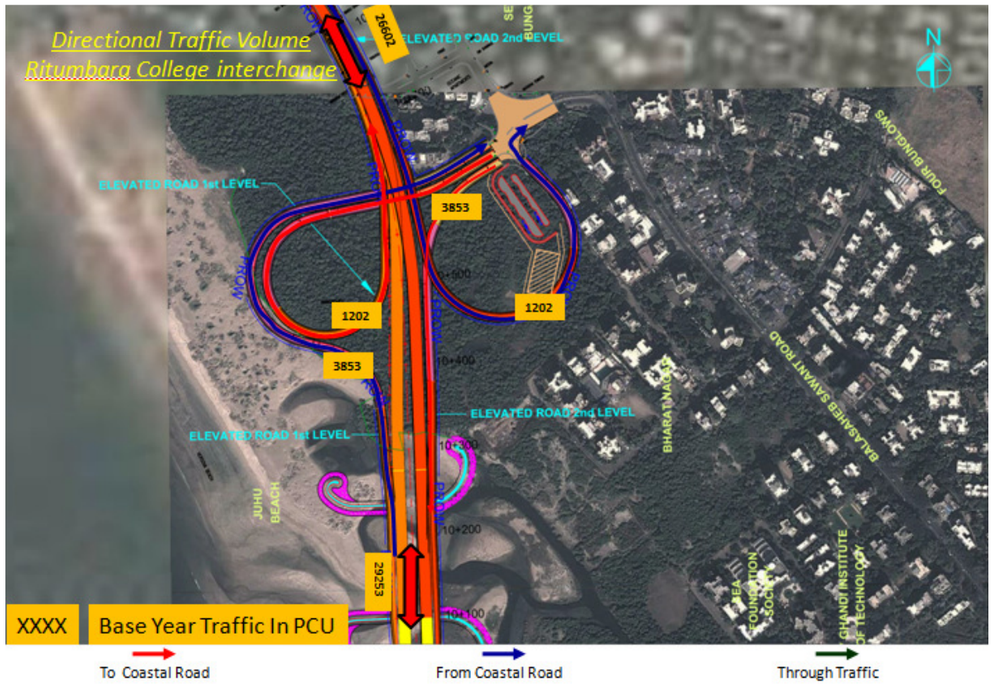


Figure 5-45: Directional Traffic Movement – Ritumbhara College Interchange

Figure 5-46: Traffic Dispersal Scheme – Ritumbara College Interchange

Proposed network development scheme for the catchment of Ritumbhara College Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5-47

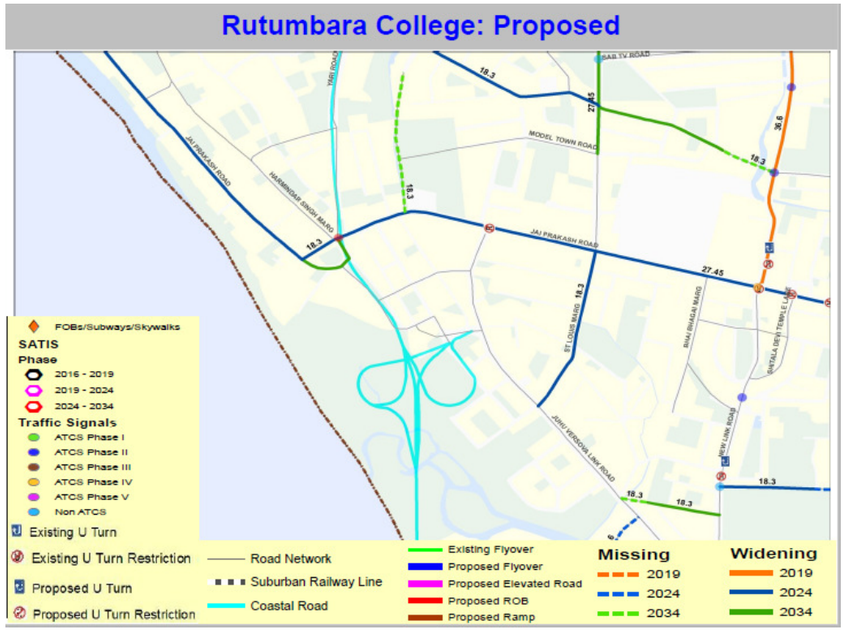


Figure 5-47: Network Development Scheme –Ritumbara College Interchange

Table 5-35: Summary of Network Development Scheme

Name of Interchange		Ritumbara college Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	New Link Road	36.6m
2024 Widening Scheme		
2	Jai Prakash Road	27.45m
	St Louis Marg	18.30m
	Jai Praksh Marg	18.3
	Mahada Road	18.30m
	Road Behind The Club Mumbai	18.30m
2034 Widening Scheme		
3	RTO Road	18.30m
	Achuthrao Patwardhan Road	27.45m
	New D N Nagar Road	18.30m
	T M Mandi Road	18.30m

Junction Development Scheme

xvii. Junction which need to be developed :

xviii. New Versova - Cosmopolitan Education Society Marg

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	Arterial Road	18m	4 lane divided	506	3600	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	506	3600	0.14	A - Excellent	-
Cosmopolitan Education Society Marg	Arterial Road	20m	6 lane divided	506	5400	0.09	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	506	5400	0.09	A - Excellent	-

Road Details				LOS - Existing road (2019)				Proposed development Scheme (2019)	LOS - After improvement (2019)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	Arterial Road	18m	4 lane divided	586	3600	0.16	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	586	3600	0.16	A - Excellent	-
Cosmopolitan Education Society Marg	Arterial Road	20m	6 lane divided	586	5400	0.11	A - Excellent		586	5400	0.11	A - Excellent	-

Road Details				LOS - Existing road (2024)				Proposed development Scheme (2024)	LOS - After improvement (2034)				Proposed development Scheme (2034)
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	Arterial Road	18m	4 lane divided	679	3600	0.19	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	912	3600	0.25	B - Above Average	-
Cosmopolitan Education Society Marg	Arterial Road	20m	6 lane divided	679	5400	0.13	A - Excellent		912	5400	0.17	A - Excellent	-

Junction Name					xix. New Versova - Cosmopolitan Education Society Marg				
Road Segment	LOS- Horizon Year (2043)				**Proposed development Scheme (2043)**	LOS- After Improvement Horizon Year (2043)				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	1227	3600	0.34	B - Above Average	6 lane divided	1227	5400	0.23	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Cosmopolitan Education Society Marg	1227	5400	0.23	B - Above Average	6 lane divided to 8 lane divided	1227	7200	0.17	A - Excellent	Site visit requested to check the availability of land for the proposed improvement

xx. New Versova – JP Road

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	Arterial Road	18m	4 lane divided	506	3600	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	506	3600	0.14	A - Excellent	-
J P Road	Arterial Road	20m	4 lane divided	506	3600	0.14	A - Excellent		506	3600	0.14	A - Excellent	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	Arterial Road	18m	4 lane divided	586	3600	0.16	A - Excellent		586	3600	0.16	A - Excellent	-
J P Road	Arterial Road	20m	4 lane divided	586	3600	0.16	A - Excellent	6 lane divided road	586	5400	0.11	A - Excellent	-
Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	Arterial Road	18m	4 lane divided	679	3600	0.19	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	912	3600	0.25	B - Above Average	-
J P Road	Arterial Road	20m	4 lane divided	679	5400	0.13	A - Excellent		912	5400	0.17	A - Excellent	-

Junction Name					xxi. New Versova - Cosmopolitan Education Society Marg				
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**			**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
New Versova Link Road	1227	3600	0.34	B - Above Average	6 lane divided	1227	5400	0.23	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
J P Road	1227	5400	0.23	B - Above Average	Minor improvements	1227	5400	0.23	B - Above Average	-

5.4.2 MADH Island

This interchange provides connectivity to MADH ISLAND using entry and exit for north and south Mumbai. This interchange has 4 conflict free traffic movement between existing and proposed roads. Road on stilts connects proposed coastal road and Madh Island. It is assumed that 2000 PCU/ day vehicle will diverts to Madh Island from Coastal road. Figure 5-48 shows the connectivity and directional movement of traffic between Madh Island and proposed coastal road. Figure 5-49 shows the traffic network dispersal scheme.

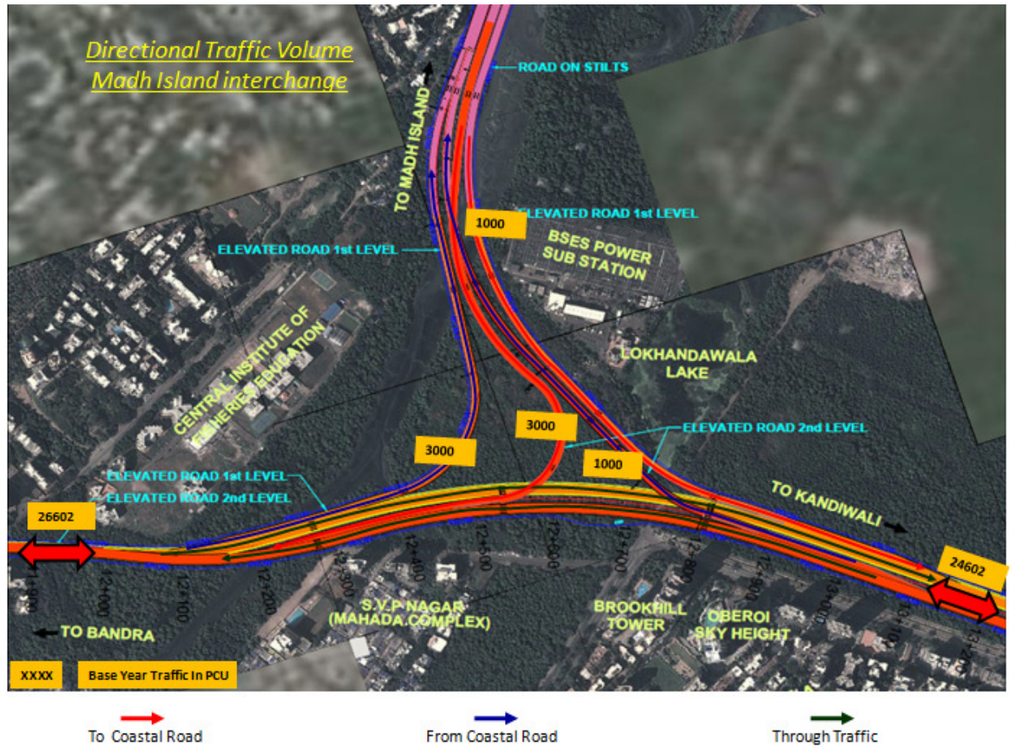


Figure 5-48: Directional Traffic Movement - Madh Island Interchange

Figure 5-49: Traffic Dispersal Scheme – Madh Island Interchange

Proposed network development scheme for the catchment of Madh Island Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5-50. Summary of network development scheme is given inTable 5-36.

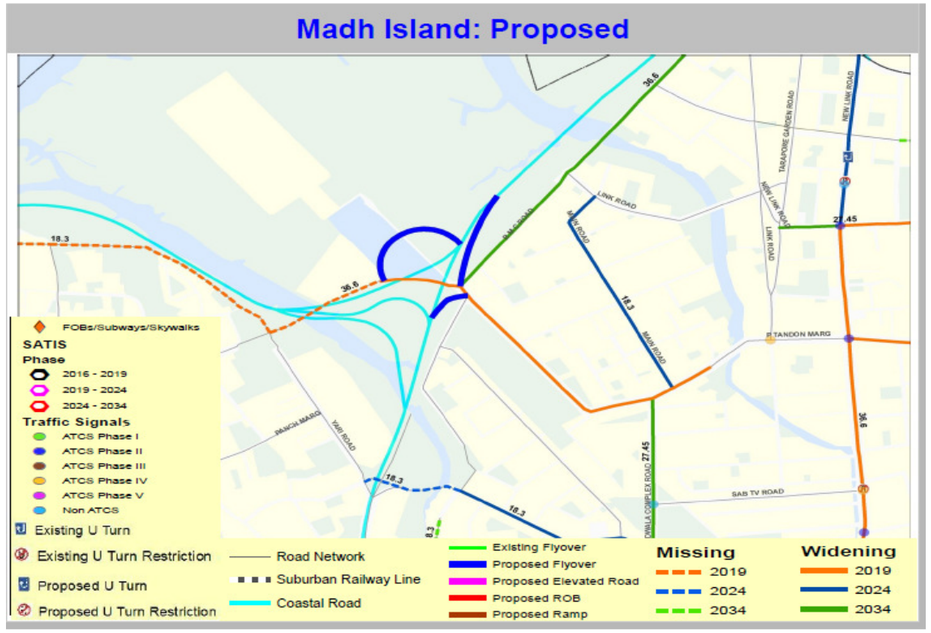


Figure 5-50: Network Development Scheme – Madh Island Interchange

Table 5-36: Summary of Network Development Scheme

Name of Interchange		Madh Island Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	New Link Road	36.6m
2024 Widening Scheme		
2	Main Road	18.30m
	New Link Road	18.30m
	Flyovers are also proposed	-
	Main Road	18.30m
2034 Widening Scheme		
3	Lokhandwala Complex Road	27.45m
	BMC Road	36.60m

Junction Development Scheme

xxii. Junction which need to be developed :

xxiii. Lokhandwala Roundabout

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lokhandwala Back Road	Arterial Road	20m	4 lane divided	400	3600	0.11	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	400	3600	0.11	A - Excellent	-
Lokhandwala Complex Road	Arterial Road	14m	4 lane divided	400	3600	0.11	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	400	3600	0.11	A - Excellent	-
P Tandon Marg	Arterial Road	20m	4 lane divided	400	3600	0.11	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	400	3600	0.11	A - Excellent	-

Road Details				LOS - Existing road (2019)				Proposed development Scheme (2019)	LOS - After improvement (2019)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lokhandwala Back Road	Arterial Road	20m	4 lane divided	463	3600	0.13	A - Excellent	6 lane divided	463	5400	0.09	A - Excellent	-

Lokhandwala Complex Road	Arterial Road	14m	4 lane divided	463	3600	0.13	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	463	3600	0.13	A - Excellent	-
P Tandon Marg	Arterial Road	20m	4 lane divided	463	3600	0.13	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	463	3600	0.13	A - Excellent	-

Road Details				**LOS - Existing road (2024)**					**LOS - After improvement (2034)**				
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	**Proposed development Scheme (2024)**	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	**Proposed development Scheme (2034)**
Lokhandwala Back Road	Arterial Road	20m	4 lane divided	537	5400	0.10	A - Excellent	6 lane divided	722	5400	0.13	A - Excellent	-
Lokhandwala Complex Road	Arterial Road	14m	4 lane divided	537	3600	0.15	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	722	3600	0.20	A - Excellent	-
P Tandon Marg	Arterial Road	20m	4 lane divided	537	3600	0.15	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	722	3600	0.20	A - Excellent	-

Junction Name	xxiv. Lokhandwala Roundabout								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Lokhandwala Back Road	971	5400	0.18	A - Excellent	-	971	5400	0.18	A - Excellent	-
Lokhandwala Complex Road	971	3600	0.27	B - Above Average	6 lane divided	971	5400	0.18	A - Excellent	Site visit requested to check the availability of land for the proposed improvement
P Tandon Marg	971	3600	0.27	B - Above Average	6 lane divided	971	3600	0.27	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

5.4.3 Oshiwara Interchange

This interchange provides connectivity to Goregaon east and west, Jogeshwari west area traffic. Entry and exit ramps connect to existing road near Park paradise Apartments. Figure 5-51 shows the connectivity and directional movement of traffic between Madh Island and proposed coastal road. Figure 5-52 shows the traffic network dispersal scheme.

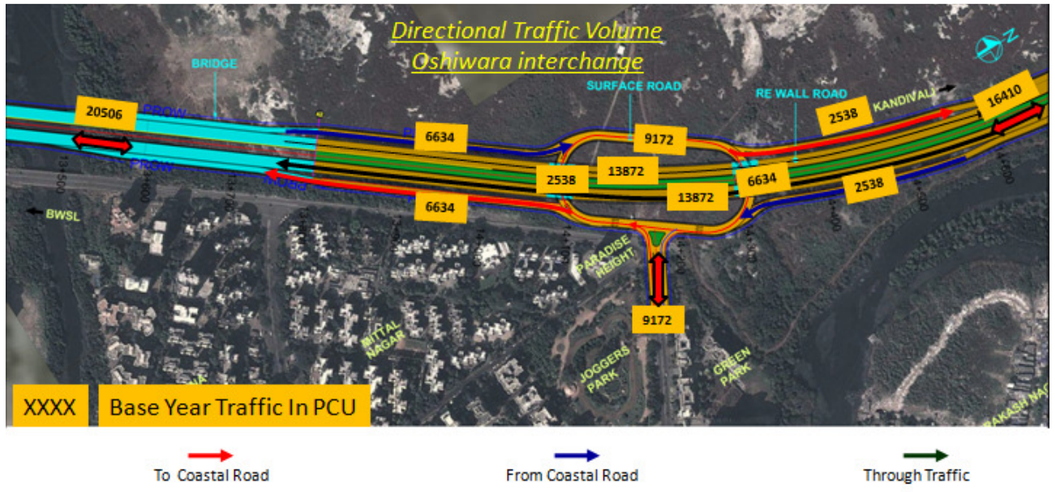


Figure 5-51 : Directional Traffic Movement – Oshiwara Interchange

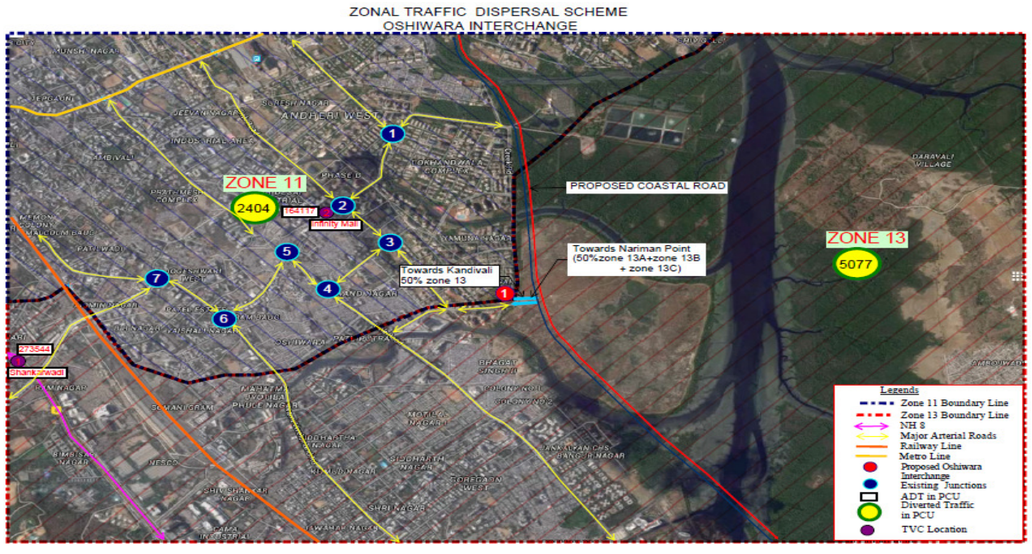


Figure 5-52: Traffic Dispersal Scheme – Oshiwara Interchange

Proposed network development scheme for the catchment of Oshiwara Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5-53. Network development scheme is summarised in Table 5-37.

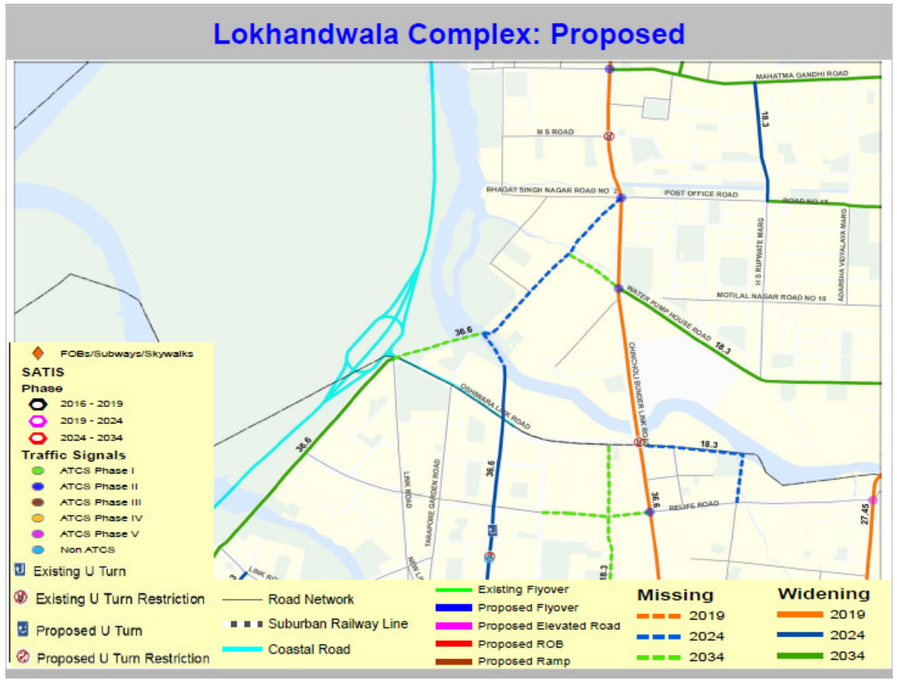


Figure 5-53: Network Development scheme – Oshiwara Interchange

Table 5-37: Summary of Network Development Scheme

Name of Interchange		Oshiwara Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Chincholi Bunder Link Road	36.60m
2024 Widening Scheme		
2	Bhau Tatoba Toraskar Marg	36.60m
	Road No 5 -M G Road	18.30m
2034 Widening Scheme		
3	Creek Road	36.60m
	Water Pump House Road	18.30m

Junction Development Scheme

xxv. Junction which need to be developed :

xxvi. T -Junction (Best Colony Road - Bhau Tatoba Toraskar Marg)

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Best Colony Road	Arterial Road	14m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-
Bhau Tatoba Toraskar Marg	Arterial Road	18m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Best Colony Road	Arterial Road	14m	4 lane divided	1063	3600	0.30	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	3600	0.30	B - Above Average	-
Bhau Tatoba Toraskar Marg	Arterial Road	18m	4 lane divided	1063	3600	0.30	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	3600	0.30	B - Above Average	-

Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Best Colony Road	Arterial Road	14m	4 lane divided	1232	3600	0.34	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1656	3600	0.46	B - Above Average	Minor improvements like installation of road furniture's

Road Details				LOS - Existing road (2024)				Proposed development Scheme (2024)	LOS - After improvement (2034)				Proposed development Scheme (2034)
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Bhau Tatoba Toraskar Marg	Arterial Road	18m	4 lane divided	1232	7200	0.17	A - Excellent	8 lane divided	1656	7200	0.23	A - Excellent	

Junction Name	xxvii. T -Junction (Best Colony Road - Bhau Tatoba Toraskar Marg)								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Best Colony Road	2226	3600	0.62	D - Below Average	6 lane divided	2226	5400	0.41	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Bhau Tatoba Toraskar Marg	2226	7200	0.31	B - Above Average	9 lane divided	2226	7200	0.31	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

xxviii. Link Road - Best Colony Road Junction

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Link Road	Arterial Road	18m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-
Best Colony Road	Arterial Road	14m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Link Road	Arterial Road	18m	4 lane divided	1063	3600	0.30	B - Above Average	8 lane divided	1063	7200	0.15	A - Excellent	
Best Colony Road	Arterial Road	14m	4 lane divided	1063	3600	0.30	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	3600	0.30	B - Above Average	-

Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Link Road	Arterial Road	18m	4 lane divided	1232	7200	0.17	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	1656	7200	0.23	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).
Best Colony Road	Arterial Road	14m	4 lane divided	1232	3600	0.34	B - Above Average		1656	3600	0.46	B - Above Average	

Junction Name				xxix. Link Road - Best Colony Road Junction				
LOS- Horizon Year (2043)				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**			**Remarks**
Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
2226	7200	0.31	B - Above Average	-	2226	7200	0.31	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
2226	3600	0.62	D - Below Average	6 lane divided	2226	5400	0.41	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

5.4.4 Malad Interchange

Malad interchange 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. This interchange has 4 conflict free traffic movement between existing and proposed road network. Figure 5-54 shows the connectivity and directional movement of traffic between Madh Island and proposed coastal road. Figure 5-55 shows the traffic network dispersal scheme.

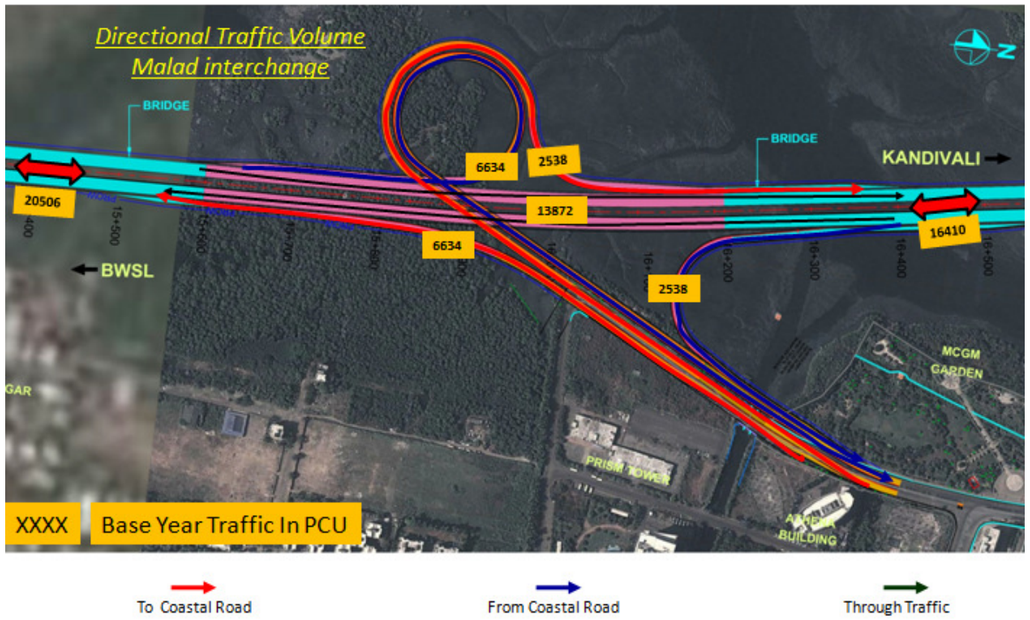


Figure 5-54: Directional Traffic Movement – Malad Interchange

Figure 5-55: Traffic Dispersal Scheme –Malad Interchange

Proposed network development scheme for the catchment of Malad Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5 57. Table 5 38 gives the summary of network development Scheme.

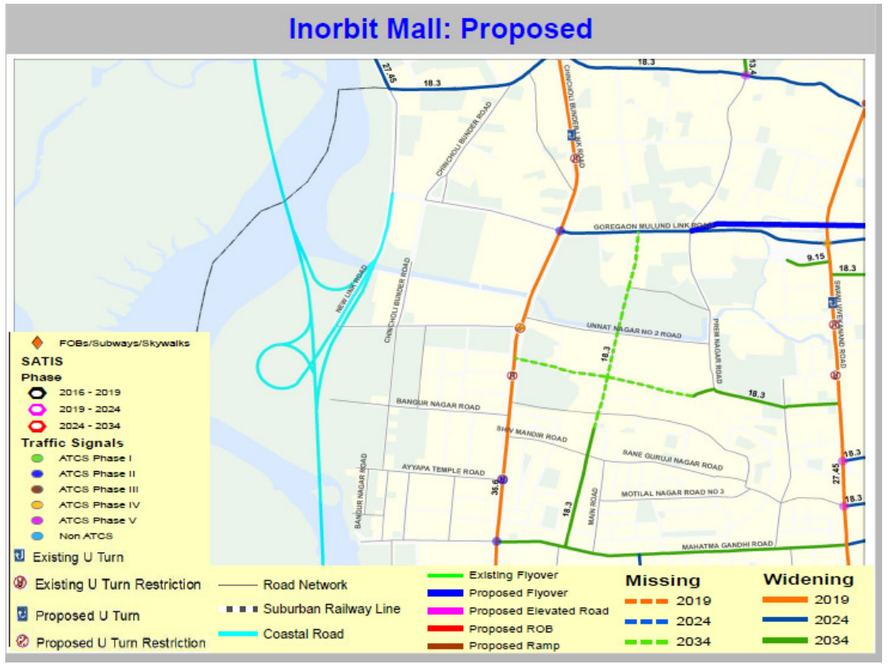


Figure 5-56: Network Development Scheme – Malad Interchange

Table 5-38: Summary of Network Development Scheme

	Name of Interchange	Malad Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Chincholi Bunder Link Road	36.60m
	Swami Vivekananda Road	27.45m
2024 Widening Scheme		
2	Chincholi Bunder Link Road	18.30m
	MDP Road	27.45m
	Aarey Road	18.30m
	Station Road	18.30m
2034 Widening Scheme		
3	L T Singh Road	9.15m
	Vindo Sanghi Road	18.30m
	Motilal Nagar Road No 3	18.30m
	Prem Nagar road	18.30m

Junction Development Scheme

xxx. Junction which need to be developed :

xxxi. T -Junction (MDP Road - Inorbit Side Road Junction)

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
MDP Road	Sub Arterial Road	18m	4 lane divided	917	2900	0.32	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	2900	0.32	B - Above Average	-
Inorbit Side Road	Sub Arterial Road	20m	4 lane divided	917	2900	0.32	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	2900	0.32	B - Above Average	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
MDP Road	Sub Arterial Road	18m	4 lane divided	1063	2900	0.37	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	2900	0.37	B - Above Average	-
Inorbit Side Road	Sub Arterial Road	20m	4 lane divided	1063	2900	0.37	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	2900	0.37	B - Above Average	-

Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
MDP Road	Sub Arterial Road	18m	4 lane divided	1232	2900	0.42	C - Average	Minor improvements like installation of road furniture's (Signages & Markings).	1656	2900	0.57	C - Average	Minor improvements like installation of road furniture's (Signages & Markings).

Inorbit Side Road	Sub Arterial Road	20m	4 lane divided	1232	2900	0.42	C - Average	Minor improvements like installation of road furniture's (Signages & Markings).	1656	2900	0.57	C - Average	Minor improvements like installation of road furniture's (Signages & Markings).

Junction Name					xxxii. T -Junction (MDP Road - Inorbit Side Road Junction)					
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
MDP Road	2226	2900	0.77	D - Below Average	6 lane divided	2226	4300	0.52	C - Average	Site visit requested to check the availability of land for the proposed improvement
Inorbit Side Road	2226	2900	0.77	D - Below Average	6 lane divided	2226	4300	0.52	C - Average	Site visit requested to check the availability of land for the proposed improvement

xxxiii. Inorbit Mall Junction

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Link Road	Arterial Road	18m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-
Inorbit Side Road	Arterial Road	20m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-
Goregaon - Mulund Link Road	Arterial Road	20m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Link Road	Arterial Road	18m	4 lane divided	1063	3600	0.30	B - Above Average	8 lane divided	1063	7200	0.15	A - Excellent	-
Inorbit Side Road	Arterial Road	20m	4 lane divided	1063	3600	0.30	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	3600	0.30	B - Above Average	-
Goregaon - Mulund Link Road	Arterial Road	20m	4 lane divided	1063	3600	0.30	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	3600	0.30	B - Above Average	-

Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Link Road	Arterial Road	18m	4 lane divided	1232	7200	0.17	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	1656	7200	0.23	B - Above Average	-
Inorbit Side Road	Arterial Road	20m	4 lane divided	1232	3600	0.34	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1656	3600	0.46	C - Average	-
Goregaon - Mulund Link Road	Arterial Road	20m	4 lane divided	1232	5400	0.23	B - Above Average	6 lane divided road	1656	5400	0.31	B - Above Average	-

Junction Name	xxxiv. Inorbit Mall Junction								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	

Link Road	2226	7200	0.31	B - Above Average	-	2226	7200	0.31	B - Above Average	-
Inorbit Side Road	2226	3600	0.62	D - Below Average	6 lane divided	2226	5400	0.41	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Goregaon - Mulund Link Road	2226	5400	0.41	D - Below Average	8 lane divided	2226	7200	0.31	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

xxxv. S V Road -Goregaon Mulund Link Road Junction

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
S V Road	Arterial Road	18m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-
Goregaon - Mulund Link Road	Arterial Road	20m	4 lane divided	917	3600	0.25	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	917	3600	0.25	B - Above Average	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
S V Road	Arterial Road	18m	4 lane divided	1063	3600	0.30	B - Above Average	6 lane divided	1063	5400	0.20	A - Excellent	-
Goregaon - Mulund Link Road	Arterial Road	20m	4 lane divided	1063	3600	0.30	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1063	3600	0.30	B - Above Average	-

Road Details				**LOS - Existing road (2024)**				**Proposed development Scheme (2024)**	**LOS - After improvement (2034)**				**Proposed development Scheme (2034)**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
S V Road	Arterial Road	18m	4 lane divided	1232	5400	0.23	B - Above Average		1656	5400	0.31	B - Above Average	-
Goregaon - Mulund Link Road	Arterial Road	20m	4 lane divided	1232	5400	0.23	B - Above Average	6 lane divided	1656	5400	0.31	B - Above Average	-

Junction Name	xxxvi. S V Road -Goregaon Mulund Link Road Junction								
Road Segment	**LOS- Horizon Year (2043)**				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
S V Road	2226	5400	0.41	B - Above Average	8 lane divided	2226	7200	0.31	B - Above Average	Site visit requested to check the availability of land for the proposed improvement
Goregaon - Mulund Link Road	2226	5400	0.41	D - Below Average	8 lane divided	2226	7200	0.31	B - Above Average	Site visit requested to check the availability of land for the proposed improvement

5.5.1 Kandivali Interchange

This interchange is end point of proposed north costal alignment. One of the entry ramp of the interchange starts from Malad –Marve road. Likewise one of the exit ramp ends at Link road. It gives connectivity of entry and exit on proposed alignment with required acceleration and deceleration. This interchange covered traffic from Malad east & west, Kandiwali east &west, Boriwali east & west area. Figure 5-57 shows the connectivity and directional movement of traffic between Madh Island and proposed coastal road. Figure 5-58 shows the traffic network dispersal scheme.

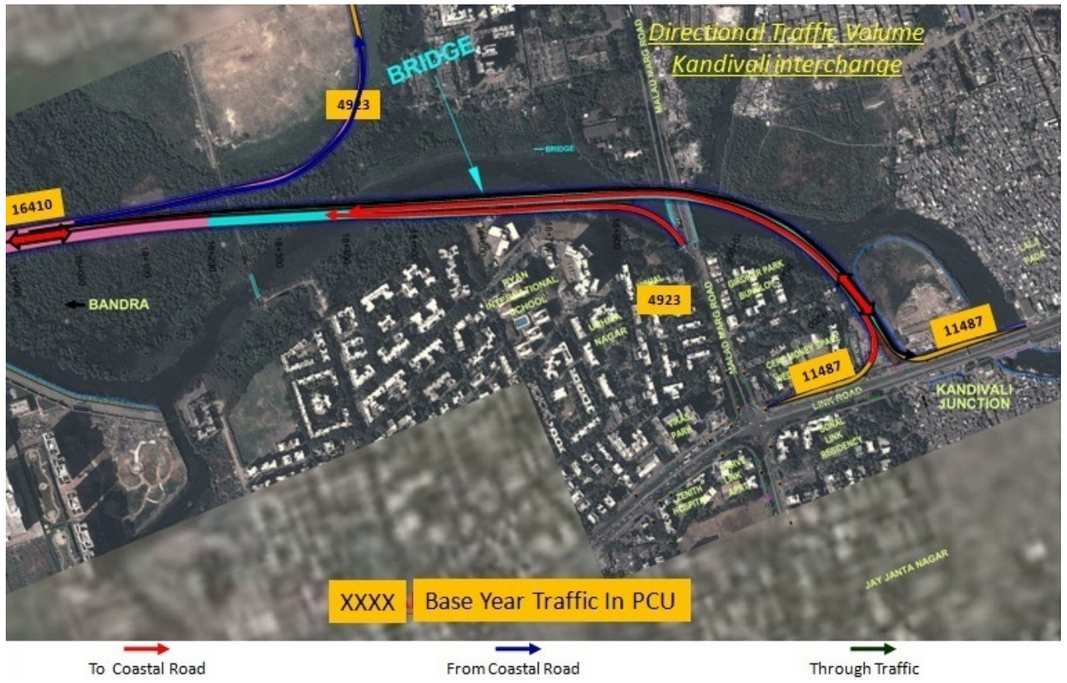


Figure 5-57: Directional Traffic Movement – Kandivali Interchange

Figure 5-58: Traffic Dispersal Scheme – Kandivali Interchange

Proposed network development scheme for the catchment of Kandivali Interchange from Comprehensive Mobility Plan has been reproduced in Figure 5-59. Table 5 39 gives the summary of network development scheme.

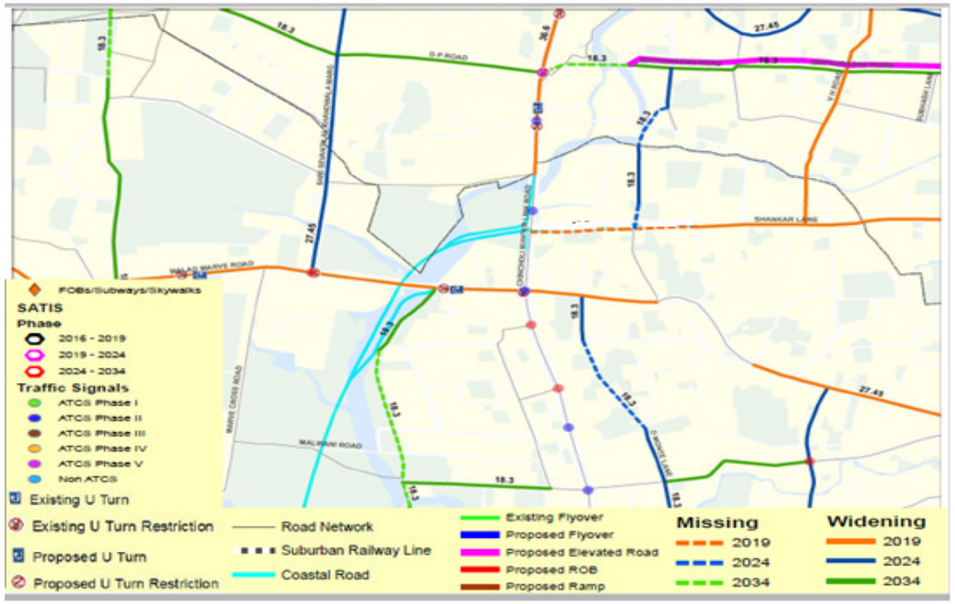


Figure 5-59: Network Development Scheme – Kandivali Interchange

Table 5-39 : Summary of Traffic Development Scheme

	Name of Interchange	Kandivali Interchange
Sl No.	Name of Road	Proposed Road Width
2019 Widening Scheme		
1	Malad Marve Road	18.30m
	Chincholi Bunder Link Road	36.60m
	Chunilala Giridharilal Marg	27.45m
	Shankar Lane	18.30m
2024 Widening Scheme		
2	Shri Sevanth Lokhandwala Marg	27.45m
	D Monte Lane	18.30m
	Mahatma Gandhi Road	27.45m
2034 Widening Scheme		
3	Baf Hira Nagar Road	18.30m
	D P Road	18.30m
	Ramachndra Ln	18.30m

Junction Development Scheme

xxxvii. Junction which need to be developed :

xxxviii. Mithchowky Junction (Malad -Marve Road and Link Road junction)

Road Details				**LOS - Existing road (2014)**				**Proposed development Scheme (2014)**	**LOS - After improvement (2014)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Malad- Marve Road	Arterial Road	18m	4 lane divided	492	3600	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	492	3600	0.14	A - Excellent	-
Link Road	Arterial Road	18m	4 lane divided	492	3600	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	492	3600	0.14	A - Excellent	-

Road Details				**LOS - Existing road (2019)**				**Proposed development Scheme (2019)**	**LOS - After improvement (2019)**				**Remarks**
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Malad- Marve Road	Arterial Road	18m	4 lane divided	570	3600	0.16	A - Excellent	6 lane divided	570	5400	0.11	A - Excellent	-
Link Road	Arterial Road	18m	4 lane divided	570	3600	0.16	A - Excellent	8 lane divided	570	7200	0.08	A - Excellent	-

Road Details				LOS - Existing road (2024)				Proposed development Scheme (2024)	LOS - After improvement (2034)				Proposed development Scheme (2034)
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Malad- Marve Road	Arterial Road	18m	4 lane divided	661	5400	0.12	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	889	5400	0.16	A - Excellent	-
Link Road	Arterial Road	18m	4 lane divided	661	7200	0.09	A - Excellent		889	7200	0.12	A - Excellent	-

Junction Name	xxxix. Mithchowky Junction (Malad -Marve Road and Link Road junction)								
	LOS- Horizon Year (2043)				**Proposed development Scheme (2043)**	**LOS- After Improvement Horizon Year (2043)**				**Remarks**
Road Segment	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Malad- Marve Road	1195	5400	0.22	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1195	5400	0.22	B - Above Average	-
Link Road	1195	7200	0.17	A - Excellent		1195	7200	0.17	A - Excellent	-

xl. Mahatma Gandhi Road - Link Road junction

Road Details				LOS - Existing road (2014)				Proposed development Scheme (2014)	LOS - After improvement (2014)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Mahatma Gandhi Road	Arterial Road	18m	4 lane divided	492	3600	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	492	3600	0.14	A - Excellent	-
Link Road	Arterial Road	18m	4 lane divided	492	3600	0.14	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	492	3600	0.14	A - Excellent	-

Road Details				LOS - Existing road (2019)				Proposed development Scheme (2019)	LOS - After improvement (2019)				Remarks
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Mahatma Gandhi Road	Arterial Road	18m	4 lane divided	570	3600	0.16	A - Excellent	6 lane divided	570	5400	0.11	A - Excellent	-
Link Road	Arterial Road	18m	4 lane divided	570	3600	0.16	A - Excellent	8 lane divided	570	7200	0.08	A - Excellent	-

Road Details				LOS - Existing road (2024)				Proposed development Scheme (2024)	LOS - After improvement (2034)				Proposed development Scheme (2034)
Road Segment	Type of Road	Width of road segment	Existing Road Configuration	Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Mahatma Gandhi Road	Arterial Road	18m	4 lane divided	661	5400	0.12	A - Excellent	Minor improvements like installation of road furniture's (Signages & Markings).	889	5400	0.16	A - Excellent	-
Link Road	Arterial Road	18m	4 lane divided	661	7200	0.09	A - Excellent		889	7200	0.12	A - Excellent	-

Junction Name	xli. Mithchowky Junction (Malad -Marve Road and Link Road junction)								
	LOS- Horizon Year (2043)				Proposed development Scheme (2043)	LOS- After Improvement Horizon Year (2043)				Remarks
Road Segment	Traffic from Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS		Traffic From Coastal Road, PCU/hr	Design Capacity of existing road, PCU/hr	V/C ratio	LOS	
Mahatma Gandhi Road	1195	5400	0.22	B - Above Average	Minor improvements like installation of road furniture's (Signages & Markings).	1195	5400	0.22	B - Above Average	-
Link Road	1195	7200	0.17	A - Excellent		1195	7200	0.17	A - Excellent	-

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 the following nature singly or in combinations:

Engineering constraint

Socio-Environmental constraint

Financial constraint

Based on estimated capacity the 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 would require 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 vehicular 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 the 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 colour.

Figure 6.2: Section 2: Priya Darshini Park to Mahalaxmi

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

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

In this section the 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.

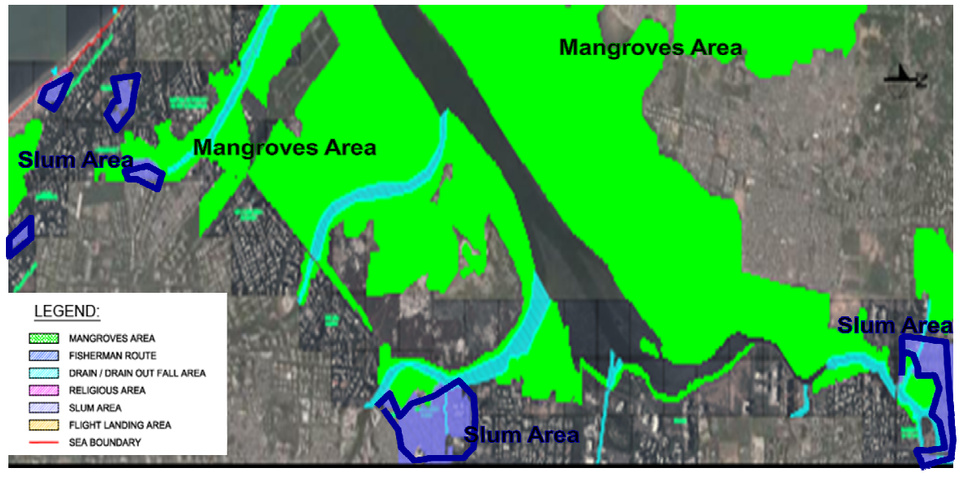
Figure 6.5: Section 5: Bandra End of Sea Link to Juhu Sea Side Garden

In this section the 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 the 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, Bharatnagar 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 the 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 basic serviceability needs. This has resulted in 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 few green spaces and public areas. Citizens of Mumbai also spend three hours on an average every day in commuting for work in overcrowded public transport. All these aspects have resulted in the degradation of the 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 stationary vehicles.

6.1.4 Financial Constraints

The proposed coastal road is an 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 to 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

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

After reviewing the same we have also 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

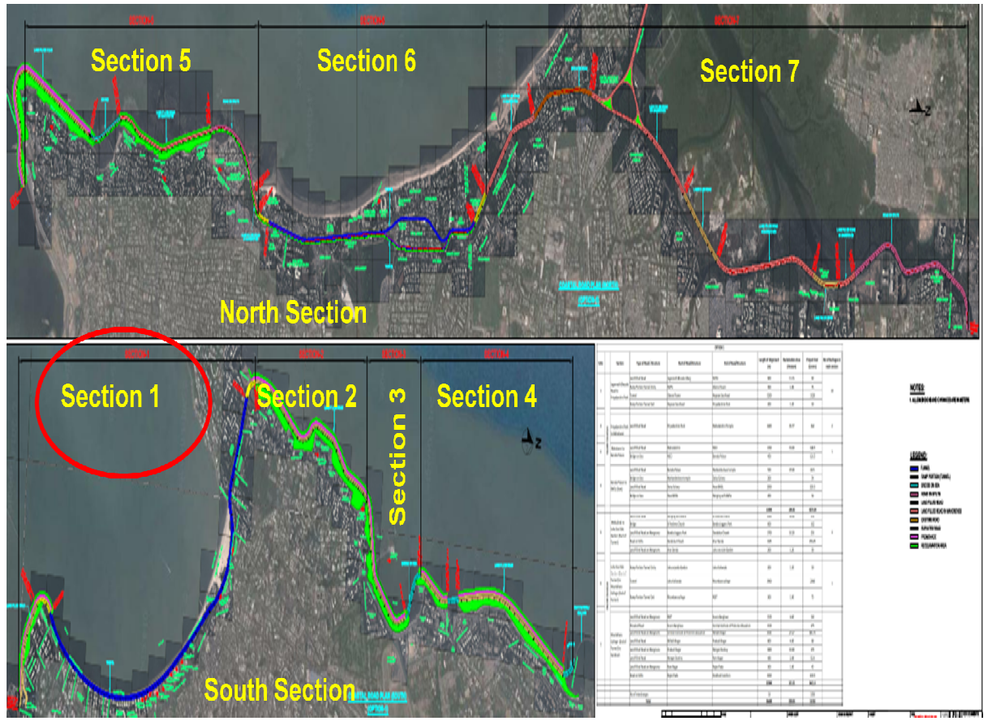
All six alignment options are briefed hereunder in subsequent paragraphs

6.2.2 Alignment Options

Seven alignment options were considered with option-1 and Option-2 adopted from the Joint Technical 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.

6.2.2.1 Section 1: Jagannath Bhosale Road to Priya Darshini Park

Section-1 starts from Jagganath Bhosle Marg near MLA Hostel and ends at Priyadarshini garden sea front. The section is characterised by the requirement of provision of a tunnel for the entire length.



Section 1 Option 1 & 2:

Option 1 and Option 2 proposed by the coastal road committee are same for section-1. Both options provide for a cut and cover tunnel below existing Marine Drive, which extends as a NATM tunnel to cross Malabar Hill to reach Priyadarshini Park.

Advantages:

A cut and cover tunnel below existing Marine Drive will enable provision of emergency exit access to ground level with ventilation shaft.

Disadvantages:

- Provision of emergency exits along with ventilation shaft will result in reduction and discontinuity of existing promenade.
- The proposal requires a 500m length of open to sky ramp cut out of existing Marine Drive near NCPA, resulting in reduction in promenade in this area for maintaining existing carriageway width at grade level.
- The alignment passes in close proximity to high rise buildings and structures of archaeological importance.

- Alignment requires provision of three sharp curves inside tunnel, thus adversely impacting user safety.
- The option also will involve high traffic management during construction, utility relocation and disruption to storm water drainage.

Sr. No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area (ha)	No of Heritage structures
1	Jagannath Bhosale Road to Priyadarshini Park	Land Filled Road	Jagannath Bhosale Marg	NCPA	900	11.15	10
		Ramp Portion Tunnel Entry	NCPA	Oberoi Tower	300	1.80	
		Tunnel	Oberoi Tower	Nepean Sea Road	5200	8	
		Ramp Portion Tunnel Exit	Nepean Sea Road	Priyadarshini Park	200	1.20	

Section 1 Option -3:

Option-3 comprised of provision of at grade road parallel to existing Marine Drive with new promenade. However, the alignment shall permanently impact Girgaon chowpati for reclamation necessary to provide approach for tunnel through Malabar Hill. Considering religious importance of Girgaon chowpati for Ganesh Festival and heritage value of existing Marine Drive the option was considered as not feasible.

Sr. No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area (ha)	No of Heritages in each section
1	Jagannath Bhosale Road to Priyadarshini Park	Land Filled Road	Jagannath Bhosale Marg	Chowpati Beach	5000	57.29	10
		Ramp Portion Tunnel Entry	Chowpati Beach	Walkeshwar	400	2.40	
		Tunnel	Walkeshwar	Russian Consulate	1200		
		Ramp Portion Tunnel Exit	Russian Consulate	Clinical Diagnostic Center	400	2.40	

Section 1 Option -4:

The option considers a tunnel parallel to existing Marine Drive outside existing shore protection wall. The alignment shall require reclamation in front of NCPA for a length of 1km for provision of ramp approach to the tunnel.

Advantages:

- Does not require traffic management, utility relocation and reduced impact on Marine Drive
- Provision of emergency exits with ventilation ducts to ground using existing promenade is possible

Disadvantages:

- The alignment is curved reducing user safety and increasing operation requirement.
- Provision of ventilation and emergency exit shaft will impact on existing promenade
- The alignment has sharp curves at entry and exit.
- Tunnel length is more as compared to a straight alignment thus increasing cost.

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
1	Jaganna th Bhosale Road to Priyadarshini Park	Bridge on Sea	Jagannath Bhosale Marg	NCPA	1200	3.10	10
		Ramp Portion Tunnel Entry	NCPA	Oberoi Tower	400	2.40	
		Tunnel	Oberoi Tower	Russian Consulate	5000		
		Ramp Portion Tunnel Exit	Russian Consulate	Clinical Diagnostic Center	400	2.40	

Section 1 Option -5

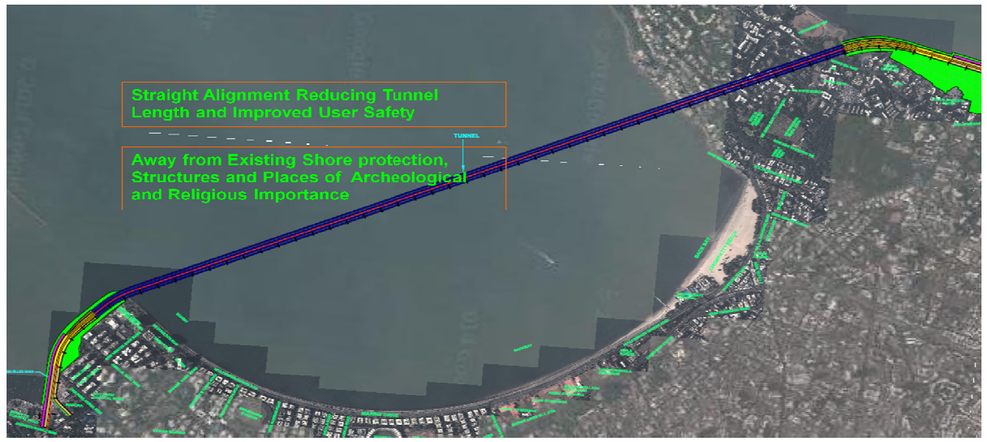
The option makes provision for two straight under sea tunnels for south bound and north bound traffic separately as per project traffic requirement.

Advantages:

- This option has probably the best alignment, with smooth curves to desired standards thus improving safety and minimising operational requirements
- Straight alignment of tunnel is easy to construct by using Tunnel Boring Machine thus reducing construction time significantly
- The alignment is away from structures of archeological importance, roads and buildings
- Option requires minimal traffic management during construction.

Disadvantages:

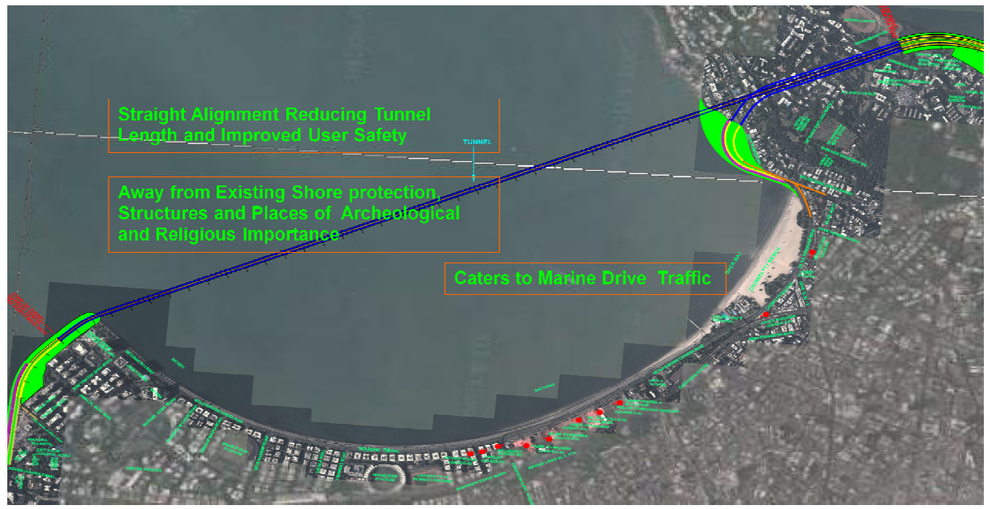
- Option requires Sump and pump arrangement at the foot of Malabar Hill inside sea
- The option requires high ventilation requirement



S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
1	Jagannath Bhosale Road to Priyadarshini Park	Land Filled Road	Jagannath Bhosale Marg	Raheja Center	410	7.94	10
		Ramp Portion Tunnel Entry	Raheja Center	NCPA	400		
		Tunnel	NCPA	Nepean Sea Road	4400		
		Ramp Portion Tunnel Exit	Nepean Sea Road	Clinical Diagnostic Center	600		

Section 1 Option -6

The option is similar to Option-5 however, additional provision of two tunnel for capturing traffic at Tambe chowk and taking to Priyadarshini Park was incorporated.



S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
1	Jagannath Bhosale Road to Priyadarshini Park	Land Filled Road	Jagannath Bhosale Marg	Raheja Center	410	7.94	10
		Ramp Portion Tunnel Entry	Raheja Center	NCPA	400		
		Tunnel	NCPA	Nepean Sea Road	4400	8	
		Tunnel Entry and Exit at walkeshwar	Nepean Sea Road	Walkeshwar junction	960	6.28	
		Ramp Portion Tunnel Exit	Nepean Sea Road	Clinical Diagnostic Center	600		

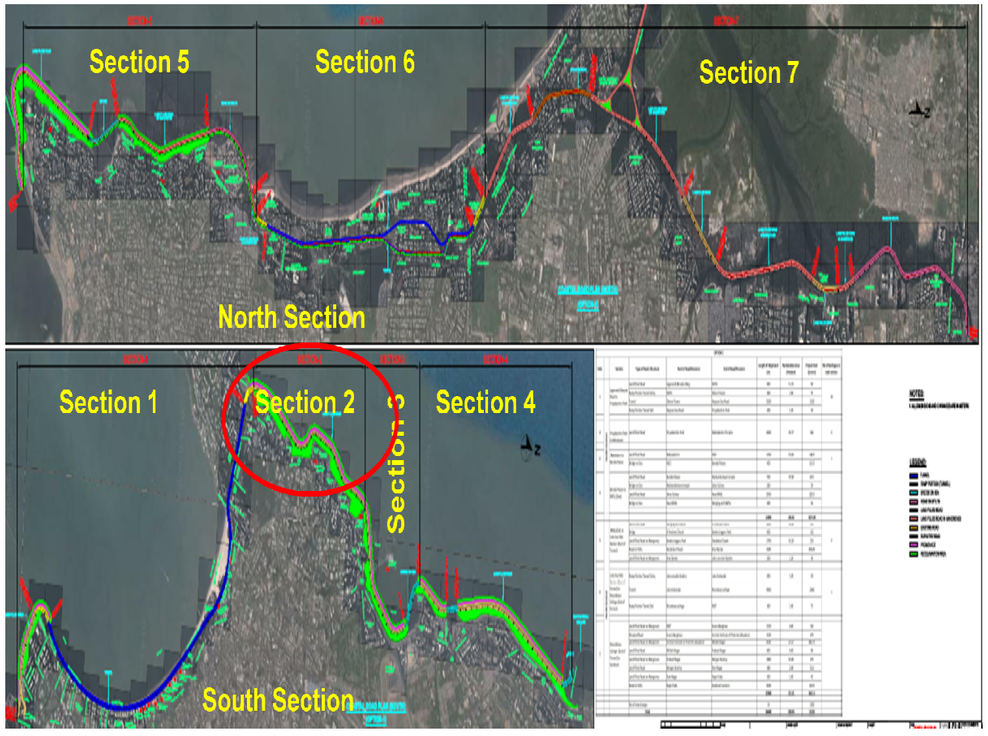
Section 1 Option -7

The option is similar to option-6, however the tunnels leading to Tambe Chowk were realigned to provide entry and exit on Marine Drive near Princess Street Flyover. This will not only avoid the traffic congestion at Tambe Chowk during peak hour, it will also serve as a bypass to Pedder Road. However, provision of this connectivity does not diminish requirement of direct connectivity to Nariman Point and connectivity towards formation of ring road. Hence it is proposed to accommodate provision for tunnels as proposed in option-6 for future connectivity. After study of all options for section-1 of proposed alignment it was decided to adopt option-7 with two uni-directional tunnels to Marine Drive with provision for additional two tunnels for future growth and connectivity for Nariman Point. Due to constraints on Marine Drive, tunnels from Priyadarshini Park to Marine drive can only be constructed as 2+2 lanes only.

6.2.2.2 Section 2: Priya Darshini Park to Mahalaxmi

The section runs from Priyadarshini park to Mahalaxmi temple area and is characterised by land-fill road in inter-tidal zone. All options are similar with variation to area of reclamation and geometry

of the alignment. Advantages and disadvantages of each option is presented in figures below. Based on the analysis it was decided to adopt option 5 for the section for detailed design.



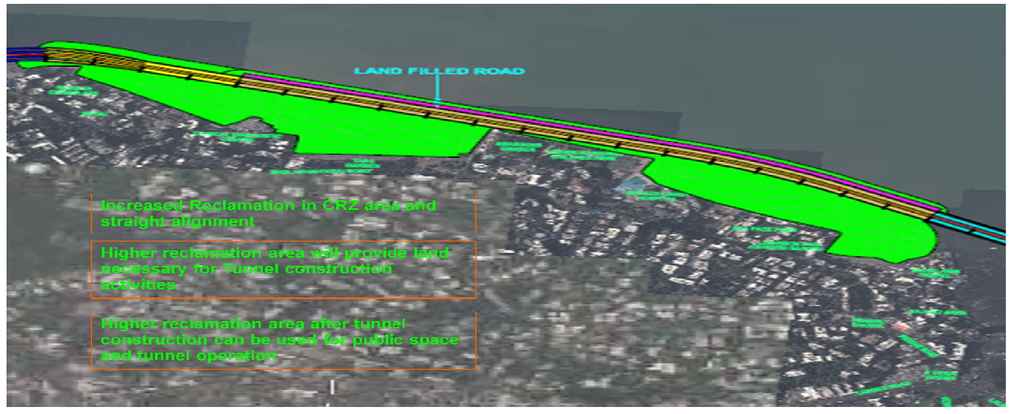
Section 2 Option -1 & 2

Priya Darshini Park to Mahalaxmi

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
2	Priyadarshini Park to Mahalaxmi	Land Filled Road	Priyadarshini Park	Mahalakshmi Temple	2400	35.77	2

Section 2 Option-3 and 4

Priya Darshini Park to Mahalaxmi



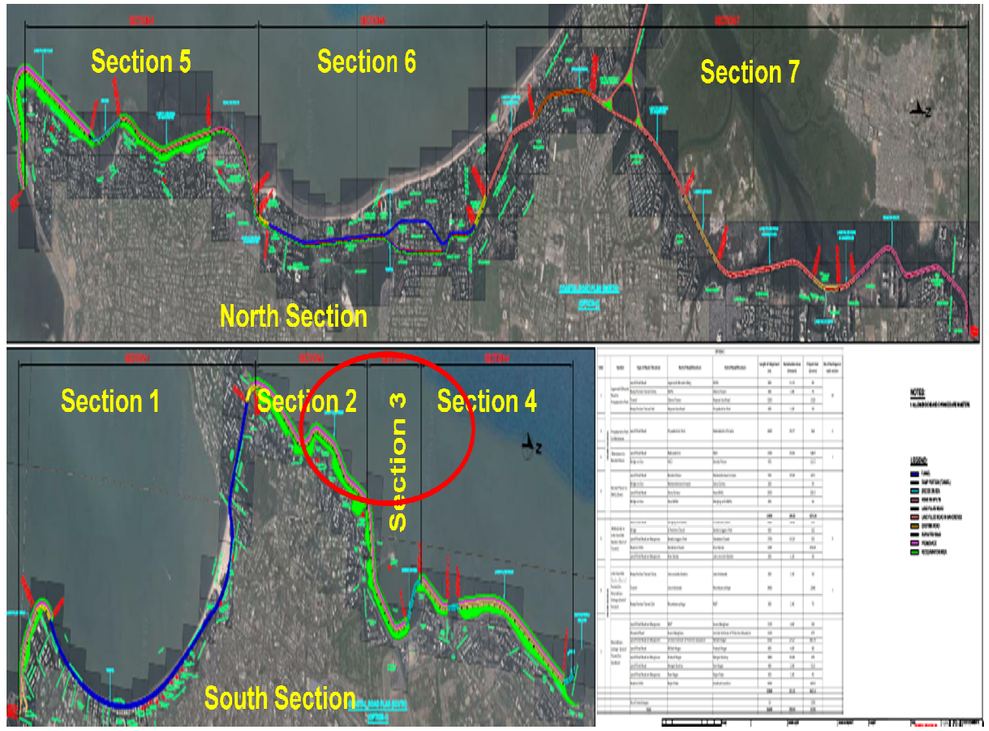
S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area (ha)	No of Heritages in each section
2	Priyadarshini Park to Mahalaxmi	Land Filled Road	Clinical Diagnostic Center	Mahalakshmi Temple	1500	38.42	2

Section 2 Option-5 & 6

Priya Darshini Park to Mahalaxmi

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area (Hectare)	No of Heritages in each section
2	Priyadarshini Park to Mahalaxmi	Land Filled Road	Clinical Diagnostic Center	Mahalakshmi Temple	1490	36.64	1

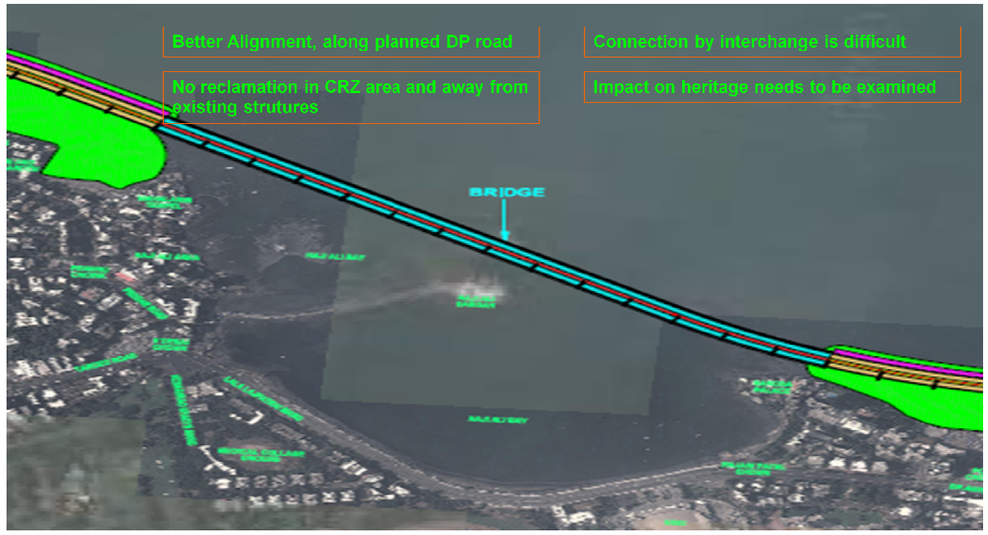
6.2.2.3 Section 3 Mahalaxmi to Baroda Palace



Section -3 is characterised by presence of structures of religious importance i.e. Mahalaxmi temple and Haji Ali along with Baroda Palace. The religious centres attract huge crowds of devotees. Thus there would be a high pedestrian circulation requirement. All options are described pictorially with their advantages and disadvantages in figures below. After due analysis and considering religious value of the area it was decided to adopt Option-1 as proposed by the JTC with provision of Pedestrian circulation and minimum obstruction to view of Haji Ali from existing road.

Section 3 Option -1 & 2

Mahalaxmi to Baroda Palace



S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
3	Mahalaxmi to Baroda Palace	Land Filled Road	Mahalakshmi	NSCI	1350	19.90	1
		Bridge on Sea	NSCI	Baroda Palace	450	8	

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
3	Mahalaxmi to Baroda Palace	Bridge on Sea	Mahalakshmi Temple	Baroda Palace	1400		1

This option was dropped mainly due to fact that it impacts on religious value of Haji Ali. Also as the proposed interchange at the location is a major point of dispersal for the success of proposed project road, connecting same on a bridge was not feasible without major impact on aesthetic view and heritage of the area.

Section 3 Option-3 & 4:

Mahalaxmi to Baroda Palace

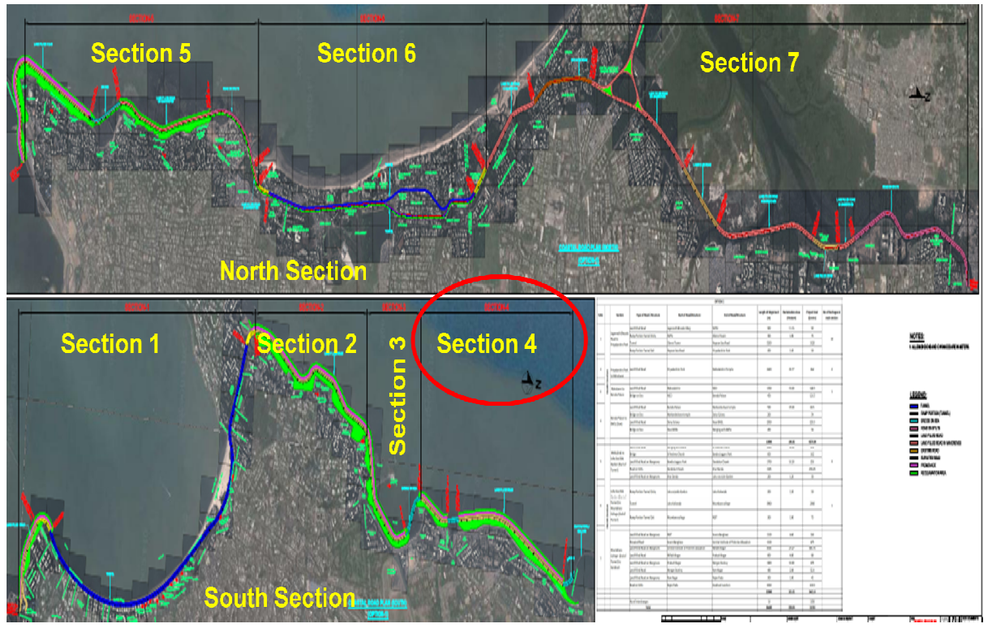
Section 3 Option-5 & 6

Mahalaxmi to Baroda Palace

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
3	Mahalaxmi to Baroda Palace	Bridge on Sea	Mahalakshmi Temple	Baroda Palace	2000		2

The option provides for a continuous bridge inside sea abutting existing shore line. Although the option does not impact on religious value of Haji Ali dagrah, it will not create any public facilities which are necessary at the locations.

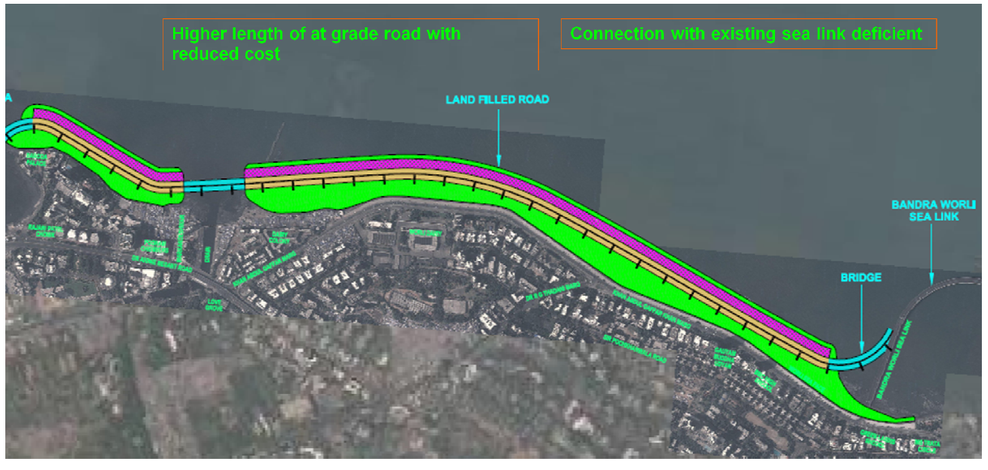
6.2.2.4 Section 4 Baroda Palace to Worli End of Sea Link



Section 4 is characterised by proposal to reclaim on sea ward side of existing shore protection. The area is marked by open rock outcrop and construction of embankment over same is proposed for all options. All options propose reclamation with varied geometry of the alignment for this area. Advantages and disadvantages of each option is depicted in figures below. Based on the option analysis, it is decided to adopt option-5 with direct a connection to the existing Bandra Worli Sea Link.

Section 4 Option 1 & 2

Baroda Palace to Worli End of Sea Link



S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
4	Baroda Palace to BWSL (Start)	Land Filled Road	Baroda Palace	Markandeshwar temple	550	37.00	
		Bridge on Sea	Markandeshwar temple	Dairy Colony	200		
		Land Filled Road	Dairy Colony	Near BWSL	2050		
		Bridge on Sea	Near BWSL	Merging with BWSL	200		

Section 4 Option-3 & 4

Baroda Palace to Worli End of Sea Link

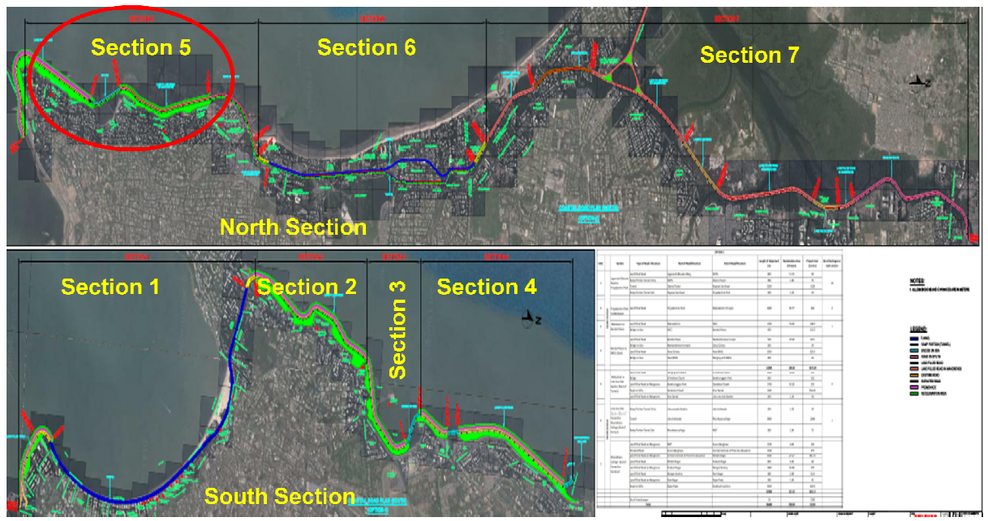
S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
4	Baroda Palace to BWSL (Start)	Land Filled Road	Baroda Palace	Markandeshwar temple	400	30.07	
		Bridge on Sea	Markandeshwar temple	Dairy Colony	200		
		Land Filled Road	Dairy Colony	Near BWSL	2100		
		Bridge on Sea	Near BWSL	Merging with BWSL	250		

Section 4 Option-5 & 6

Baroda Palace to Worli End of Sea Link

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
4	Baroda Palace to BWSL (Start)	Land Filled Road	Baroda Palace	Markandeshwar temple	400		
		Bridge on Sea	Markandeshwar temple	Dairy Colony	200		
		Land Filled Road	Dairy Colony	Near BWSL	1830	10.30	
		Bridge on Sea	Near BWSL	Merging with BWSL	470		

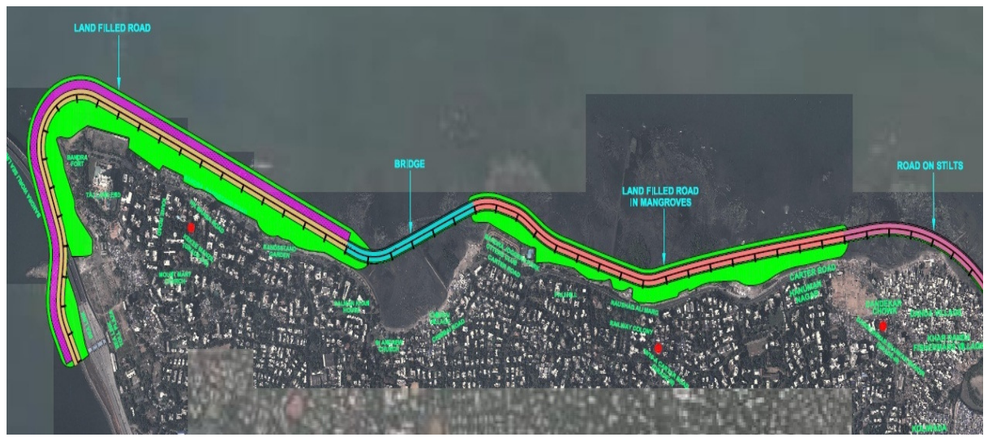
6.2.2.5 Section 5 Bandra End of Sea Link to Juhu Sea Side Garden



Section 5 is characterised by proposed reclamation along the sea for all options. The alignment hugs existing coastal line and runs from Bandra end of Sea Link till Khardanda Village. The area has several fishermen communities and dense mangrove forest (notified reserve forest) adjoining Otters club. It was decided to provide a bridge on sea ward side of Chimbai Village to allow navigational facility for the fishermen.

Section 5 Option-1

Option-1 has been proposed in line with recommendation of Coastal Road committee option-1. The option proposes land filled road on mangroves.

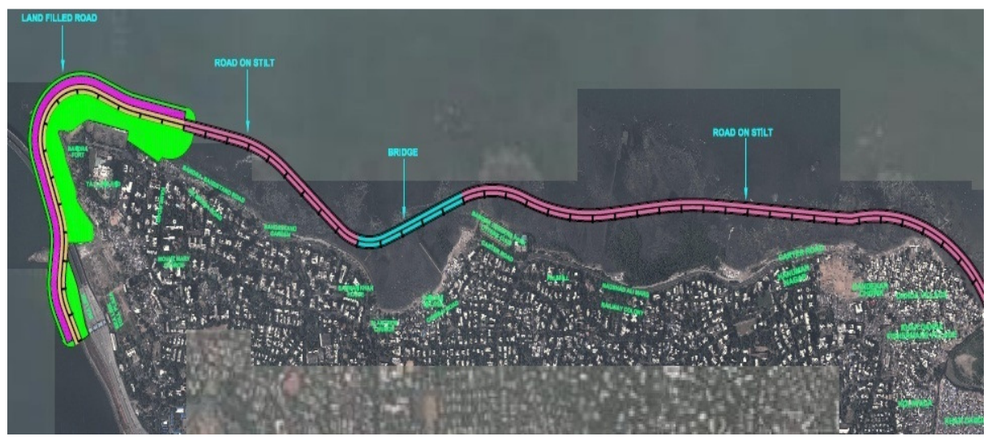


S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
5	BWSL (End) to Juhu Sea Side Garden (Start of Tunnel)	Land Filled Road	Merging with BWSL	St'Andrew Church	2300	52.66	3
		Bridge	St'Andrew Church	Bandra Joggers Park	600		
		Land Filled Road on Mangroves	Bandra Joggers Park	Dandekar Chowk	1700	10.20	
		Road on Stilts	Dandekar Chowk	Khar Danda	1025		
		Land Filled Road on Mangroves	Khar Danda	Juhu seaside Garden	200	1.20	

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
5	BWSL (End) to Juhu Sea Side Garden (Start of Tunnel)	Land Filled Road	BWSL Toll Plaza	Band Stand	1500	22.88	3
		Road on Stilts	Band Stand	St'Andrews Church	900		
		Bridge on Sea	St'Andrews Church	Bandra Joggers Park	500		
		Road on Stilts	Bandra Joggers Park	Khar Danda	2700		
		Land Filled Road on Mangroves	khar Danda	Juhu seaside Garden	200	1.20	

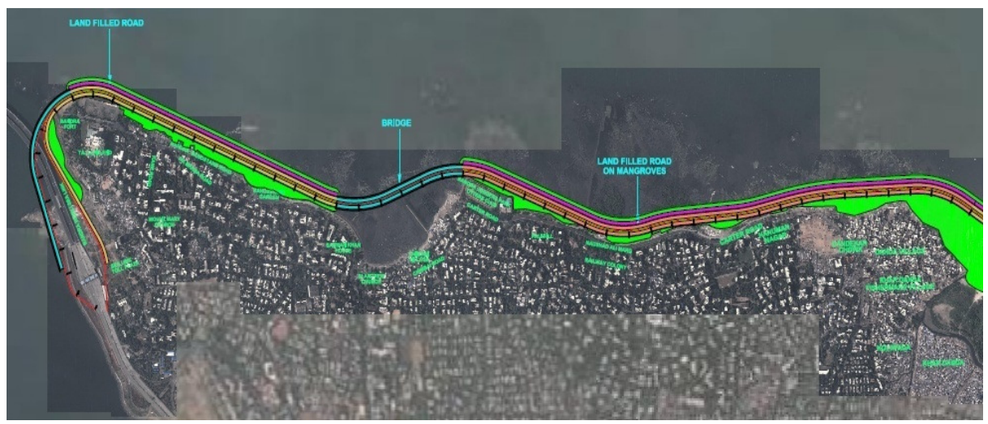
Section 5 Option-2

Option-2 has been proposed in line with recommendation of Coastal Road committee option-2. The option proposes road on stilts in mangrove areas.



Section 5 Option-3 & 4

Option 3 is similar to option-1 with improved geometry.



S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section

5	BWSL (End) to Juhu Sea Side Garden (Start of Tunnel)	Bridge on Sea	Merging with BWSL	Bandra Fort	775		3
		Land Filled Road	Bandra Fort	St'Andrews Church	2075		
		Bridge on Sea	St' Andrews Church	Bandra Joggers Park	600	47.24	
		Land Filled Road on Mangroves	Bandra Joggers Park	Khar Danda	2400		

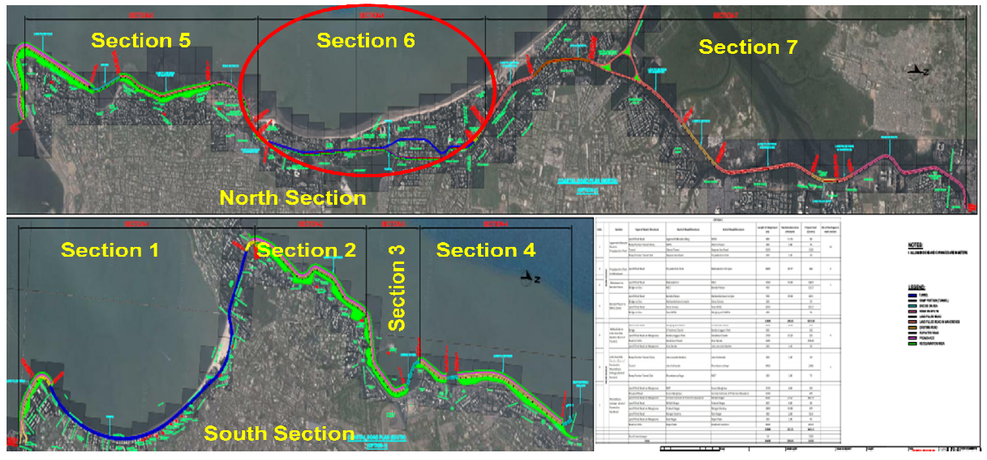
Section 5 Option-5 & 6

Bandra End of Sea Link to Juhu Sea Side Garden

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
5	BWSL(End	Land Filled Road	Merging with BWSL	St'Andrews Church	2180		2
	) to Juhu Sea Side Garden (Start of Tunnel)	Bridge on Sea	St'Andrews Church	Bandra Joggers Park	600		
		Land Filled Road on Mangroves	Bandra Joggers Park	Dandekar Chowk	1810	10.86	

An option of direct connection to the Sea-Link near Bandra Fort is under study including contractual modalities and corresponding changes may be incorporated at bid stage.

6.2.2.6 Section 6 Juhu Sea Side Garden to Ritumbhara College



Section 6 is discussed below, for all the Alignment Options

Section 6 Option 1 & 2

Juhu Sea Side Garden to Ritumbhara College

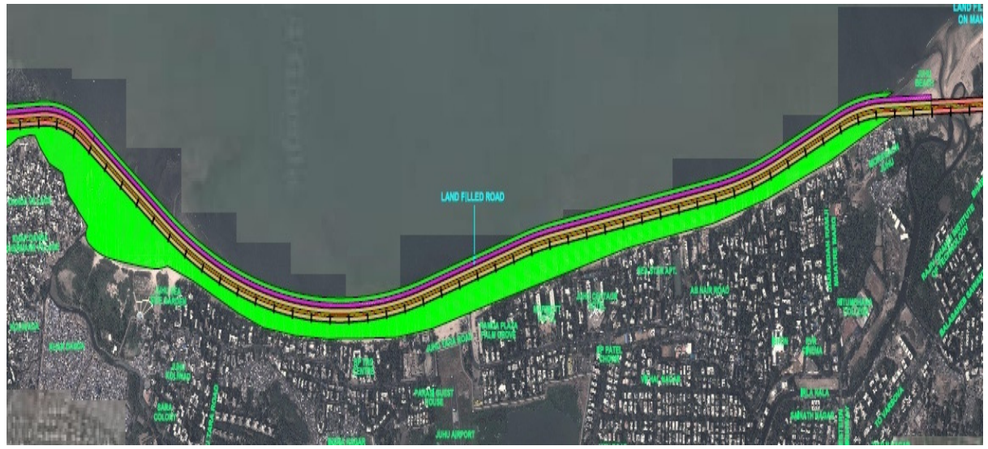
The options recommended by Coastal Road Committee was to provide tunnels initially passing through the Juhu Sea Side Garden followed by Juhu Airport and then following existing roads as shown in Figure---. This would require a poor geometry of tunnels. In case the proposed tunnels are built with cut and cover type of construction, it will require high traffic management with heavy disruption to public utilities, In case deep tunnels are provided with TBM method, the path is likely to interfere with other TBM tunnels planned for sewage disposal, water supply and metro line. With four tunnels necessary to carry planned eight lanes, this will require construction equipment

movement to access the shaft location. The option will have advantage of providing emergency exits and ventilation shafts at regular interval.

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
6	Juhu Sea Side Garden (Start of Tunnel) to Ritumbhara College (End of Tunnel)	Ramp Portion Tunnel Entry	Juhu seaside Garden	Juhu Koliwada	200	1.20	1
		Tunnel	Juhu Koliwada	Ritumbara college	3900		
		Ramp Portion Tunnel Exit	Ritumbara college	RGIT	300	1.80	

Section 6 Option-3

Juhu Sea Side Garden to Ritumbhara College



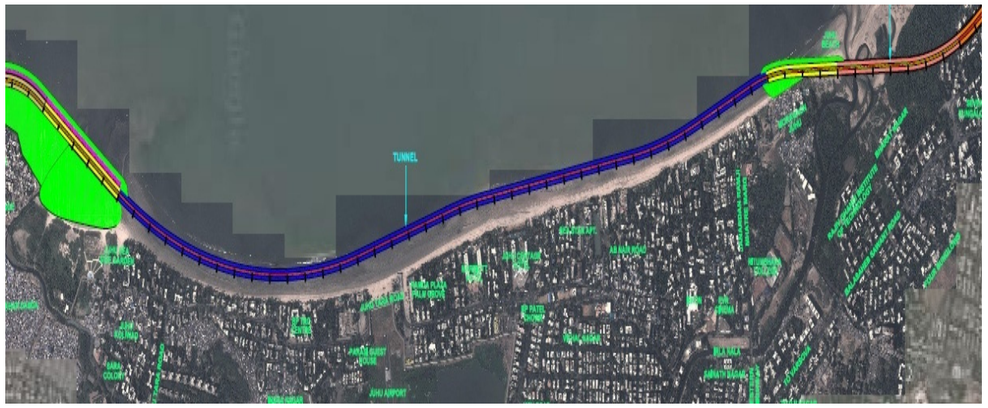
The option will impact on natural beach available at the sea front, hence not recommended for further studies.

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
6	Juhu Sea Side Garden (Start of Tunnel) to Ritumbhara College (End of Tunnel)	Land Filled Road	khar Danda	Ritumbara college	4700	62.14	1

Section 6 Option-4

Juhu Sea Side Garden to Ritumbhara College

Option of cut and cover tunnels each per direction of traffic was studied. The option will require heavy disruption to sea front during construction. Presence of rock outcrop at sea bed level will result in difficult excavation activity, requiring blasting operation close to populated beach front. Therefore the option is not considered as viable.

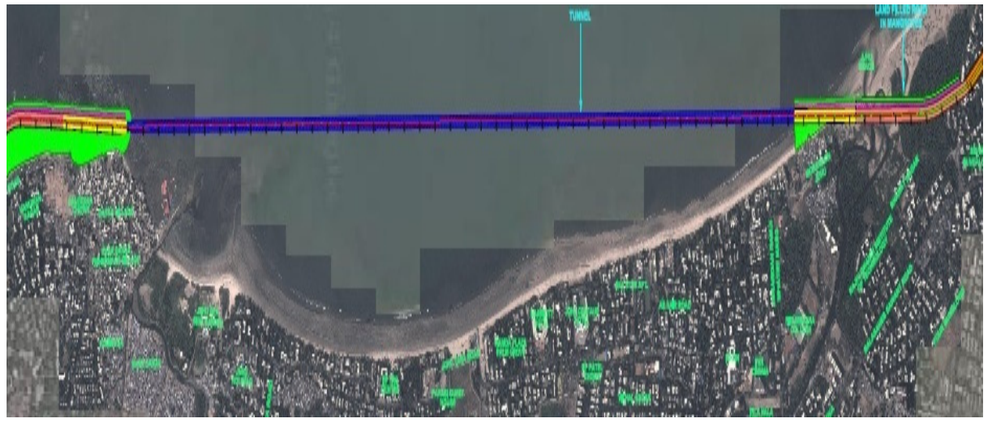


S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
6	Juhu Sea Side Garden (Start of Tunnel) to Ritumbhara College (End of Tunnel)	Ramp Portion Tunnel Entry	Khar Danda	Juhu seaside Garden	500	9.40	1
		Tunnel	Juhu seaside Garden	Ritumbara college	3800		
		Ramp Portion Tunnel Exit	Ritumbara college	RGIT	400		

Section 6 Option-5 & 6

Juhu Sea Side Garden to Ritumbhara College

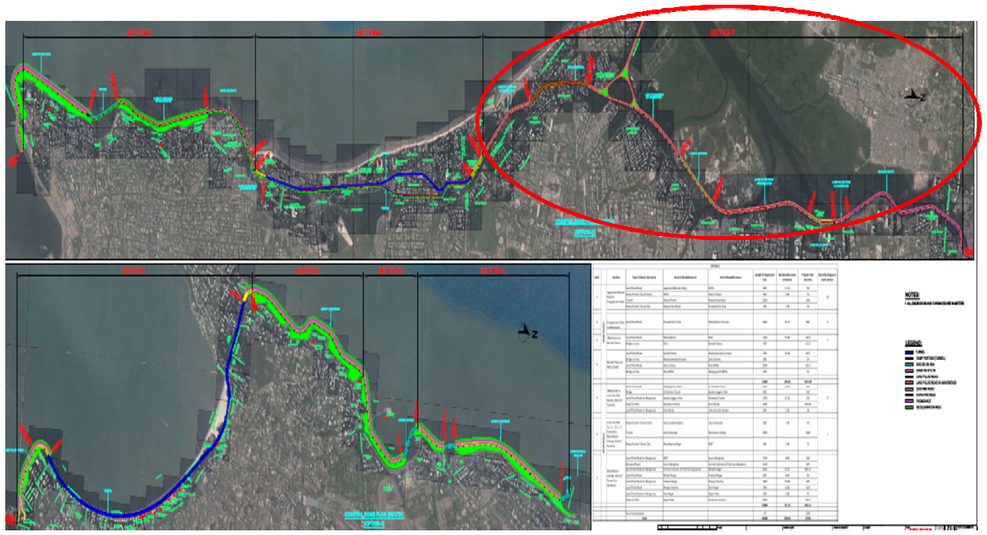
The option proposes four TBM tunnels with straight alignment with cut and cover portion limited to start and end of tunnel. TBM entry shafts shall be located near Ritumbara College by forming a temporary platform to +6m GTS level through reclamation. A shaft of 130m x 80m will be constructed to adequate depth for entry of TBM. Vertical faces shall be constructed and retained with touching piles/Diaphragm walls. Necessary dewatering arrangements shall be made to tackle water seepage. Similarly exit shaft shall be constructed near tunnel end near Khar Danda Village. The options was chosen on its merits for adoption.



S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
6	Juhu Sea Side Garden (Start of Tunnel) to Ritumbhara College (End of Tunnel)	Ramp Portion Tunnel Entry	Dandekar Chowk	Khar Danda	400	4.00	2
		Tunnel	khar Danda	Ritumbara college	4350		
		Ramp Portion Tunnel Exit	Ritumbara college	RGIT	400	4.00	

6.2.2.7 Section 7 Ritumbhara College to Kandivali Junction

The section of project road alignment traverses through Nana Nani Park, slum area of Andheri West, followed by Mangrove Area up to Kandivali. The alignment is very well defined due to non availability of any other option. In all the options it is proposed to construct a double deck elevated corridor up to Institute of Fisheries on existing road. This will affect very few structures erected on existing road land. However, minimum resettlement and rehabilitation will be necessary. The project road will then traverse through dense mangrove area at the rear of the Institute of Fisheries to include spur to Madh island. Continuity of the double deck bridge over existing road will lead in to road on stilts in this dense mangrove area, also crossing various perennial water bodies. Small sections of land fill over mangroves are proposed in this area for cost reduction.



6.2.2.8 Section 7 Option 1, 2, 3, 4, 5 & 6

Ritumbhara College to Kandivali Junction

Section 7 Option 1, 2, 3, 4, 5 & 6

Central Institute of Fisheries, Versova to Madh Island

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
7	Ritumbhara College (End of Tunnel) to Kandivali	Land Filled Road on Mangroves	RGIT	Seven Bungalows	1100	6.60	
		Elevated Road	Seven Bungalows	Central Institute of Fisheries Education	1100	??	
		Land Filled Road on Mangroves	Central Institute of Fisheries Education	Millat Nagar	4545	27.27	
		Land Filled Road	Millat Nagar	Prakash Nagar	800	4.80	
		Land Filled Road on	Prakash Nagar	Morgan Stanley	1800	10.80	

S.No	Section	Type of Road / Structure	Start of Road/Structure	End of Road/Structure	Length of Alignment (m)	Reclamation Area(Hectare)	No of Heritages in each section
		Mangroves					
		Land Filled Road	Morgan Stanley	Ram Nagar	480	2.88	
		Land Filled Road on Mangroves	Ram Nagar	Rajan Pada	300	1.80	
		Road on Stilts	Rajan Pada	Kandivali Junction	2450		

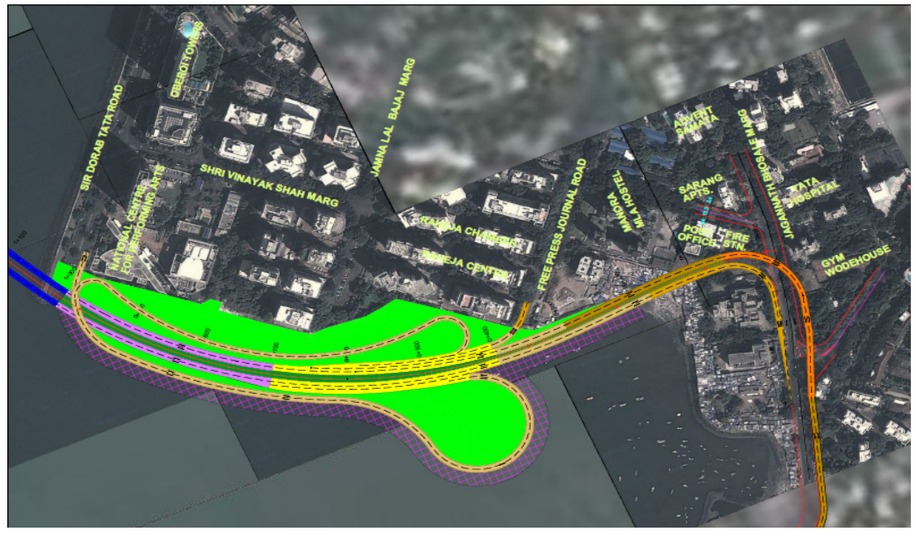
6.2.3 Recommended Alignment Option- Option 7

Based on above analysis alignment option-7 was formed and presented to the MCZMA. Based on the observations and suggestions received from the MCZMA the final option for section-7 has been formulated and presented in the figure below.

6.3 Interchange Design and Dispersal Scheme

6.3.1 Coastal Road Interchange (South Mumbai)

Jagannath Bhosale Marg Interchange:



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.

Entry Exit on Marine Drive near Pricess Street flyover:

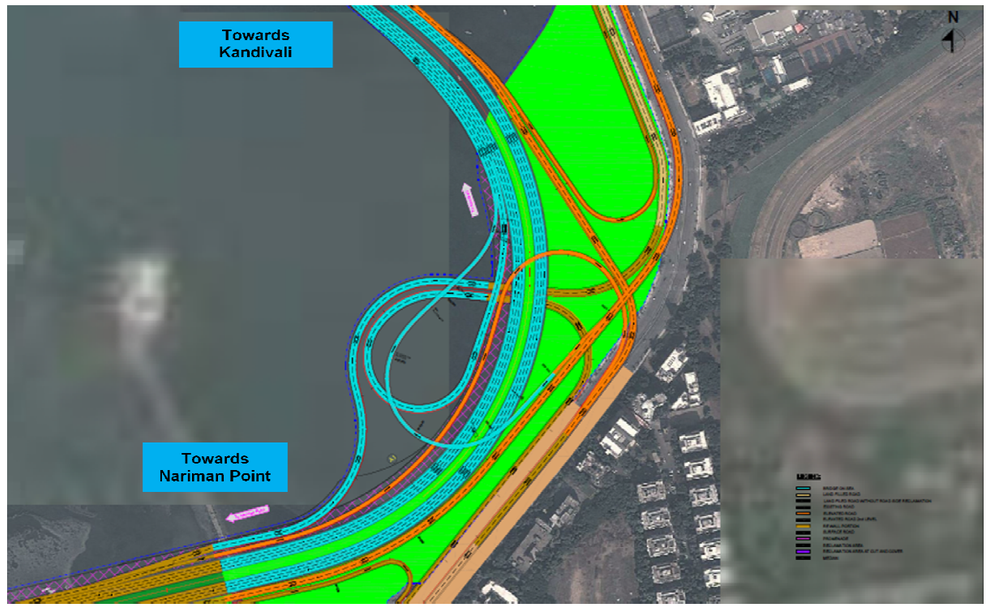
The proposed project road alignment starts by widening of existing promenade on an catilever maintaining the curved geometry of the marine drive. This is necessary to widen the existing road by 8m to provide for entry/exit of proposed tunnels on the Marine Drive. The proposed tunnels will start with a cut and cover section to be constructed by driving secant piles and providing a temporary steel structure to support traffic while excavation is carried out from top to bottom for cut and cover section.

Amarsons Garden Interchange:

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

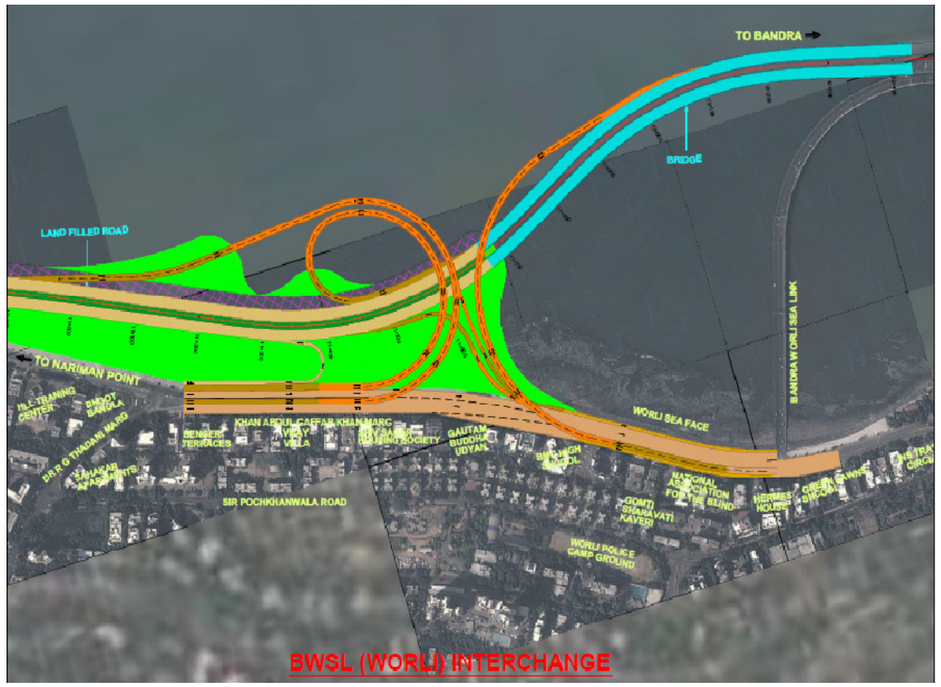
This interchange has 8 free flow movement of traffic between existing road and proposed costal road without any traffic conflict. Interchange location is near to Ch. 6+250 of proposed costal road south alignment just after end of marin drive tunnel section.

Haji Ali Interchange:



This Junction is the most important interchange, to provide connection for the religious places and the business area. It provides the connectivity with Lala Lajpatrai Marg by using three level Interchange. 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 coastal road traffic, free from conflict. This interchange location is near to Ch. 8+500Km of proposed costal road south alignment, near Haji Ali Dargah Junction.

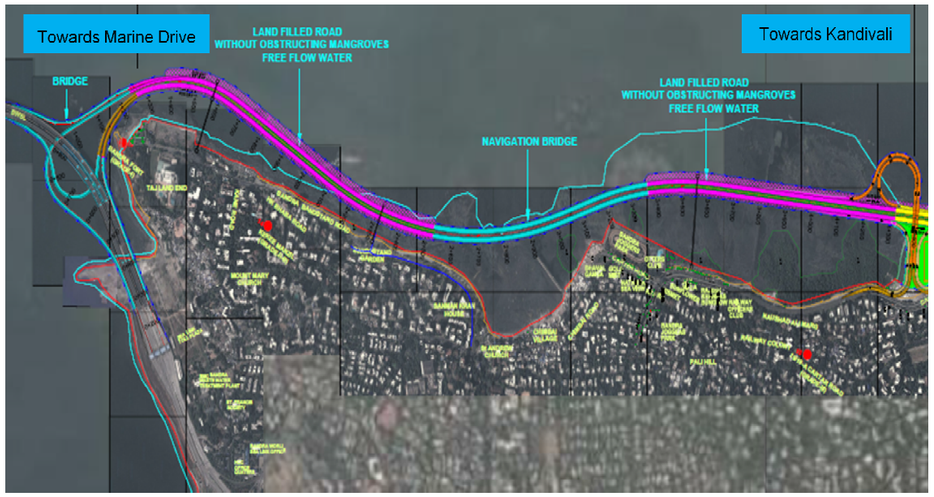
Bandra Worli Sea Link Interchange (Worli):



South face of Bandra Worli Sea Link (BWSL) atWorli will connect to the proposed alignment and before this merging, one interchange is proposed to provide the connectivity with the existing road. This trumpet interchange will connect the Khan Abdul Gaffar Khan Marg near Gautam Buddha Udyan to the proposed alignment, by an 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 all round.If Traffic coming from north of BWSL wantsto exit from coastal road, it will follow the existing bridge of BWSL. In this case, it will conflict with existing road traffic. To avoid this conflict it is proposed to provide one VUP at existing road. The Interchange location is Ch. 11+600Km of proposed coastal road south alignment, before the existing Bandra Worli sea link road.

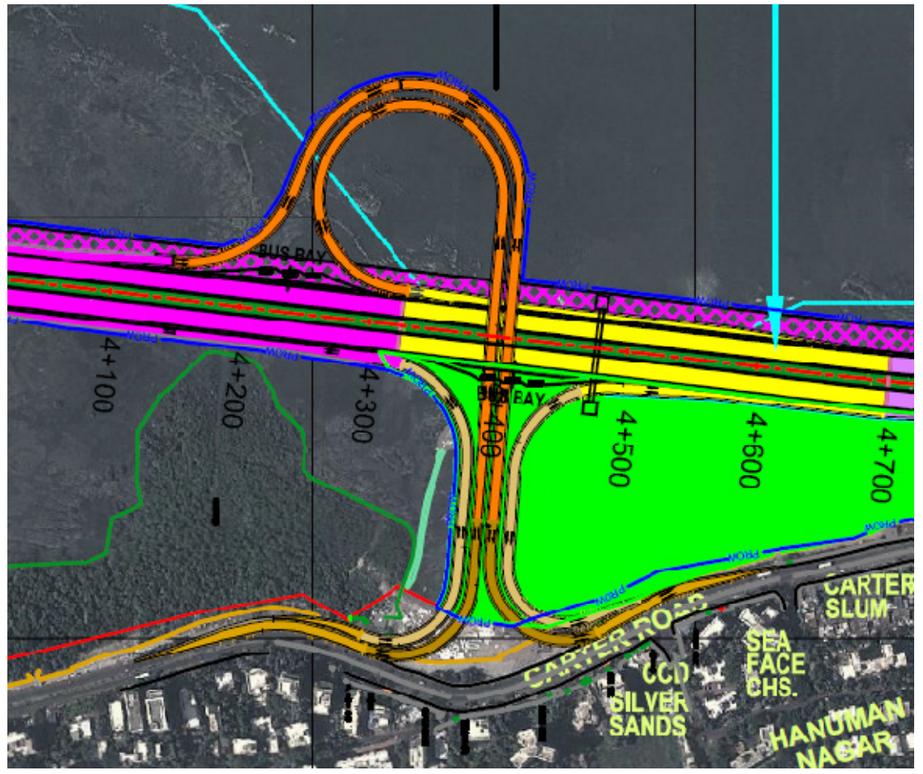
6.3.2 Coastal Road Interchange (North Mumbai)

Bandra Worli Sea Link Interchange (Bandra):



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

Carter Road Interchange (Danda Village):

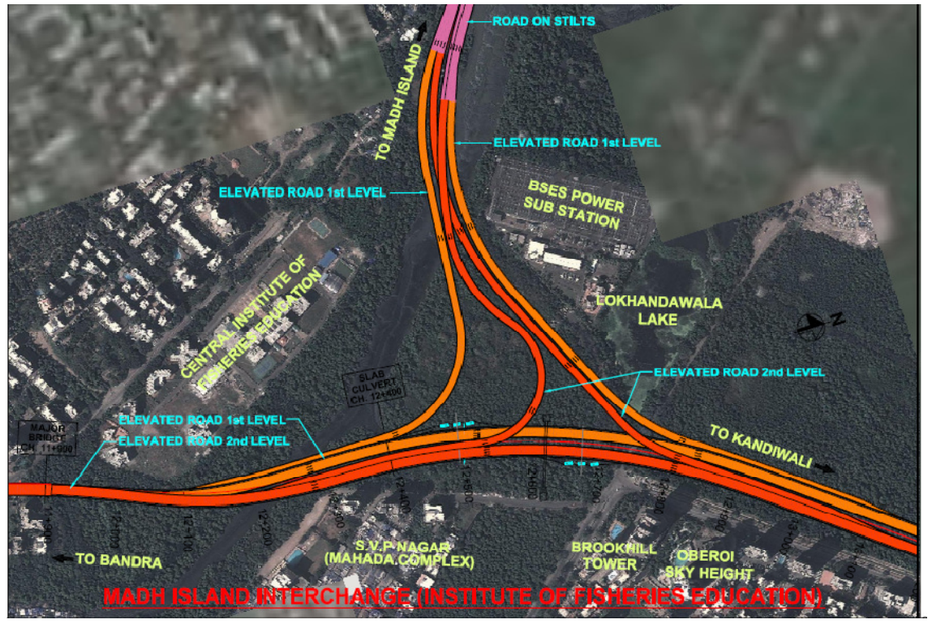


This interchange provides connection to Carter road in front of Danda Khala fish drying ground at ch. 4+500Km before start of Juhu tunnel ramp. Entry and exit ramp is provided with acceleration and deceleration length towards south or north Mumbai. This provides connectivity to Khar East & West, Juhu, Santacruz East & West area. This interchange location is near ch. 4+000Km of proposed coastal road North Alignment.

Ritumbra Interchange collage:

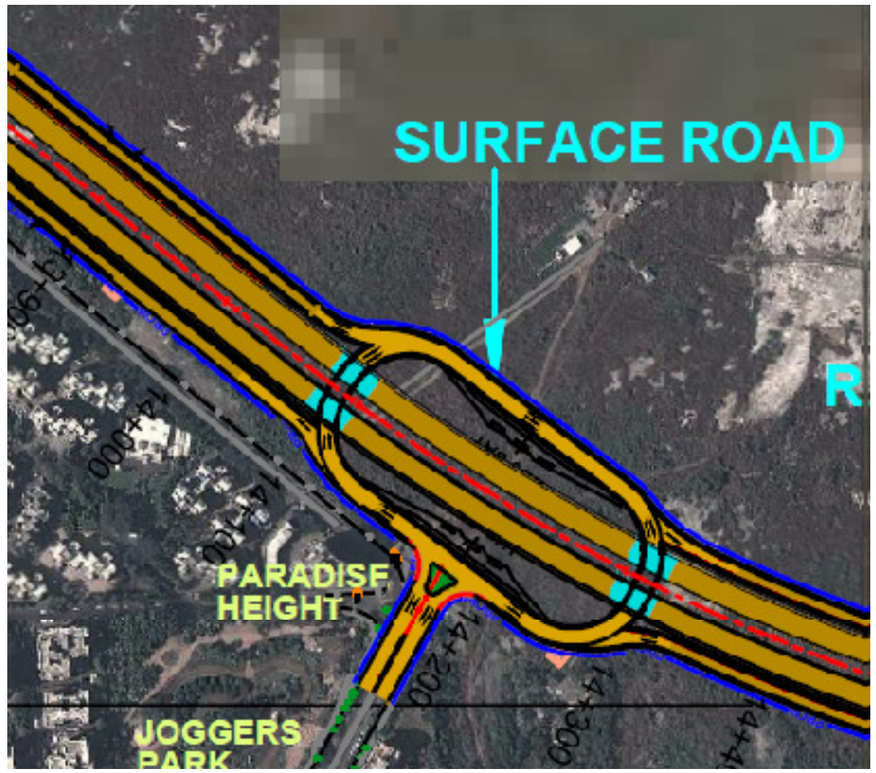
This Interchange passes near to Moragaon Juhu and merges with the road in front of Ritumbra college in Juhu west. Entry and exit ramps are provided for both sides, moving traffic on proposed alignment. This interchange provides the connectivity for Andheri East & West and Juhu area. Interchange location is near to Ch. 10+600Km of proposed coastal road north alignment just after end of Juhu tunnel.

Madh Island Interchange (Institute of Fisheries Education):



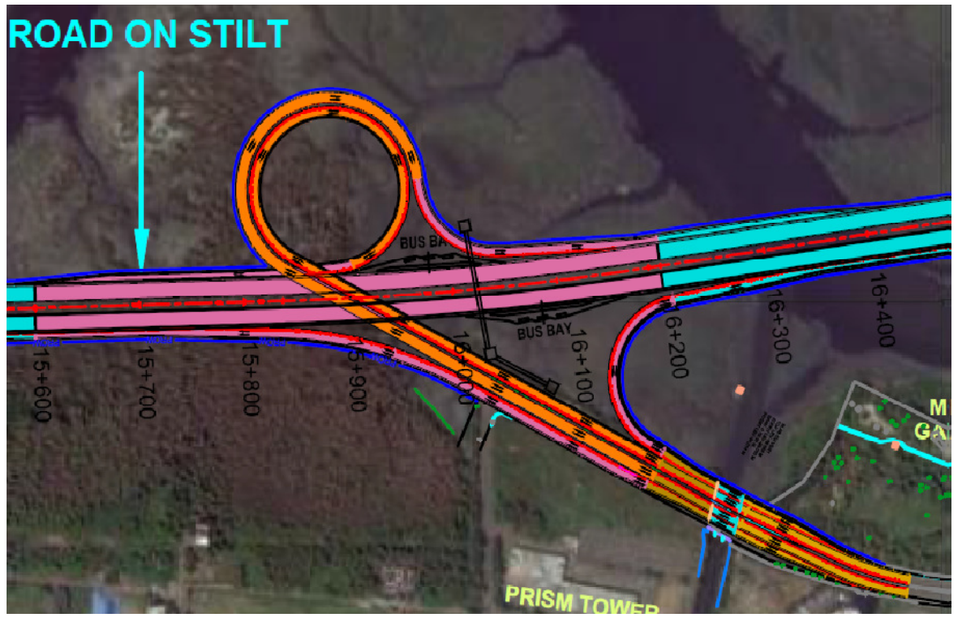
This interchange provides connectivity to MADH ISLAND using entry and exit for north and south Mumbai. Only one side connection towards MADH Island is provided by this interchange located at ch. 12+600 of coastal road north alignment.

Oshiwara Interchange:



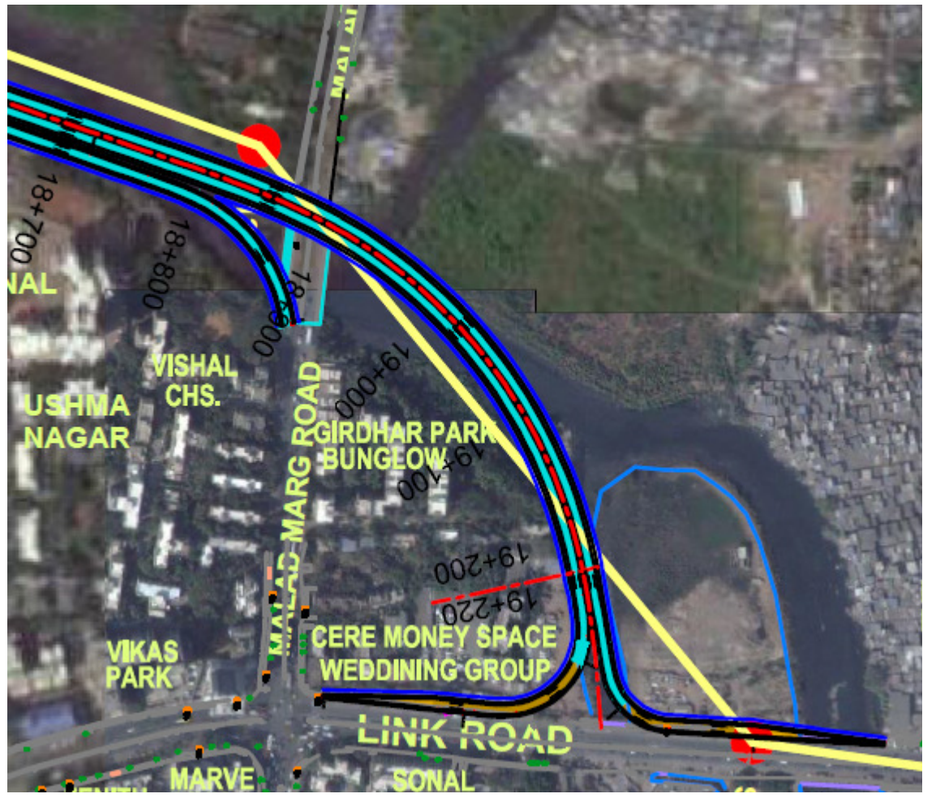
This interchange provides connectivity to Goregaon east and west, Jogeshwari west area traffic. Entry ramp taper starts from Park paradise Aparrments and exit ramp taper end near to Windmere CHS. This interchange provides free traffic flow in all directions at ch. 14+200Km of north coastal road alignment.

Malad Interchange:



Malad interchange at ch. 16+000Km of north coastal 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 movement, with free flow of traffic. Traffic movement areas are covered from Goregaon East & West, Malad East & West location.

Kandivliinterchange:



This interchange is at the end point of the proposed north coastal Road alignment at ch 19+450Km, which merges with the existing link road by providing trumpet interchange. It gives connectivity of entry and exit on to proposed alignment, with required acceleration and deceleration. This interchange coversed traffic from Malad East & West, Kandivli East & West, Borivli East & West area

7. Engineering Survey and Investigations

7.1 Site Investigation

The Field investigations were conducted on the alignment of Project Corridor approved at feasibility stage. 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

Material Investigation

Bathymetric survey

Hydrological Survey

Utilities Survey

7.1.1 Topographical Survey

General

To know the topographical conditions within the proposed roadway boundary a 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 was selected by MCGM through feasibility stage and recommendations therein , a topographic survey (a large scale instrument survey by running a traverse along the selected route/alignment) was conducted to capture all physical features which affect the location on the selected new route/improvement alignment. Longitudinal and cross sections shall be taken for a width covering proposed cross section along the proposed alignment and Bench Marks were established. Total station / Global positioning system were used for conducting survey. In order to collect sea bed levels (bathymetry), the surveys were conducted during low tide in such areas to cover entire area where road is planned. Permanent Control pillars and Bench Marks shall be established at suitable intervals. Based on the data collected, centre line of the road was finalized.

The Topographic survey report is presented in Volume II of Detailed Project Report

Geotechnical Investigations

Bore holes at each abutment and at locations across the structure at not more than 200m intervals, subject to there being at least two intermediate bores for structures of more than one span will be taken. Findings of Geotechnical Investigations are presented in Geotechnical Report. Additional investigations are to be undertaken for tunnel alignments and separate additional reports shall be submitted for these investigations.

7.2 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 was used to compute the discharge. The discharges computed as per guidelines in IRC: SP-13-1998 and reccomondation of BRIMSTOWAD report are presented in the Drainage report.

7.3 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 are being collected from various agencies along with planned relocation of these utilities.

7.4 Land acquisition plans

Cadastral maps were 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 were collected for preparation of Land acquisition proposals. Also land acquisition proposal has been prepared for MCGM and assistance rendered to comply with remarks which the competent authority during the process of Land Acquisition. The land acquisition plans are provided as appendix to Rehabilitation and Resettlement Report

7.5 Material Survey and Investigation

Material investigations were carried out to determine available quality and quantities of materials with their lead from the proposed site of construction. The findings are presented in the Material Report.

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 JTC 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 and along the Marine Drive areas, allows the tunnel to bypass the main present day traffic bottlenecks. The tunnel length would be around 5 km and 3km respectively. 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 an average, the tunnel would be located about 20-30m below the ground level.

8.3 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).

8.3.1 Tunnel Design

Tunnel design depends upon the following:

Design Criteria

Design Basis

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 of 20000 PCU

- Signalling system beyond entry & exit points.
- Number of Lanes = 2 lanes in each tube.

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

8.4 Design Basis for Tunnel

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 and adequate headroom. Initial portion shall be cut and cover to accommodate up ramp and down ramps at entry and exit of tunnel.

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 insitu depending on construction methodology to be adopted.**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 500m a 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 would need to be provided.

8.5 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 extinguishers at a spacing of 50 m

Alignment: -

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

- 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 of primary concern while deciding Geometrics of the tunnel i.e.

- Cross section
- Gradient
- Curvature
- Width of the tunnel:
- 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

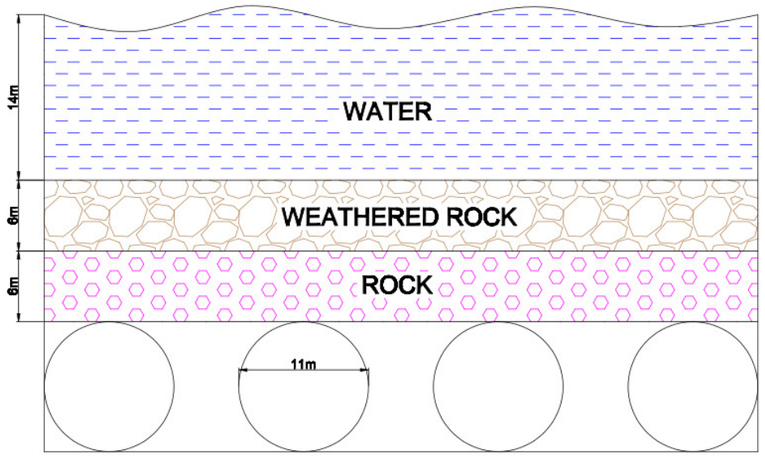
For this project 0.3% gradient shall be adopted in viewing the length of the tunnel being 5km to break the monotony after 2.5 km reverse gradient shall be provided. Design speed is considered as 80 km/hr.

Horizontal Alignment:-

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

Crown Level of Tunnel:

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



8.6 Assessment of Technical Feasibility

Geology: - Typical bore log near Marine lines is considered for preliminary assessment.

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

Tunneling option is preferred for following consideration:

- Road Tunnel is a feasible alternative to cross the water body, in view of the geological set up in the continental shelf.
- This satisfies environmental and ecological requirements.
- Girgaon chowpatty 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.
- Drainage details shall be shown in good for construction drawings. These drainages 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 TBMs (Tunnel Boring machines) 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	Circular
Support	Shotcrete, Ribs, Bolts	Precast Segments
Progress	22m per month	500m per month
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 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.

Tunnel Boring Machine

8.7 Details of TBM 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..

TBM excavation represents a big investment in an inflexible but potentially very fast method of excavating and supporting a rock tunnel (Barton, 1996). When unfavorable 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 influence is 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

8.8 Design of the tunnel in the TBM alternative

8.8.1 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 breccias/basalt rock as specified in the geological report. During construction, the Contractor shall enable and assist the Supervisory Agency 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 TBM which will give 6m per day progress even with 32% efficiency of TBM utilization this 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. On completion of geotechnical investigations and additional studies on new alignment of proposed tunnel a separate Tunnel Report as an appendix to this report shall be submitted.

8.9 Tunnel Safety Services

8.9.1 Introduction

Mumbai Coastal Road is proposed to decongest Western Expressway in order to reduce travel time, allow bus rapid transport and eventually raise quality of the citizens. The road is planned to also create new public places and redefine western coast line characteristics. Final alignment consists of two sections of tunnels with 3.2km length and 5.7km. First twin tube tunnel starts near Princess Street flyover and ends at Priyadarshini Park and second four tube tunnel starts at Khar Danda village and ends near Ritumbhara College. Both proposed tunnels will be constructed by boring with Tunnel Boring Machines with 11m diameter predominantly under sea bed.

Safety in tunnels requires a number of measures relating, amongst other things, to the geometry of the tunnel and its design, safety equipment, including road signs, traffic management, training of the emergency services, incident management, the provision of information to users on how best to behave in tunnels, and better communication between the authorities in charge and emergency services such as the police, fire-brigades and rescue teams.

- **Design standards**

The requirement of tunnel services is based on best international practices and following codes have been referred:

- United Kingdom: Highway agency standard BD78/99 design of Road Tunnels
- PIARC Tunnel Design Manual
- European Directive 2004/EC/54 of the European Parliament and council Members
- Indian Road Congress Code **IRC 92**

8.9.2 Design Objectives:

The design of tunnel services shall meet following design objectives:

- Provide continuous control of internal air quality to meet the specified requirement;
- Provide adequate visibility levels in all conditions at all times of the day and night;
- Provide appropriate collection, treatment and desposal of ground water and surface wash waters;
- Provide mechanical ventilation and smoke control systems capable of fully functional continuous operation for a range of fire events;
- Provide emergency egress from all areas of tunnels;
- Provide emergency response facilities in accordance with operational standards required by the authority;
- Minimize whole life costs;
- Incorporate mitigation measures from risk analysis as per EU directive
- The strategy for design of tunnel services shall be to adopt minimum acceptable provisions, with due regard to international best practices. The design of tunnel services shall achieve safe tunnel environment for following stake holders:
    - Road users;
    - Local residents;
    - Tunnel owner and operator;
    - Maintenance staff;
    - Police and civil defence
    - Fire Authority;
    - Emergency services;
    - Government control authorities;
    - Basis of tunnel services design
- The length of tunnels are as follows:
- Tunnel-1: Princess Street Flyover to Priyadarshini Garden with length of 3200m with maximum gradient of 4%
- Tunnel-2: Khar Danda to Rutumbhara College with length of 5700m and maximum gradient of 4%
- Traffic Volumes:
    - The design of tunnels shall be based on traffic volumes provided in Traffic Report.
    - Average age of vehicles considered as 14 years.
    - With respect to above traffic conditions, the design of tunnel services is based on assumption that, no motorcycles, pedestrians and dangerous goods vehicles shall be allowed to enter the tunnels. These vehicles shall use alternative routes available.

- **Design Life:**

Design life is defined as the period over which the asset must perform its functional requirements without replacement with adequate maintenance. The design life for various aspects of tunnel services shall be as per table below:

Asset	Design Life
Inaccessible elements of drainage, fire protection, lighting, mechanical, electrical, traffic management and control system	100 years
Tunnel lining and structures	100 years
Buildings	50 years
Signs structures and road furniture	40 years
Drainage elements that are accessible for replacement	20 years
Mechanical and electrical equipments	20 years
Lighting	20 years
Fire protection system	20 years
Traffic management and control system	20 years

- **Risk Assessment**

Risk assessment is essential part of tunnel services and structural design. This has been considered in related to various incident scenarios which may occur during operation of the proposed tunnels. Risk analysis is based on risk rating of various incidents and their impact on the proposed tunnel structure and users.

- **Event Probability:**

Description	Scenario	Probability
Highly likely	Very frequent occurrence	Over 85%
Likely	More than even chance	51-85%
Fairly likely	Occurs quite often	21-50%
Unlikely	Could happen but not very often	1-20%
Very unlikely	Occurrence is not expected to happen	Less than 1-0.01%
Extremely unlikely	Just possible but very surprising	Less than 0.01%

- **Event Impact:**

Description	Scenario Examples
Disastrous	Tunnel operation could not be sustained
Severe	Serious threat to tunnel operations
Substantial	Increases operational costs/difficulties substantially
Marginal	Small effect on operational cost /difficulty
Negligible	Trivial effect

- **Risk response strategies**

Risk Action Required	Possible Response
Elimination	Change provision such as that risk cannot occur.
Avoidance	Modify provision so that risk greatly reduced.
Transfer	Not likely to be able to do this for safety aspects.
Mitigation	Measures taken to reduce impact of risk if it were to occur
Acceptance	It is an accepted risk and it is negligible or there are no cost effective solutions available.

Vehicle related incidents: Tunnels are being design to carry traffic loading and there are events of varying probability which may affect safe operation of the tunnel.

- **Fire in the Tunnel:**

Fires in tunnel are a serious risk and the probability of such incidence is based on likelihood of a serious accident occurring inside the proposed tunnel and the vehicle involved catching fire. Tunnel alignment for tunnels have been maintained as straight alignment with maximum grade of 4% allowing high visibility distance. It is proposed to reject all vehicles carrying flammable and dangerous goods on entire coastal road. This is to eliminate risk of such vehicle entering in to tunnels and getting involved in to an accident. Such type of vehicles may cause fires of up to 100MW having disastrous effect on tunnel structure. Based on present traffic volumes the HGV percentage is likely to be less than 5% of overall traffic volume. Hence a 50MW fire (BD 78/99 table 8.2) is adopted for design of ventilation to bring the impact to an acceptable level.

- **Accidents:**

Probability of occurrence of accident in an uni-directional tunnel is very unlikely. To reduce the probability of same to extremely unlikely event, alignment of the tunnels has been designed as straights with maximum grade of 4%. This will ensure high visibility to stopping vehicle/ debris on road. It is also proposed to restrict the vehicle speeds to 80Kmph for entire coastal road and enforce the same through speed detection cameras.

- **Breakdown and debris on road:**

Risk of occurrence of such event is similar to accidents. Automatic incident detection system shall be implemented to reduce the impact of such event.

- **Oversize vehicles:**

It is proposed to restrict entry of all over sized vehicles to coastal road to eliminate such risk.

Non Vehicle related incidences

- **Animals in Tunnel:**

It is proposed to provide guard rails along entire costal road to restrict entry of animals on the traffic lanes. Therefore, risk of such event is extremely unlikely.

Vandalism: considering that this is an urban tunnel, it is necessary to provide for securitization of likely entry points to the tunnels by pedestrians. Such a vandalism event may have very high impact on tunnel services. Therefore control room shall be provided with automatic incident detection system to report stoppage of vehicles and pedestrian inside tunnel. Control rooms shall be manned 24x7 to register and act on such incidence. However to eliminate risk of this high impact event, the SCADA software shall be capable of sending message to enforcement agency automatically with details of location.

- **Terrorist Attack:**

Impact of such event on tunnel operation would be disastrous and would require immediate action by local police. The method of reducing risk of such event shall be discussed with the authority.

- **Traffic Queues:**

Risk of occurrence of traffic queues is unlikely considering adequate number of lanes have been proposed with adequate distances from tunnel entry/ exit points from proposed interchanges. However, event of traffic queuing is unlikely to impact on tunnel services. Environmental monitoring sensors are proposed to adjust level of tunnel services such as lighting and ventilation.

Compliance of EU Directive

Structural measures	Twin tubes Mandatory where a 15-year forecast shows that traffic > 10 000 veh./lane.	Twin/ Multiple uni-directional tunnels proposed
	Gradients less than 5% are mandatory	Gradients shall be restricted to 4%
	Emergency walkways are mandatory where no emergency lane is provided	Provision of emergency walkway is proposed
	Emergency exits every 500m are mandatory	Cross connections proposed at every 500m
	Mandatory cross-connections for emergency services at least every 1 500 m	Cross connections proposed at every 500m
	Crossing of the central reserve outside each portal (mandatory requirement)	It is proposed to provide continuous cut section to adopt the same
	Drainage for flammable and toxic liquids is mandatory where such goods vehicles are allowed	Although such inflammable and toxic goods carrying vehicles will be rejected. Drainage provisions have been made underneath the pavement
	Fire resistance of structures is mandatory where local collapse of structure may have disastrous effect	Complied by making such provisions
Lighting	Normal Lighting	Proposed as per CIE 88, 2004
	Safety lighting	Proposed as per CIE 88, 2004
	Evacuation lighting	Provided over footways
Ventilation	Mechanical ventilation	Proposed longitudinal ventilation by providing jet fans
	Mandatory semi transverse ventilation for tunnels of more than 3000m length	Provisions made through supply ducts and ventilation shafts.
Emergency stations	Mandatory provision of emergency stations at 150m equipped with telephone and two fire extinguishers necessary	Provision to be made at every 150m.
Water supply	At every 250m	Water supply pipe attached to water tank to be provided with supply point at every 150m to match location of emergency station.
Road signs	Mandatory	Provided with road signs
Control center	Surveillance of several tunnels may be 120entralized into a single control centre.	Two control centers shall be provided first near Priyadarshini Park and second near Rutumbhara college to cover two tunnel sections. The control centers are located at start of tunnel as well as center of south and north section of coastal road to respond to incident on entire stretch with provision of SCADA.
Monitoring systems	Video	CCTV cameras shall be provided along tunnels as well as highway
	Automatic incident detection and/or fire detection	SCADA system connected to CCTV equipped with automatic incident detection system and response is proposed.
Equipment to close tunnel	Traffic signals before the entrances	The mandatory provision is to be complied by provision of gate controlled from Control center
	Traffic signals inside the tunnel at least every 1 000 m	It is propsed to provide traffic signals at every 500m before every cross connection to enable traffic diversion to parallel tunnel in case of incident.
Communications system	Radio re-broadcasting for emergency services	Provisions made connected to SCADA system
	Emergency radio messages for	Provisions made connected to SCADA

	tunnel users	system
	Loudspeakers in shelters and exits	Provisions made connected to SCADA system
Emergency power supply	Mandatory	It is proposed to equip control center with necessary capacity of standby generators with necessary fuel storage
Fire resistance of equipment	Mandatory	All tunnel fixtures and fitting shall be fire resistance compliant.
Additional Provisions	Drainage	It is proposed to provide sump and pumping arrangement to collect seepage/ storm water at lowest point of tunnels and dispose the same to sea.
	Leaky feeder cable	It is proposed to provide leaky feeder cable to enable use of mobile services within tunnels.
	Environmental monitoring censors	It is proposed to provide environmental monitoring censors to monitor visibility levels, air quality and smoke detection
	Linear Heat Detection	Linear heat detection is proposed through adoption of OFC cables cross looped to detect exact location of fire.
	Varibale Message signs	It is proposed to provide VMS system attached to SCADA at control center to enable safe tunnel operation.

The electrical and mechanical utilities have been planned in accordance with International practice followed as per standard codes of practice. It is intended to present in the following, an overall view of the design criteria adopted for the various services for the road tunnels proposed along the Coastal Road Project.

In order to optimize the cost of services, the location of HT Substation, Fire & Water Supply pumps, and the Nodal Operation Centers (NOC) play a very important role in terms of saving in cost of expensive cables length & minimizing the line losses and similarly piping between water tanks and pumps including location of various load centres in the tunnel.

The proposed tunnels are being constructed in two sections, i.e. the South Portal and North Portal. The Electro-Mechanical Services considered for both the sections is covered in this report.

The design of all Electro-Mechanical and Safety Systems shall be as per the guidelines laid down under;

1. IRC: SP: 91 (2010).
2. PIARC
3. SOLIT²
4. ASHRAE
5. NFPA

In this report the services that shall be covered area Ventilation, Electrical, Lighting, Fire Protection Systems& Detection Systems, Video Surveillance and Access Control Systems, Public Address and Emergency Telecommunication Systems, Traffic Control Systems and SCADA.

8.9.3 Ventilation System

8.9.3.1 Introduction

Internal combustion engines used for powering most of the vehicles are either of spark-ignition type or of compression ignition type. These types of engines generate exhaust fumes and smoke with different characteristics. Major constituents of these obnoxious exhaust fumes and smoke are carbon monoxide, carbon dioxide, oxides of nitrogen and sulphur dioxide. In addition to these components, spark-ignition type engines also emit small amounts of un-burnt hydrocarbons.

8.9.3.2 Carbon monoxide (CO)

Carbon Monoxide is an odorless toxic gas which when inhaled readily combines with blood hemoglobin in preference to oxygen, reducing the oxygen carrying capacity of the blood. This has very toxic effects which could be fatal on extended exposure to CO. The process gets reversed upon timely exposure to fresh air.

8.9.3.3 Carbon Dioxide ($C0_2$)

Carbon Dioxide is a very stable compound which does not readily react with other compounds and is toxic only at very high levels of concentration. These levels of CO_2 which are found in vehicular traffic tunnels are generally well within the human threshold level of CO_2.

Nitric Oxide (NO) and Nitrogen Dioxide ($N0_2$)

These oxides unite with water and form nitrous and nitric acid in the lungs and destroy the functioning of lungs.

8.9.3.4 Sulphur Dioxide ($S0_2$)

Sulphur Dioxide in presence of water forms sulphuric acid and causes toxic effects. However, the levels of $S0_2$ found in vehicular emissions are very small to be of any major concern.

8.9.3.5 Hydrocarbons

Hydrocarbons are also a very small component of vehicular emissions. To ensure a safe environment within the tunnels, these compounds need to be removed. This can be done either by oxidation or physical replacement in cases of stable compounds like CO_2. Both these can be achieved through ventilation. The main intention of ventilation is to create user-friendly healthy environment inside a tunnel.

When a vehicle travels on an up-gradient, it needs extra power causing increased fuel consumption and resulting in increased quantum of pollutants, as compared to a vehicle moving on level road. A vehicle may have to slow down and move in low gears causing slightly increased emission of pollutants while traveling upgrade. When traffic comes to a halt and the vehicles are required to idle, production of CO increases. However, during idling, the rate of consumption of fuel is very low and the total emission of CO is generally not more than that for normal traffic.

Characteristics of Traffic are of paramount consideration for the designers of ventilation system. Traffic Volume, Traffic Density and Traffic Composition have a direct bearing on the vehicular exhaust emissions.

In vehicles with spark-ignition engines, at higher elevations, air fuel mixture becomes richer due to lack of oxygen in the atmosphere. This results in higher concentration of CO in the exhaust.

In case of compression-ignition engines, lack of oxygen in the atmosphere causes increase in smoke production.

8.9.3.6 Methods of Ventilation

Ventilation in tunnels is either done through by natural means or by mechanical means.

8.9.3.7 Natural Ventilation

Natural Ventilation is caused by movement of air due to chimney stack effect created by the difference in level between two portals of a tunnel. Difference between the ambient temperature at the two portals and wind also plays a part in creating natural draft. Piston effect created by the vehicular traffic creates additional draft.

As per IRC: SP: 91 (2010), normally, for tunnels shorter than 500 m. in length, natural ventilation is enough. Exception would be urban tunnels with heavy traffic volume having possibility of congestion during peak hours, tunnels in high altitudes and tunnels longer than 500 m. having very low traffic volume.

Where technically feasible, provision of a vertical shaft near about the center of a tunnel would effectively improve natural ventilation because of additional chimney stack effect created by it. If such a shaft is fitted with an exhaust fan, the chimney stack effect will not be affected by change in atmospheric conditions.

8.9.3.8 Mechanical System of Ventilation

In case of all tunnels more than 500 m. in length, Mechanical System of Ventilation should be provided unless the traffic volume is very low.

The two types of ventilation systems used separately or in combination are as linear system and transverse system. In this case as both the tubes are unidirectional with ventilation shafts provided at either ends, linear system of ventilation is being proposed.

Two speed, truly reversible jet fans are proposed for these tunnels.

For South Portal (Left Tube)

Sn. No.	Particulars	L1 (Left Wall) m	L2 (Right Wall) m	L (Total) m
1.0	Ramp	269.39	269.87	269.63
2.0	Cut & Cover	495.54	500.27	497.91
3.0	Tunnel	1997.17	1994.43	1995.80
4.0	Cut & Cover	390.44	385.26	387.85
5.0	Ramp	250.03	250.00	250.02
6.0	Total	3402.57	3399.83	3401.20

For South Portal (Right Tube)

Sn. No.	Particulars	L1 (Left Wall)m	L2 (Right Wall)m	L (Total)m
1.0	Ramp	325.89	325.92	325.91
2.0	Cut & Cover	528.10	533.07	530.59
3.0	Tunnel	1988.55	1985.81	1987.18
4.0	Cut & Cover	374.73	369.55	372.14
5.0	Ramp	250.00	250.03	250.02
6.0	Total	3467.27	3464.38	3465.83

For North Portal (Left Tube T1)

Sn. No.	Particulars	L1 (Left Wall)m	L2 (Right Wall)m	L (Total)m
1.0	Ramp	376.07	376.16	376.12
2.0	Cut & Cover	497.72	498.64	498.18
3.0	Tunnel	4322.99	4323.38	4323.19
4.0	Cut & Cover	375.12	375.16	375.14
5.0	Ramp	200.00	200.00	200.00
6.0	Total	5771.90	5773.34	5772.62

For North Portal (Left Tube T2)

Sn. No.	Particulars	L1 (Left Wall) m	L2 (Right Wall)m	L (Total)m
1.0	Ramp	376.07	376.16	376.12
2.0	Cut & Cover	497.31	498.23	497.77
3.0	Tunnel	4324.20	4324.58	4324.39
4.0	Cut & Cover	374.90	374.91	374.91
5.0	Ramp	200.00	200.00	200.00
6.0	Total	5772.48	5773.88	5773.18

For North Portal (Right Tube T3)

Sn. No.	Particulars	L1 (Left Wall) m	L2 (Right Wall)m	L (Total)m
1.0	Ramp	376.23	376.31	376.27
2.0	Cut & Cover	499.03	499.94	499.49
3.0	Tunnel	4325.41	4325.79	4325.60
4.0	Cut & Cover	375.05	374.54	374.80
5.0	Ramp	200.00	200.37	200.19
6.0	Total	376.23	376.31	376.27

For North Portal (Right Tube T4)

Sn. No.	Particulars	L1 (Left Wall) m	L2 (Right Wall)m	L (Total)m
1.0	Ramp	376.23	376.31	376.27
2.0	Cut & Cover	499.44	500.35	499.90
3.0	Tunnel	4326.61	4327.00	4326.81
4.0	Cut & Cover	375.54	375.23	375.39
5.0	Ramp	200.00	200.37	200.19
6.0	Total	5777.82	5779.26	5778.54

8.9.3.9 Tunnel Ventilation Calculation

- **Tunnel South Portal (L)**

1. **Effective cross-sectional Area of Tunnel = 63.35 m²**
2. **Total Length of Tunnel = 1995.80 m**
3. **Effective Volume of Tunnel,(V) = Effective C/S Area of Tunnel * Total Length of Tunnel = 63.35 * 1995.80 = 1,26,433.93 m3**

- **Tunnel South Portal (R)**

4. **Effective cross-sectional Area of Tunnel = 63.35 m2**
5. **Total Length of Tunnel = 1987.18 m**
6. **Effective Volume of Tunnel,(V) = Effective C/S Area of Tunnel * Total Length of Tunnel = 63.35 * 1987.18 = 1,25,887.853 m3**

- **Tunnel North Portal (LT1)**

7. **Effective cross-sectional Area of Tunnel = 63.35 m2**
8. **Total Length of Tunnel = 4326.81 m**
9. **Effective Volume of Tunnel,(V) = Effective C/S Area of Tunnel * Total Length of Tunnel = 63.35 * 4326.81 = 2,73,874.08 m3**

- **Tunnel North Portal (LT2)**

10. **Effective cross-sectional Area of Tunnel = 63.35 m2**
11. **Total Length of Tunnel = 4324.39 m**
12. **Effective Volume of Tunnel,(V) = Effective C/S Area of Tunnel * Total Length of Tunnel = 63.35 * 4324.39 = 2,73,950.10 m3**

- **Tunnel North Portal (RT3)**

13. **Effective cross-sectional Area of Tunnel = 63.35 m2**

14. **Total Length of Tunnel = 4325.60 m**
15. **Effective Volume of Tunnel,(V) = Effective C/S Area of Tunnel * Total Length of Tunnel = 63.35 * 4325.60 = 2,74,026.76 m³**

- **Tunnel North Portal (RT4)**

16. **Effective cross-sectional Area of Tunnel = 63.35 m2**
17. **Total Length of Tunnel = 4325.60 m**
18. **Effective Volume of Tunnel,(V) = Effective C/S Area of Tunnel * Total Length of Tunnel = 63.35 * 4325.60 = 2,74,103.41 m3**

8.9.3.10 Fan Selection

Considering the fan selection from *table 1.7* below,

Speed (r/min)	Airflow maximum (m³/h)	Thrust (N)	Speed Impulsion (m/s)	Discharge area (m²)	Max. Power installed (kW)	Approx. weight (Kg)
2950	27669	289	31	0.25	18.5	350
2950	39314	461	35	0.31	18.5	355
2950	48876	561	34	0.40	18.5	380
2950	72489	972	40	0.50	37	520
1450	38205	270	21	0.50	30	425
2950	66754	1100	38	0.64	37	770
1450	56466	466	25	0.64	30	650
2950	115013	1566	41	0.79	55	835
1450	81586	788	29	0.79	55	710
1450	112949	1204	32	0.99	45	940
1450	157857	1888	36	1.23	90	1030
1450	201032	2441	36	1.54	90	1385
1450	318874	4644	44	2.01	200	1890

- **The capacity of the fan considering 4 Poles = 38,205 cmh**
- **No of fans required for each of the tubes will be as given in *table 1.8*.**

Sn. No.	Particulars	Fan Capacity (CMH)	No. of Fans	Power Required (KW)
1.0	South Portal (L)	38205	50	11
2.0	South Portal (R)	38205	50	11
3.0	North Portal (LT1)	38205	110	11
4.0	North Portal (LT2)	38205	110	11
5.0	North Portal (RT3)	38205	110	11
6.0	North Portal (RT4)	38205	110	11

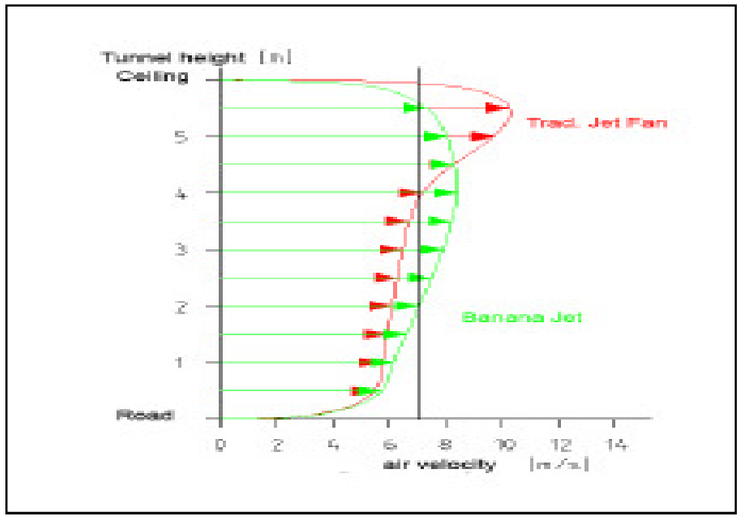
Banana Jet Fans are being proposed for this project.

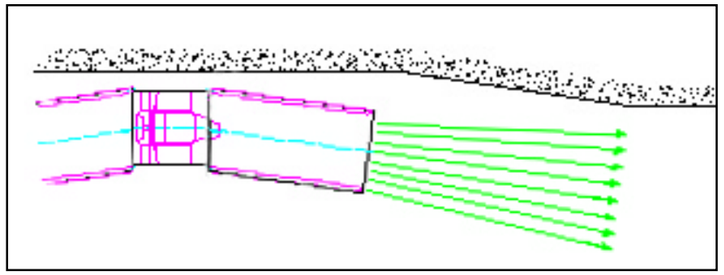
8.9.3.11 Banana Jet Fans

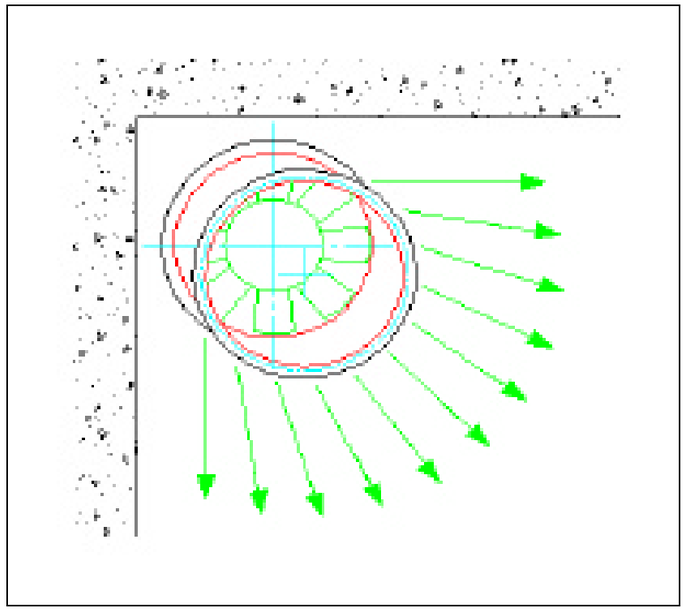
By bending the air jet from a jet fan in a tunnel away from the restrictive surface (walls /ceiling) the performance of the fan in the system can be dramatically improved. This can be done with silencers or ducts which are bent with an angle of 5 – 25 %. The source of the improvement is that not only are the losses directly behind the fan virtually eliminated, but the airflow profile downstream in the tunnel can be improved, further significantly reducing aerodynamic losses. The net result is a reduction of the required installed thrust by 30 – 50 %. Not only does this mean that far fewer (or smaller) fans need to be installed, but the installation cost for cabling, mounting etc. is also reduced in the same proportion. A 30 – 50 % reduction in required thrust directly translates into a reduction in energy cost in the same order of magnitude so there is a larger savings in operating costs in addition to the benefit of lower capital cost. The use of Banana Jet can reduce these losses by 25 – 50 %, depending on the design of the tunnel. The physics behind this improvement is relatively straightforward:

8.9.3.12 Friction loss

An air stream that blows along a surface becomes "glued" to the surface due to the induced swirl and one-sided low pressure. This effect, called "Coanda-Effect" creates a less uniform flow in the tunnel, with larger velocities along the wall).







8.9.3.13 Background velocity correction

The energy that a fan gives to the air flow in the tunnel is a function of the difference in airspeed at the outlet compared to the speed of the air at the inlet of the fan. The higher the background velocity is around the fan, the less impulse can be transferred to the air streaming by the fan. Due to the Coanda-Effect the actual air velocity around the down-stream jet fans is higher than it would be in a free field. The different airflow profile with Banana Jet means a slightly smaller correction factor is required. Measurements in various tunnels have shown a difference in airspeed around the fans of 10 – 20 %. A 3 – 5 % reduction in losses can be expected, more if the fans have to be spaced closely together. (Less than 100 m between the fans).

8.9.3.14 Impulse losses

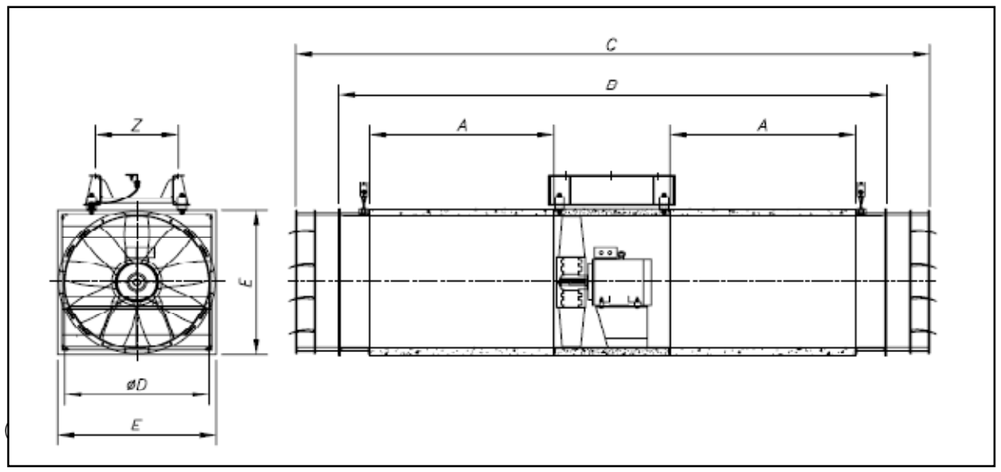
10 – 20 % of total the thrust generated by traditional jet fans is lost right behind the fans as part of the air jet hits the surface the fans are mounted on with a high velocity *(Fig. 1.2)* due to friction and impulse losses. By bending the flow away from the surface this loss can be virtually eliminated. Since the losses are a fixed factor of the overall losses in the tunnel, so at least the above mentioned 10 – 20 % can always be avoided by using Banana Jet.

8.9.3.15 Losses in corners, niches and other installations.

Fans are generally hung outside the traffic area, typically in corners or niches of the tunnel. The same space is also used for lamps, road signs and other installations. Because the jet from a Banana Jet can be flexibly directed, the losses can be reduced, especially in corners and niches *(Fig. 1.3)*. Also, the jet can help overcome losses from bends, changes in diameter etc. The actual design of the tunnel must be analysed to estimate the improvement that can be achieved.

The fan dimensions shall be as highlighted in *table 1.9* below.

A	B	C	øD	E	Z
1950	4380	4780	562	762	380
1950	4600	5000	632	832	462
1950	4630	5030	713	913	546
1450/1950	3900/4900	4300/5300	804	1004	610
1450/1950	4000/5000	4400/5400	904	1104	660
1450/1950	4025/5025	4425/5425	1005	1205	730
1700	4750	5150	1128	1328	760
1700	4750	5150	1258	1458	786
1950	5610	6010	1410	1610	768
1950	5900	6300	1610	1810	868



8.9.3.16 Fan Construction

The jet fans should be manufactured in a simple and sturdy manner. To avoid corrosion the jet fans and the mounting structure should be manufactured in stainless steel 1.4571(V4A). The fans should be exchangeable. The jet fans should be designed to run in both directions. The volume flow has to reach at least 95% of the forward mode duty. In the event of emergency it should be possible to change the direction with a de-energized period of 15 seconds. Under normal duties the jet fan has to be constructed to run at temperatures between –20 and +40°C. In the event of fire, the jet fan has to withstand a temperature up to 250°C for 90 minutes.

8.9.3.17 Casing

The casing and the motor support should be manufactured from heavy construction 6mm stainless steel. To avoid corrosion in cracks the flanges have to be formed at the fan casing (no welded construction). Welds must be continuous. The external terminal box in stainless steel 1.4571 is heavy duty and corrosion resistant in IP65.

8.9.3.18 Impeller

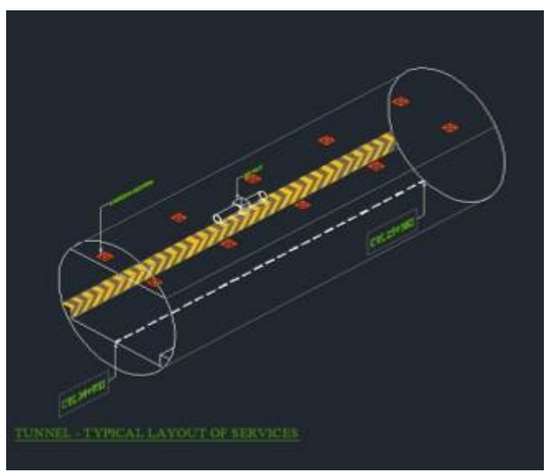
The impeller is made of corrosion-resistant, cast aluminium. The nucleus of the hub is made from stainless steel 1.4571.

8.9.3.19 Silencers

Due to corrosion protection, all components of the silencers are manufactured in stainless steel 1.4571. At the inlet and the outlet side, an aerodynamically shaped cone has to be provided.

8.9.3.20 Motor

Three-phase, fully enclosed, squirrel cage motors according to IEC standards in IP 55 should be used.



8.9.3.21 Building HVAC

The basis of design for air conditioning of the Nodal Operation Centres is as follows:-

Outside Weather Data:

i. Location - Mumbai

a) Latitude (°N) - 27.10°N

Outside Thermal Data

		Summer	Monsoon	Winter
a.	Dry Bulb	90.32°F (32.4°C)	87.08°F (30.6°C)	84.38°F (29.1°C)
b.	Wet Bulb	82.76°F (28.2°C)	81.86°F (27.7°C)	75.56°F (24.2°C)

Inside Design Conditions

Area Description	Dry Bulb Temperature		Relative Humidity
	Summer	Winter	
Office Area	72 + 2°F (22 + 1°C)	70+2°F (21+1°C)	Not exceeding 65%
Corridors	76 + 2°F (24 + 1°C)		

Inside dry bulb temperature shall be maintained within + 2°F (or + 1°C) by using suitable controls.

8.9.3.22 Design Basis For Cooling Load Calculation

Description	Occupancy (Sqft/Person)	Fresh Air (cfm/Person)	Lighting/ Equipment Load (W/Sqft)
Admin. Offices	100	25	4
Meeting Room	15	20	6

(Table 1.12)

Note: Lighting, Equipment & Fresh Air requirement considered as per standard design practices followed. Some assumptions were made where the information was not available.

Plant Rooms:

a) General Ventilation : 15 Air Changes / Hr.
b) Additional in case of fire : 15 Air Changes / Hr.
c) Total in case of fire : 30 Air Changes / Hr.
d) Toilets : 12 - 15 Air Changes / Hr.

8.9.3.23 Noise Criterion

All air conditioning equipment and materials (like pumps, chillers, motors, ducts, grilles, acoustic lining etc.) shall be selected, designed and installed in such a manner that the inside noise criterion for all conditioned spaces will be in the range NC- 35 to NC- 40.

It is proposed to install wall/ ceiling mounted unitary split type air conditioners for the NOC airconditioning requirements.

8.10 Lighting

A tunnel is a linear enclosed space, covered by ground all around. Thus even in broad daylight inside a tunnel is always dark.

It is, therefore, necessary to create a well-lit environment inside a road tunnel. During daytime when a vehicle approaches and enters a tunnel, a motorist has to travel from a brightly lit area into a lightly lit area. Thereafter when the motorist leaves the tunnel, he has to travel from a lightly lit area to a brightly lit area.

At night the situation gets totally reversed. When a motorist approaches and enters a tunnel, he has to travel from a dark area to a brighter lit area. Thereafter when the motorist leaves the tunnel, he has to travel from a brighter lit area to a dark area.

Thus when a motorist travels through a tunnel, his vision has to get adapted to changing lighting conditions. This adaptation is not instantaneous but takes a short time. Such adaptation has to be a smooth transition. Such smooth transition can be produced only by suitably designed lighting conditions at the entry and exit areas of the tunnel and the portion of the tunnel in between these areas.

Properly designed tunnel lighting ensures smooth transition of lighting environment between approaches to the tunnel and the tunnel itself. This helps the vision of a motorist to get smoothly adapter to changing lighting environment. This time for such smooth adjustment is generally considered as about 4 seconds. At a speed of 60 kmph, the length traveled in 4 seconds would be about 70 m.

To enable the vision of a motorist to get smoothly adjusted to changing lighting environment, the approaches to a tunnel and the tunnel itself are divided into various zones as given below. For design speed of 60 kmph, length of these zones would be about 70 m.

8.10.1 Access Zone

It is the portion of the open/approach cut of the tunnel immediately adjacent to Tunnel Portal. The Luminance Level in this zone is generally kept at around 70 candelas/ sqm of road surface.

8.10.2 Threshold Zone

It is the first zone next to the entrance to a tunnel. In the Threshold Zone, the intensity of lighting is gradually adjusted from that outside the entrance to that in the beginning of the transition zone. The Luminance Level in this zone is generally kept at around 40 candelas/ sqm of road surface.

8.10.3 Transition Zone

It is the zone next to the Threshold Zone. In the Transition Zone, the intensity of lighting is gradually adjusted to that in the Interior Zone.

8.10.4 Interior Zone

It is the zone beyond the transition Zone. It is sometimes also termed as Normal Lighting Day Zone. In the Interior Zone, the vision of a motorist needs no further adaptation. This is the longest zone in case of very long tunnels. The Luminance Level in this zone is generally kept at around 15 to 20 candelas/ sqm. of road surface.

It would be good practice in the case of very long tunnels to provide some variations in lighting at regular intervals, through variation in intensity or colour of lighting etc., so as to break the monotony of traveling under the same conditions for a long distance. Extra lighting is required in lay-bys, emergency parking locations and at locations of escape paths and emergency services access locations.

8.10.5 Exit Zone

It is the zone beyond the Interior Zone and between/before the exit portal of the tunnel. In the Exit zone, the intensity of lighting is gradually adjusted to that in the portion just beyond the Exit Portal.

8.10.6 Street Lighting

In Mumbai, street lighting is required only during the night. The Luminance Level in this zone is generally kept at around 15 to 20 candelas/ sqm. of road surface. At all major intersections high mast LED flood lights are proposed. Extra lighting is required in lay-bys and emergency parking locations.

8.10.7 Lighting installations

The purpose of properly designed tunnel lighting is to ensure smooth transition of lighting environment so as to enable smooth adjustment in the vision of a motorist.

Since requirement of intensity in the Threshold, Transit and Exit Zones during day time is different than that during night time, required intensity can be achieved by putting the luminaries in two

different circuits. Alternatively, luminaries that can give variable output by use of dimmers can also be used.

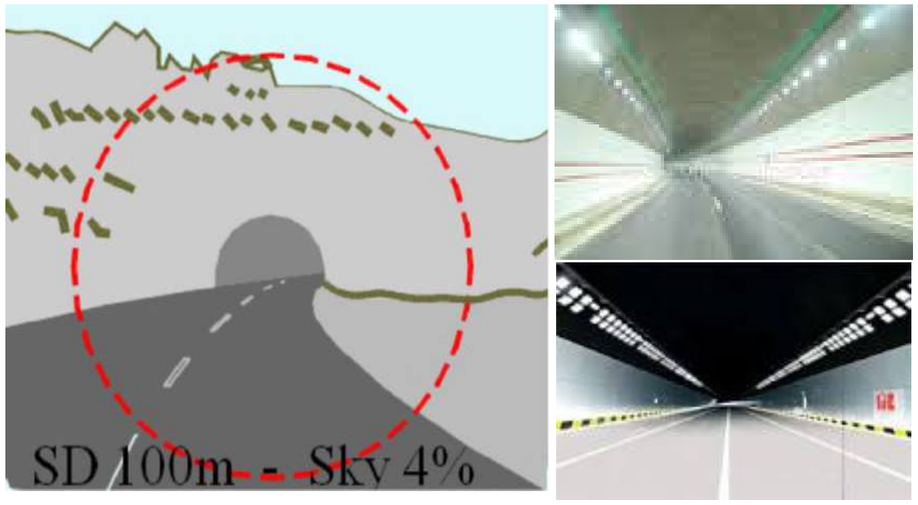
Gradual increase or decrease in the intensity of lighting within different zones, as described above, can be achieved by installing different types of luminaries or by using one or two types of luminaries at a closer or wider spacing as required. For easier adjustment in spacing, the luminaries can be mounted on sets of ladders arranged in longitudinal direction and hung from the crown of the tunnel.

Tunnel lighting has to be highly reliable. Tunnel lighting is required round the clock. It is therefore necessary to install and maintain a 100 percent back-up system.

The amount of maintenance required would depend on where the tunnel is located, the type and volume of traffic it is required to handle, quality of ventilation and the size and grade of the tunnel itself.

The luminary units should be sealed so as to prevent entry of water from water sprays, dust and smoke. The luminaries have to be cleaned frequently to clear dust and soot that may collect on their outer surface. Proper routine maintenance programme should be conceived and implemented.

Instead of waiting for the luminaries to fail before replacement, systematic replacement and renewal programme should be conceived and implemented.



(Fig 2.2)

A combination of 90 watt, 120 watt and 200 watt LED luminary units are proposed for the tunnel lighting. For street lighting 60 watt solar powered LED luminaries are proposed.

Space Served	Luminaire	Nos.	Lighting Load (W)	Total Load (KW)
Tunnel	Wall/Ceiling Mounted	2060	90	185.40
Tunnel	Wall/Ceiling Mounted	5005	120	600.60
Tunnel	Wall/Ceiling Mounted	590	200	11.80
Road	Street Light	3190	60	191.4
Road	High Mast	25	5000	125.00

8.11 Electrical

8.11.1 Design Standards & Codes

Electrical system design shall be in confirmation to the requirement of:

- **Indian Electricity Rule 1956.**
- **Standards & Code Practice of Bureau of Indian Standard for various equipments & Systems.**
- **National Building Code of India -2005 (Part -8)**
- **National Electricity Code of India**

8.11.2 Design Criteria

Design Criteria	Proposal to Achieve Same
Energy Efficiency	Use of energy efficient light fittings, ballast and LED light fixtures shall be considered. Provisions of SCADA to allow energy saving in off-peak operation.
Safety of the passengers and end users	Strict compliance with Indian Electricity Rules & other safety code requirements. All lighting and power circuits shall be protected by the circuit breakers and ELCBs. Surge Arrestor shall be provided at the Main Panel and other SDBs/FDBs which has external in/out cable connections. NOC building shall be protected by the Lightening Protection System.
Reliability of the Installation	Transformers with power from 2 different sources shall be considered for redundancy. Additionally provision for the DG Sets can be considered.
Flexibility and Adaptability	Planning shall be in such a way that distribution system will not have major change in case of change in design of utilities.
Maintainability	Space planning shall be done with consideration of regular service, maintenance; and future replacement.
Expandability	Sufficient spare capacity (about 20-25%) in the design of switchboard and distribution network to meet future load growth.

Following design parameters are considered while estimating the NOC electrical loads:-

Sn. No.	Description	Light (Watt/Sqft)	Convenience Power (Watt/Sqft)	Ups/Equipment (Watt/Sqft)
1	Stair case	0.7	-	-
2	Corridors, Toilets, Elec. Room	2.0	0.2	-
3	Office/Meeting Rooms	2.5	4.0	2.0

8.11.3 Electrical Load Estimates

Based on the above parameters and design brief for M & E services, the load requirement of whole complex works out as below;

Sn. No	Description	Estimated Connected Load (kW)	Overall Max. Demand (mW)
1	Tunnel Ventilation	5940	10.51 (mW) Approximately 6.3 mW at 0.9 P.F. say ≈ 5.67 mW
2	NOC	48.6	
3	Tunnel Lighting	797.8	
4	High Mast Lighting	125	
5	Street Lighting	Nil (Solar)	
6	Fire Panel Room	3600	

8.11.4 Source of Power

Total electrical power requirement for the project (overall maximum demand) shall be 3720 kW. It is proposed to source the power from 2 different power sources to have redundancy in the system to have emergency source of power also. The required power may be made available through DG Sets.

8.11.5 Backup Power Supply

100% Power backup is planned for the in the case of power outage and transformer maintenance. In case DG Sets are being provided, sets of 415 Volt are proposed in the DG Plant Room at Basement. As per the load calculations, the DG Sets of a total capacity of 14.86 ≈ 15 mVA are required.

All DG Sets shall be air cooled. DG Plant Room shall be acoustically treated to arrest the noise pollution as per CPCB Norm. DG Sets are envisaged to be operated in synchronizaion mode. Provision of PLC shall be done with Manual override facility, so that auto as well as manual synchronization can be done. PLC shall have in-built feature of synchronization, auto load sharing and auto load shading for the DG Sets.

Exhaust piping for the DG Sets shall be taken up to the highest point as per CPCB guidelines.

8.11.6 Power Distribution System

8.11.6.1 LT Distribution

- Power supply shall be terminated to the MV switchgear panel. MV switchgear panel shall have cubical type construction, multi-tier designed MV switchgears MDO / EDO / ACB/ MCCBs provided with short circuit and earth fault protection are being envisaged. These will be located

in the NOC buildings and will be feeding power to different floors through L.T Cables/Rising Mains.

- There are two methods for distribution of power;

Option-I: Through cables. Here we propose to have Main Distribution Board at the NOC and distribute the power to each load center through cables.

Option-II: Through Rising Mains. This system is not envisaged for this project as it is technically unviable.

- Further distribution from will be through DBs located near the equipment / individual area load centers. These DBs will be fed from the specific utility panels located in the NOC.

- Power Factor Control

In order to achieve the economy due to improvement in P.F, it is proposed to install required capacitor banks on each bus of the substations switch gears. Capacitors of required Capacity will be provided in capacitor panel / bank to take care of the reactive load and also meet the power factor of system 0.95 or better.

- For Electricity Measurement, Energy Meters shall be provided in the incoming and outgoing feeders of MV Switchgear panels. However, Electrical panels for each utility shall be provided with sub energy meters.

8.11.6.2 Cabling/ Wiring

- **MV Power Cable**

Adequately sized PVC sheathed, XLPE insulated Aluminum conductor, 1100 V grade armoured power cables conforming to IS-7098 Part-I shall be provided for power distribution in pipe /cable trays. For outdoor application wherever required, cables shall be installed underground as per BIS and road crossing etc shall be through already laid GI /RCC Hume pipes. Copper Conductor Cable shall be used upto 25 Sq.mm size and above 25 Sq.mm size, Aluminium conductor cable shall be used.

8.11.6.3 Wiring Installation

- Generally, the electrical wiring installation will conform to IS standard (IS:732-1989). The complete wiring installation concealed or exposed will be installed in heavy gauge rigid steel conduit (black steel).

- The wiring for light and small convenience power outlets within the NOC shall be with PVC insulated (HRFR) copper conductor wires conforming to IS:694. The lighting circuit wiring/point wiring shall be carried out with 2.5 Sqmm copper conductor while power wiring shall be carried out with 4 Sq.mm. copper conductor wires. Colour code shall be maintained for the entire wiring installation i.e. Red, Yellow and Blue for the phases and black for the neutral and green for earthing.

8.11.6.4 Earthing System

Safety in using electrical energy is of paramount importance considering its dangers. The earthing system will be in conformity with the IS: 3043. All non-current carrying metal parts forming part of the electrical system shall be connected to the grounding system. The requirement of Indian Electricity Rules and statutory requirement of local Electricity Authority shall also be met fully.

a) The earthing system is divided into two sections;

1	Substation Earthing (Copper)	a. Transformer neutral solidly earthed b. DG Set neutral solidly earthed
2	Protective Earthing (GI)	a. HT panel body earthing b. Transformer & DG Set body earthing c. LT Panels d. Power Panel e. Equipment

b) Separate Earth stations shall be provided for all IT, electronic equipment and communication system.

8.11.7 Lightning Protection System

Lightning protection is required only for the NOCs. Since this is not a high rise complex, sprawling over large area, conventional lightening protection system shall be provided. The lightning protection system shall consist of adequate lightning rods/ arrestors at terrace level, connected directly to earth station by 70 sq. mm single core PVC insulated flexible copper conductor. Required number of earthing Stations shall be provided for lightening protection.

8.12 Plumbing and Sanitary System

8.12.1 Codes and Regulation

Plumbing/Sanitary systems will be designed and installed conforming to the following codes and standards:

- Regulations of the local authority.
- NBC 2005 (National Building Code of India) Part-9.

- Manual on water supply and treatments published by Central Public Health and Environment Engineering Organization Ministry of Urban Development, Govt. of India.
- Manual on sewerage and sewage treatment published by Central Public Health and Environment Engineering Organization Ministry of Urban Development, Govt. of India.
- SP 35 (Hand Book of Water Supply and Drainage)
- Relevant BIS Codes.
- IS: 10500 for drinking water specification, BIS.
- IS: 1172 - Code of basic requirement for water supply drainage & sanitation, BIS
- Good Engineering Practice.

8.12.2 Water Supply System

The water supply from City Water (Municipal Main) shall be brought to underground fire storage tank and overflow from fire storage tank shall be taken to domestic water storage tanks in order to replenish the fire storage water. The truck fill points provision shall be made to meet emergency requirement.

Water from domestic water storage tank shall be pumped through to the overhead tank and shall be distributed from there to meet the domestic/ flushing water requirement.

8.12.3 Sewerage

Drainage system for soil & waste is based on the most efficient, functional design & considering, minimum maintenance after installation and available site topography to minimize the excavation work in laying the pipes. Two pipe systems (soil and waste) are proposed to carry soil and waste separately from the building under gravity.

Waste pipes are connected to manhole through gully trap and soil pipes are to be directly connected to the manhole.

Each fixture in the system shall be vented to the atmosphere to provide protection of trap seals against siphonage and gas leak due to positive pressure, to promote rapid and silent flow of waste, and to ventilate the sanitary system to reduce corrosion.

Floor drain in guest room bathrooms should be avoided. If required, provide traps with trap primers to eliminate the potential for methane gas entering guestrooms.

Air-gaps on sanitary system drains for food service equipment shall be provided.

When sewer ejectors are required, duplex submersible sump pump system with each pump sized at 65% of peak load shall be provided. System includes control panel for alternating pumps, pump failure alarm and high water level. Sewer pump shall be connected to backup power.

8.12.4 Basis of Design for Sewerage

- The sewer lines have been designed for three times average dry weather flow in relation to the water supply demand.
- It has been assumed that 90% of the domestic water supply (non-flushing) shall find its way into the proposed sewer, 100% of the flushing water supply shall find its way into proposed Sewer.
- All the sewers have been designed to run half full.
- Necessary provision for laying S.W. sewer lines and half flow condition.

4.4 Storm Water Drainage System

- Storm water drainage systems will be designed based on a rainfall intensity of 150 mm per hour. Rainwater harvesting pits of size 4m diameter x 3.5m effective depth shall be provided.
- Storm water drainage system will be provided for the building roof drainage and the site drainage.
- Required earth filling shall be provided to rain storm water pipes through catch basins and manholes.
- The Storm water will be collected by gravity through catch basin, storm water manhole and RCC pipe and finally discharged into the municipal drainage system.

8.13 Fire Suppression System

8.13.1 High Pressure Water Mist Fire Suppression System

- **Scope**

This specification sets off the minimum requirements for the high pressure mist system to be installed for the proposed tunnel project.

The works outlined shall cover the design, supply of all materials, equipment and labour necessary for the complete installation, testing, commissioning and handing over a completed, approved and working high pressure mist system.

8.13.2 Technical Specifications

The detailed calculation and design data shall be submitted at the tender stage as a minimum requirement.

The design, supply and installation shall be made in strict accordance with codes, regulations and applicable standards.

The high pressure mist system is intended to control and suppress the fire.

8.13.3 Codes and Standards

8.13.3.1 The following Codes and Standards shall apply with respective parts applicable to tunnels.

a) NFPA 502 Standard for Road Tunnels, Bridges and Other Limited Access Highways, 2014.

b) SOLIT Engineering Guidance for a Comprehensive Evaluation of Tunnels with Fixed Fire Fighting Systems, 2012- Annex 3. Engineering guidance and – Annex 7. Fire testing specifications.

8.13.3.2 References

The following documents are references as guidance:

a) Uptun, Engineering Guidance for Water Based Fire Fighting Systems for the Protection of Tunnels and Sub Surface Facilities, September 2007.

b) PIARC World Road Association

i. Road Tunnels: Vehicle Emissions and Demand for Ventilation, latest edition.

ii. Fire and Smoke Control in Road Tunnels, latest edition.

iii. Systems and Equipment for Fire and Smoke Control in Road Tunnels, latest edition.

iv. Transport of Dangerous Goods

8.13.4 System Design Basis

8.13.4.1 Requirements

The water mist shall comply in every aspect with the National Fire Protection Association (NFPA) 502, SOLIT2 guideline including Annex 3. Only open type nozzles shall be used. All tests shall be carried out in accordance to SOLIT2 guideline Annex 7 and shall be witnessed by an independent surveyor being experienced in the field of full scale fire testing for vehicular tunnels. Provide a minimum reduction on heat release rate of fire of 50% for a potential 200 mW un-sprinkled. Details of testing that has been conducted, engineering analysis and calculations or cited references in support of the reduced heat release rate shall be provided. The system shall be capable of application to heavy good vehicle fires. Excluded vehicles shall require further consideration for escorted travel by the tunnel user group. The water mist system shall ensure that prevention of fire from spreading from one to another vehicle, demonstrated by using a fire target consisting wooden pallets positioned in 5m distance downstream from the main fire load measuring temperatures in this location. The water mist system shall be high pressure, operating between 45-140 bar. The operation time of the water mist system shall be calculated for a minimum of 60 minutes and the tank capacity shall be dimensioned accordingly.

8.13.5 System Description and Operation

The high pressure water mist system has to be a zoned system. Whole tunnel has to be divided to the multiple fire zones/ sections. In case of fire, the fire zone will be detected and activated by the installed detection and control system. Additionally, the two adjacent sections will be activated. So in a fire scenario 3 sections can be activated. The minimum length of each section has to be 18mtrs.

As more detailed system operation, the system has three basic modes:

8.13.6 Stand-by

During stand-by the system waits the fire alarm, detection and localization. The jockey pump will pressurize the wet main pipes to approx. 5-15 bar pressure. The pressure at the main pipe will be monitored continuously. This is due to avoid delays filling the main pipe. The section valves stays closed in all sections and the access of water is stopped to the zones.

8.13.7 Detection and Activation

During detection, the system will recognize and localize the fire. This will trigger through the control system the respective section valves and sends an activation command to the pump station. First the booster pumps (providing the pre-pressure) will start and then the high-pressure pumps will start in a cascade mode and the water will be pumped through the main pipes to the activated sections.

The system remains activated for 60 minutes or until qualified staff or the fire brigade has manually shut off the system. The system should operate in the specified way so that the farthest nozzle should operate at a minimum at 45 bar pressure.

Deactivation:

System deactivation will happen on the command of the fire services or the operator. The pump station will be switched off and section valves will be closed with the control system. Finally the system will be returned to the stand-by mode.

8.13.8 System Components

8.13.8.1 Pumps and Accessories

The pump station should consist of multiple pump units having a combination of N +1 unit with each pump having a capacity of minimum 100 lpm capacity. Every pump is started in a star delta mode to avoid high requirement of current.

The excess water will be drained through an overflow valve at the pump station. Along the main pipe vent valves, drain valves and service valves will be installed.

The pump type is a plunger pump. All pumps are totally identical and their parts interchangeable. The pump lubrication should be done by oil. Water lubricated pump is not acceptable.

The high pressure pump unit consists of the following main components:

i) Plunger pump
ii) Combined safety valve, overflow and unloading valve
iii) Safety valve
iv) Each Electric driven motor approx. 30 kW
v) Direct coupling between electric motor and pump
vi) Base frame for pump unit

Material Specification

i) Pump head: stainless steel
ii) Plungers: ceramics or non-corrosive steel
iii) Crankshaft / Pinion shaft: forged carbon steel
iv) Gear casing: carbon steel

Suitable 100µm stainless steel filters shall be installed at the suction end of the high pressure mist system pump. They shall be installed in such that they are accessible for operation, maintenance and inspection.

All high-pressure pumps shall be installed on steel skids with anti-vibration mounts. All pumps shall be delivered complete with factory test certificate.

Control Panel

A local pump control panel shall be provided to provide control of all pumps (high-pressure pump units, booster pumps and jockey pump) and shall provide local control within the pump room. Manual control shall be possible. The control panel shall have alarm indication of on/off/fault. The control panel shall be interfaced to the SCADA system to provide notification of pump status.

Booster Pump

Booster pump units (two) shall be provided a duty & standby, and shall be centrifugal type pumps providing the minimum suction condition as required by high-pressure pumps.

Basket Filter

Filters shall be provided and shall be manufactured from stainless steel. A pressure differential switch shall be provided to the main filter to provide notification of when the filter requires cleaning. An alarm shall be raised to indicate the filter requires maintenance. Visual indication shall also be provided. The size of the filter apertures shall be in accordance with the manufacturer's requirements. Jockey pumps shall be provided with self-flushing filters. The filters shall allow the continuous operation of the system for 60 minutes at the required flow rate.

Jockey Pump

The jockey pump pre-pressurizes the wet main supply pipes in the stand-by operation and it consists of the following main components:

i) Automatic self-cleaning filter (100 µm)
ii) Triplex plunger pump
iii) Electric motor
iv) Pressure gauge
v) Safety valve
vi) Pressure accumulator.

Material specification:

i) Pump head: brass
ii) Inner pump head parts: high grade stainless steel
iii) Plungers: ceramic

8.13.8.2 Nozzles

The high pressure mist nozzles shall be made out of stainless steel material. The Nozzle should have imbedded micro nozzles with filters. The Nozzles shall be installed in accordance with the manufacturer's approved listing/fire test. The droplet size shall be in the range of between 20 to 1000µm. Each nozzle will have a Filter. Operating pressure shall be minimum 45 bar at Nozzle. The nozzles shall not be glass bulb type nozzles. The nozzle shall consist of multiple orifices that are dismountable from the nozzle body. The number of orifices shall be 5 or 7 and k factor should be either 4.7 or 7.3. The nozzle shall be installed with separate installation socket to the pipe work for easy removal for maintenance purpose. The nozzles shall be screwed into the sockets. The sockets will be welded to the pipe.

8.13.8.3 Section Valve

The section valve that controls the release of suppression water to each dry-pipe zone from the wet main pipe shall be in accordance with SOLIT2 guideline Annex 3. The valve shall be a ball valve type and the parts that are in contact with water shall be made of stainless steel. (AISI 316). The time taken for opening / closing of the valve shall reduce the water hammer effect.

The section valve shall be capable of remote opening / closing via electric motor actuator using 24 Volt signal. The solenoid operated or other actuator types are not allowed. Actuator shall have self-diagnostics for possible faults. The valve shall have visible indication of the position of the valve and electric monitoring of the position. Manual override locally at the valve shall be possible. The valve shall be monitored by SCADA and shall be able to be tested without discharging the water.

Lockable isolation valve(s) shall be provided to enable maintenance of the each section valve. This shall be installed on the upstream side of the section valve. The valve shall be a ball valve type and the parts that are in contact with water shall be made of stainless steel. (AISI 316). The diameter of isolation valve shall be same as the used section valve.

All valves shall be rated to withstand operating pressures and shall be tested to 1.5 times the design pressures.

Factory test certification for the integrated section valve including actuator shall be provided by the manufacturer, providing evidence of accepted functional testing within the factory. The valve shall be delivered as a complete, integrated unit.

Section valves shall be located within protected stainless steel box enclosures to protect against damage within the tunnel. The enclosures shall be sized to allow for maintenance activities and shall be constructed of fire retardant material. Fire test certificates shall be produced for the completed enclosure.

Valve boxes and pipework shall be installed in locations which avoid damage to the suppression system in the event of an accident. All fire control equipment shall be monitored via SCADA systems (i.e. valves, pressure switches, flow switches etc.) at the control room.

8.13.8.4 Control System

All section valves will be connected to the control system and can be monitored. The control system is furthermore connected to the detection system and the pump system.

The control unit allows to operate the system in a fully automatic mode as well as in a manual mode, e.g. for maintenance, test runs or when fire fighters and trained staff shall modify or stop the activation mode of the high pressure water mist system.

The installation of control cabling shall be coordinated with the SCADA system design.

8.13.8.5 Water Tank

The high pressure water mist pumps are connected to a tank. The total capacity of the water tank shall be sufficient to provide water supply for 60 minutes of operation. The tanks shall be placed closed to the pump room.

8.13.8.6 Pipes and Fittings

The wet main pipe-works shall have a pressure rating of at least 140 bar and be made of stainless steel duplex type (1.4462). The manifold and branch pipes shall be of AISI316 (1.4571/1.4404), PN140bar. The dimensions must be calculated so that the pressure at all nozzles is at least 45 bar, taking into account the pressure losses due to flow resistance. The pipe-work must be flushed after installation and tested to at least 1.5 times the working pressure. The pipes will be connected by welding. The main pipe is equipped with thermal compensation loops to deal with dilations.

The main pipe is equipped with the drain/flushing valves. The purpose of the valves is to allow the pipe flushing to be carried out in various locations of the main pipe. Additionally the main pipe can be drained through these valves.

All pipework shall be properly flushed prior to before commissioning. Hydrostatic pressure testing shall be undertaken which shall be witnessed by the client. Records of all hydrostatic testing shall be forwarded to the client.

8.13.9 Co-ordination with the Tunnel Ventilation System

1) The design shall consider the effects that the tunnel ventilation system will have on the performance of the suppression system. The contractor shall take into account the velocity generated by the tunnel ventilation system within the tunnel in order to select a suitable discharge nozzle. Trajectory analysis is required to be undertaken and discharge spray patterns assessed in both non-emergency tunnel ventilation and emergency tunnel ventilation mode conditions to ensure that adequate fire suppression is maintained to the fire suppression zones operated in a fire. The analysis may be carried out by CFD based on full scale fire test data.

2) The maximum tunnel ventilation velocity that the suppression system is capable of operating successfully shall be determined by the contractor and this shall be coordinated with the ventilation system design.

3) The design of the suppression system and ventilation system are inherently linked. The suppression system will reduce the size of the chemical heat release rate and will cool its fumes and will reduce the heat convection to the air of fire which benefits the ventilation system.

These shall be taken into account for the design of the ventilation system. Additionally the effects that the ventilation system has on the suppression system must be considered. Therefore the design of both systems is linked and each shall take consideration of the other.

8.13.10 Co-Ordination with Other Services

Coordination with all other services shall be undertaken to determine termination points /interface points with the water mist suppression system. This shall include, but not be limited to the following:

a) The electrical services power requirements.
b) The ventilation systems.
c) The detection system.
d) SCADA control systems.
e) The lining of the tunnel.
f) The civil works including construction of the tanks that supply the suppression systems.
g) Drainage.

8.13.11 Reliability Of The System

Particularly high requirements are established regarding the availability of a fire suppression system. The same requirements must therefore be met for all individual components and units, e.g. for the Pump system.

Thus, e.g. in a unit consisting of more than one pump, each pump must be furnished with a drive motor of its own. Multiple drives, e.g. one motor / two pumps as well as gears or V-belt drives are not permissible. In order to keep the susceptibility to failure and the amount of maintenance of the pump units as low as possible, the number of individual components used must be limited. For safety purposes, every high pressure pump must be equipped with a safety valve.

8.14 Integrated Tunnel Control System (SCADA)

8.14.1 Network Architecture

At South Portal Control Room

1) 24 Copper & 2 Fiber port Layer 3 Network Switch- 2 nos.
2) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
3) 24 Copper & 2 Fiber port Aggregation Switch- 2 nos.
4) Patch Panel- 1 no.
5) 42U Network Rack- 4 no.

At North Portal Control Room

1) 24 Copper & 2 Fiber port Layer 3 Network Switch- 2 nos.
2) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
3) 24 Copper & 2 Fiber port Aggregation Switch- 2 nos.
4) Patch Panel- 1 no.
5) 42U Network Rack- 4 no.

At South Portal of Tunnel/Ventilation building

1) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
2) Patch Panel- 1no.
3) 15U Network Rack- 1no.

At South Portal Round About

1) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
2) Patch Panel- 1no.
3) 15U Network Rack- 1no.

At North Portal of Tunnel/Ventilation building

1) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
2) Patch Panel- 1no.
3) 15U Network Rack- 1no.

At North Portal Round About

1) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
2) Patch Panel- 1no.
3) 15U Network Rack- 1no.

At Cross Passage LV Room at All Locations

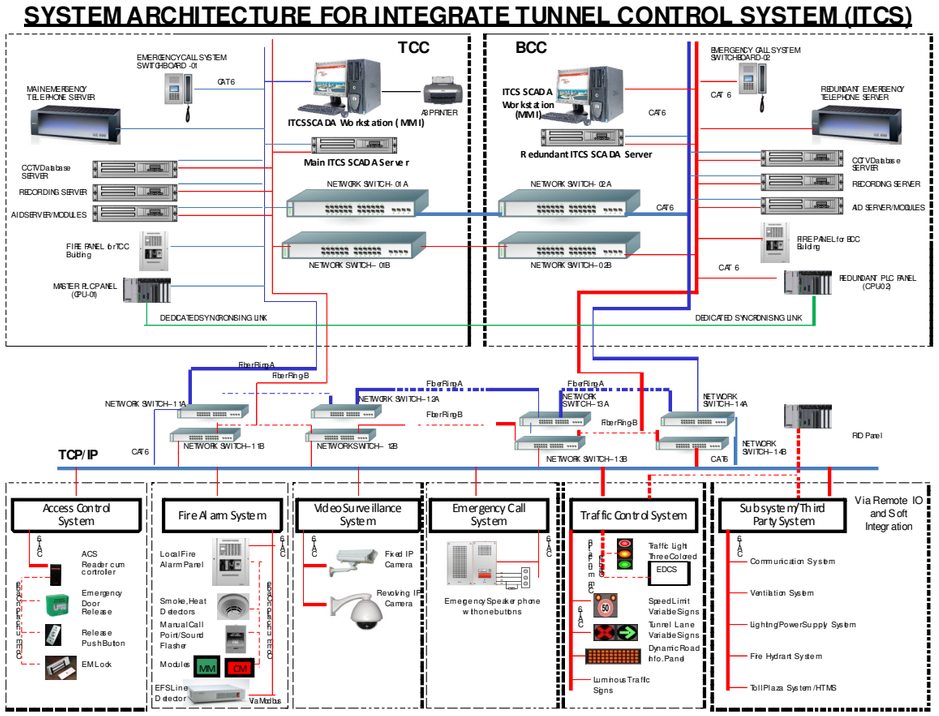
1) 24 Copper & 2 Fiber port Layer 2 Network Switch- 2 nos.
2) Patch Panel- 1 no.
3) 15U Network Rack- 1 no.

At SOS Boxes Junction Box at All Locations

1) 4/8 Copper & 2 Fiber port PoE Managed Network Switch- 2 nos. per Box

Dual fiber ring is proposed inside the tunnel for ITCS. Fiber Ring-A will start from Layer-3 Network Switch in South Portal Control Room, will move through the Tunnel T1 cross-passage LV rooms, North Portal Control Room and return to South Portal Control Room through a different path from Tunnel T2. The same scheme will be used for the Fiber Ring-B i.e. Fiber Ring-B will start from Layer-3 Network Switch in North Portal Control Room, will move through the Tunnel T2 cross-passage LV rooms, South Portal Control Room and return to North Portal Control Room through a different path from Tunnel T1

8.14.1.1 System Architecture



8.14.1.2 PLC Solution Overview

At South Portal Control Room

1) Main PLC with CPU- 1 no.
2) HLI Module- 1 no.

At North Portal Control Room

1) Redundant PLC with CPU- 1 no.
2) HLI Module- 1 no.

At South Portal

1) PLC Remote IO Modules- 1 set
2) HLI Module- 1 no.

At North Portal

1) PLC Remote IO Modules- 1 set
2) HLI Module- 1 no.

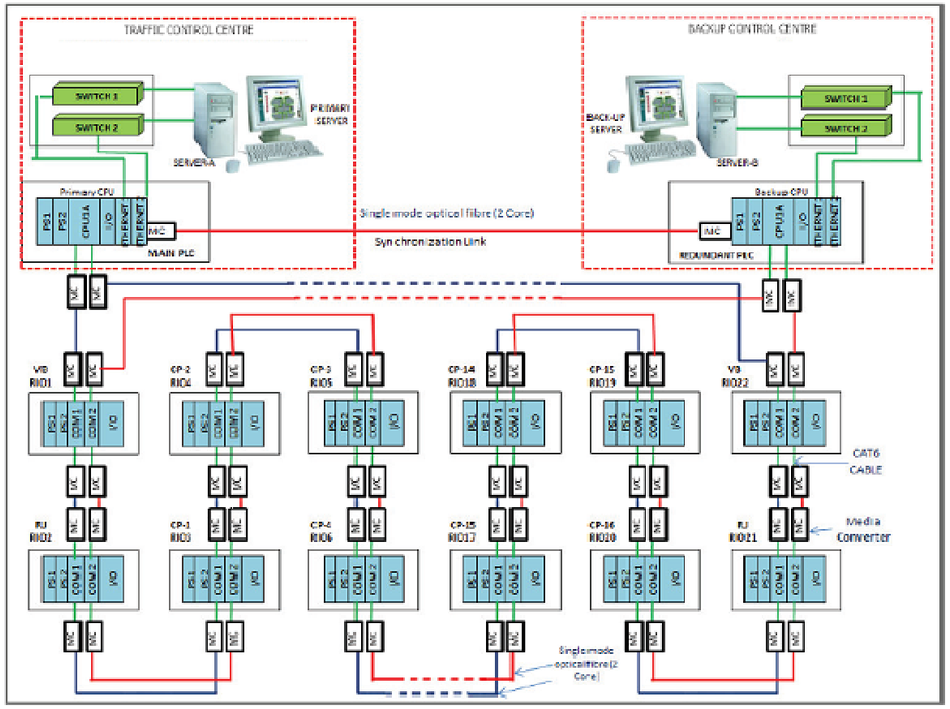
At Cross Passage LV Room at All Locations

1) PLC Remote IO Modules- 1 set
2) HLI Module- 1 no.

We are proposing PLC for Integrated Tunnel Control System (ITCS). Main PLC with CPU at south portal and Redundant PLC with CPU at north portal has been proposed. We are proposing Remote I/O (RIO) at the LV rooms at ECP/VCP cross passages inside the tunnel & at Portals. The PLCs at South and North Portal have fiber Optic synchronization link /bus between them. PLCs have dedicated dual redundant Fiber Optic network to connect the RIOs at all LV rooms in VCP/ECP. Both main and redundant PLC will be connected to a dual redundant TCP/IP network. SCADA servers at South and North portal will also connect to the same TCP/IP network. SCADA Server at both South and North Portals are in redundant hot standby mode. In normal condition, the main server at South Portal will monitor and control the entire system. Real time database synchronization between main and redundant server would enable both the servers to be on the same platform at any given point of time.

8.14.1.3 Network Architecture At ECP/VCP Cross Passages inside Tunnel

PLC System Architecture



Note –

1. Redundant set of PLCs with CPU considered at TCC and BCC wherein primary PLC will be installed with CPU at TCC and its Backup PLC with CPU will be installed in BCC.
2. Remote IO (RIO) will be provided in each cross passage, portal, Ventilation building and roundabout.
3. PLC will be connected to RIOs using dual redundant communication with optical fibre cables.
4. Optical fiber cable path will be physically separate to ensure high availability of network from TCC, BCC to Tunnel T1 and T2

8.14.2 Video Surveillance System

8.14.2.1 System Overview

We are proposing Video Surveillance System with Automatic Incident Detection System. IP based Fixed cameras with Video Incident Detection System inside both the tunnels are proposed. All these cameras will connect through CAT6 on TCP/IP network which in turn connects to Video Management System for live view and recording purpose. Proposed System provides server level redundancy. The system has the capacity to store all the cameras for upto 24 hours. The Video Management System has seamless integration with SCADA.

8.14.2.2 Video Surveillance System Components

1. Fixed Cameras

We have proposed Fixed IP based 720p camera with varifocal lens (5-50mm) with Video compression H.264 and resolution 1280 x 720 support 25 FPS Frame rate.

2. PTZ Cameras

PTZ camera is an IP based 1080p camera with Pan/Tilt/Zoom feature, Video compression H.264 and resolution 1920 x 1080 support 25 FPS Frame rate.

3. Traffic Counting System

Fixed IP based 720p camera with varifocal lens (5-50mm) with Video compression H.264 and resolution 1280 x 720 support 25 FPS Frame rate.

4. Automatic Incident Detection

AID DEVICE is an IP based Automatic Incident detection (AID) device with feature of In-built detection system. It captures streaming video from IP cameras, support H.264 video compression and provides real-time streaming video over IP.

8.14.2.3 Equipment & System deployment locations

- **Fixed Cameras**

Fixed cameras shall be installed inside the tunnel under ventilation slab at a height of 5 m –5.5 m above the road level. The distance between individual cameras shall be about 50 m. All fixed cameras inside tunnel shall be installed at the/close to centre of tunnel to monitor traffic lane of tunnel. Purpose of having camera at centre shall not only able to view and detect the incidents but also minimize the vehicle being occluded in the adjacent lanes. All cameras inside tunnel shall be installed watching towards one direction to view carriage way, SOS box and lay bays surrounding areas.

One Fixed Camera on each side of tunnel at portal shall be installed to monitor traffic entering tunnel. Also, one camera shall be installed on each side of tunnel entrance for Traffic count data collection application. To detect different vehicles in view of vehicle classification, the detection system shall be able to distinguish the gap between different vehicles. This condition implies that a camera should be mounted at sufficient height 9m and under an angle of typically 45° with a lens between 3 to 8 mm. System shall have feature to generate reports of Historical traffic data for further analysis. Classification: recognize 5 distinct vehicle classes during daytime, based on length of vehicles at day-time. 2 classes during night-time based on headlight position of upcoming traffic.

- **PTZ Cameras**

PTZ cameras shall be installed outside the tunnel on both ends which is north and south portals. It shall be installed on 6 m pole at a distance of 60 m away from South and North Portals. Revolving Cameras shall be used for monitoring traffic & surveillance, building surrounding etc at portals.

- **Automatic Incident Detection (AID)**

Automatic Incident Detection (AID) devices shall be installed at LV rooms at cross passages inside tunnel and LV room in ventilation building. One AID device shall be associated per fixed camera. Alternate AID associated with camera shall be connected with network switches Ring A & Ring B respectively for example Camera# 1 associated AID#1 shall be connected with Ring A switch and Camera# 2 associated with AID#2 shall be connected with Ring B switch and so on. These devices shall be installed in 19" rack and the rack shall be mounted in respective location LV rooms.

AID device shall also provide hardwired output for interface with PLC-RIO digital input module and with monitor module of Fire Detection for monitoring Heat alarm.

- **Video Surveillance & Automatic Incident Detection Server application**

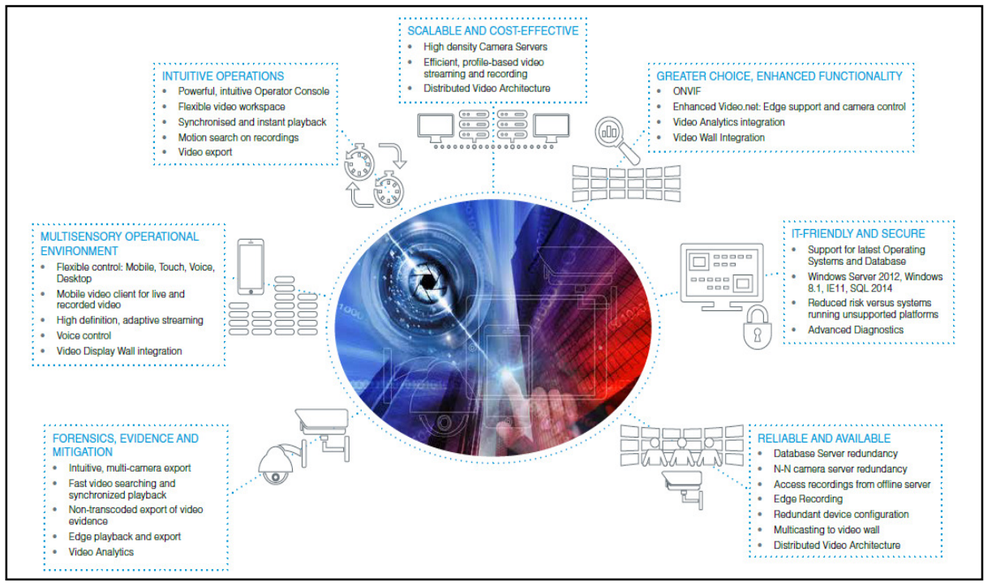
Main Automatic Incident detection server shall be installed at south portal NOC and its redundant AID server shall also installed at north portal NOC. Video surveillance database & Camera server main & redundant shall be installed at Control Switch Room south portal.

Network Video Recording Servers shall be installed at south and north portal NOCs.

- **Video Management Software**

The Video Management System is a scalable, digital closed-circuit television (CCTV) surveillance solution that sets a new standard in cost-effectiveness, flexibility and performance.

The solution addresses head-on the challenges of today's video surveillance, security and enterprise operations. Its architecture takes advantage of your enterprise's network communications structure – eliminating the need for coaxial cables and providing unmatched camera portability and flexibility.



- **Multi-Fold Benefits**

VMS flexible architecture also allows you to re-use your existing CCTV infrastructure of analog switchers, multiplexers, monitors and coaxial cabling, while extending their functionality through integration to the enterprise network. This protects your existing CCTV investment while taking advantage of the latest digital video technologies.

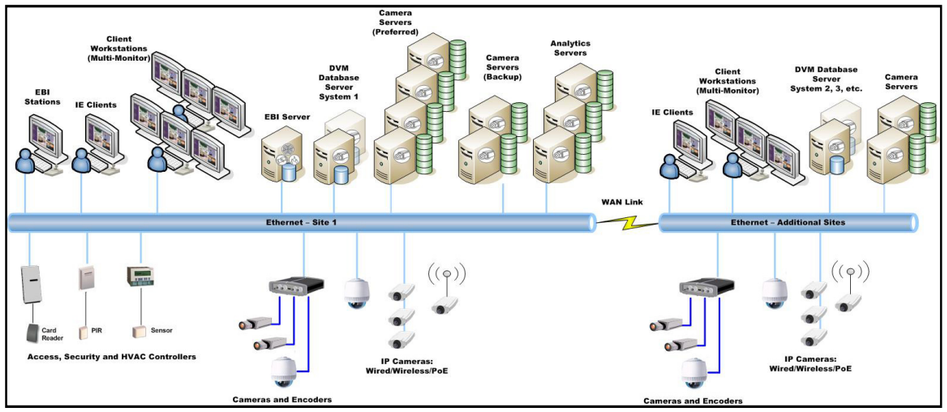
Your staff won't have to spend valuable time searching through hours of unnecessary recordings looking for a particular incident; the video images are stored in the system and referenced in the VMS database, from where they can be quickly located and viewed using VMS's advanced search capabilities. In addition, VMS is tightly integrated with SCADA, providing alarm and event-activated recording so that you only capture the video you need, when you need it most.

With VMS, you receive all the benefits of digital CCTV and much, much more. In an environment where you are continuously seeking ways to optimize your resources, this powerful tool can help enhance the productivity and effectiveness of your surveillance operations, reduce equipment and space needs, provide flexibility, and drive down installation and lifecycle costs.

With VMS, your surveillance system is always available, always vigilant and always providing a deeper, real-time understanding of what's going on in, at and around your events and facilities.

VMS are built upon industry standard open networking, PC hardware, and software applications, taking advantage of the most cost-effective, powerful components available.

Using commercial off-the-shelf hardware allows you to use the cameras, PC, storage, and networking hardware of your choice – no need to pay premiums for proprietary hardware. Unlike proprietary digital video recorders (DVRs) and Network Video Recorders (NVR's), VMS allows you to deliver system hardware and software upgrades independently. This lowers your support costs and ensures a "future-proof" upgrade path. Use of off-the-shelf components also ensures that VMS can easily be integrated into your existing enterprise system support strategy, further simplifying support needs and reducing the cost of ownership.



VMS's advanced High Availability architecture makes it one of the most reliable digital surveillance systems on the market today. With the VMS, Database and Camera Servers are available in redundant configurations; hence a failure in the Preferred Server can be immediately addressed with the system reverting to the Backup Server. Disruption is thus minimized and recordings and live view can be maintained without the need for manual cable swapping or hardware replacement.

- **Intelligent Recording**

The Video Management System helps incident investigation by recording not only the video after an event trigger (post-event recording), but also what happened prior to the event (pre-event recording). This provides a complete picture of the entire event, significantly enhancing investigations, evidence and outcomes.

- **Video Management System provides multiple options for recording video:**

i. Alarm/Event-activated Recordings: Integration with SCADA enables activation of a recording when an alarm or event occurs. Your SCADA system determines when recordings should be made on any camera, with video prior to the alarm or event also captured using the pre-record feature.

ii. Video Analytics Recordings: Video is recorded when VMS detects motion or receives notification from the video analytics subsystem of an event of interest. Again, video prior to the event can also be stored with the recording using the pre-record feature.

iii. Camera Tamper Recordings: Video is recorded when VMS detects potential tampering on a camera. Video prior to the event can also be stored with the recording using the pre-record feature – since the tamper event may result in unusable video, the pre-event record feature may be very useful in providing evidence of the actual tampering.

iv. Device Input/ Output Recordings: Video is recorded when an input device connected to an IP camera or video encoder is triggered or an output is activated on configured devices. Video prior to the event can also be stored with the recording using the pre-record feature.

v. Operator-initiated Recordings: These recordings are initiated by an operator during viewing of the camera. An operator, who has noticed an incident, simply clicks the record button to record the video. Video prior to the record button being pressed is also stored in the recording using the pre-record feature. Manual recordings can either run for a pre-determined length of time or can be terminated by the operator.

vi. Scheduled Recordings: Recordings are scheduled on particular cameras at specified times. Each camera has its own schedule, which can be configured for any time in the future. Re-current (repeated) scheduling is also provided on a daily, weekly and monthly basis.

vii. Continuous Background Recordings: Video and audio if applicable can be continuously recorded on any camera at configurable frame rates without the need to enable complex schedules. This type of recording is resilient to network communication errors between the Camera and Database Server.

- **Digitally Signed Recordings and Audit Trail (LOG)**

The Video Management should provide for the ability to export recordings (or segments of recordings) into standard Windows Media files (MPEG4 format). Every exported recording is digitally signed to provide authentication (of the origin of the recording) and integrity (prove that the recording has not been tampered with).

The alternative to Digital Signatures is "Watermarking", which is used by some digital video systems. Digital Signatures provides many inherent advantages over watermarking. A visible watermark may obscure part of an image, whilst an invisible watermark can potentially introduce visual artifacts. In either case, the original file is altered, which could reduce the evidential weight of the digital image. Digital Signatures, on the other hand, do not alter the original files, ensuring that there is no loss of evidential weight.

VMS should also provide a complete audit trail (log) of all operator actions and system events. This audit trail provides you with a record of all changes made to the VMS configuration, as well as when and who controlled cameras, viewed cameras, initiated and viewed recordings. It also documents VMS's condition at the time of the recording. As with the exported recordings, the exported audit logs are also digitally signed.

The audit trail can be exported when exporting a recording, and then saved with the recording. When used in conjunction with site chain-of-custody processes and procedures, digital signatures and the audit trail greatly enhance the evidentiary weight of a recording in a legal proceeding.

We have proposed unified storage for 1 day storage for all cameras at 4CIF resolution and 25fps. The storage will be installed at south and north portal NOCs.

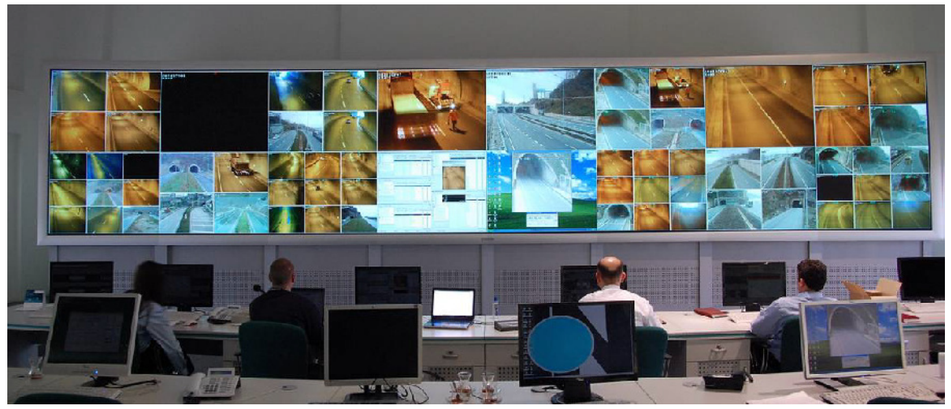
- **Video Incident Detection System**

AID System software is an intelligent software platform for use with an Incident video detection system. AID System software collects traffic data, events, alarms and video images generated by the video detectors. The main goal of AID System software is to manage and control all traffic information generated by these various detectors and to make it useful, meaningful and relevant to the user. Communication with the video detection system goes over Ethernet. AID System software stores all traffic data, events and alarms in a relational database.

AID System software provides a user-friendly interface composed of a monitoring and a reporting application. AID System software enables real-time monitoring of events and alarms. All event info is automatically documented and visualized in a straightforward way, allowing managing each traffic situation efficiently.

Real-time video can be viewed from several cameras simultaneously. Via the reporter application the database is queried to generate data or event reports as exportable graphs or tables. AID System software allows defining different intelligent filtering functions to ensure relevant data presentation and event alerting to the operator during situations such as maintenance or roadwork.

AID System software visualises the layout of the video detection system. The customised graphical user interface allows intuitive handling of the total video detection system to respond efficiently to any traffic alarm and event. The open architecture of AID System software allows scaling the system



Key Features

- Collection and storage of traffic data, events and alarms generated by the Incident video detection system
- Real-time traffic analysis and visualization: monitoring, alerting and reporting
- Graphical user interface for stand-alone use with powerful event alerting and extensive event logging
- Intelligent filtering management
- Streaming video from multiple cameras simultaneously

Key Benefits

- Fast, reliable and stable system
- Easy installation, Windows and Linux compatible
- User-friendly configuration and operation
- Browser-based Graphical User Interface
- Instant recording with pre- and post-event information
- Customisable and multi-user setup with levels of authorization
- Expandable, scalable system with modular design
- Integration of redundancy activation
- Open architecture for easy integration with larger traffic management systems

(1) Detection of Stopped Vehicle on road side

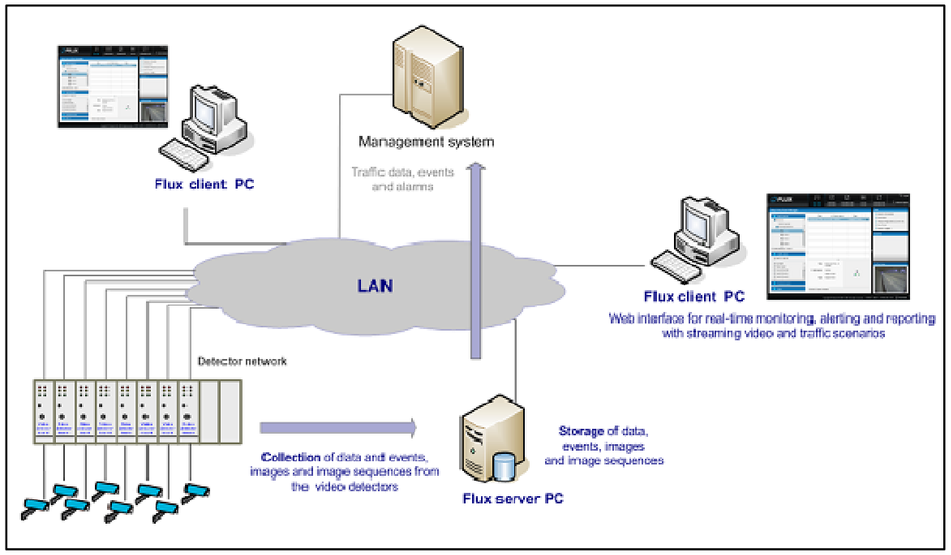
(2) Detection of Fallen Object in Tunnel

(3) Detection of Smoke in a Tunnel

(4) Detection of wrong way driver

(5) Detection of pedestrian on road

(6) Vehicle Data Collection in lanes



- **Aid System Software System Architecture**

AID device is a multi-functional Video Image Processing module for traffic control. AID device provides automatic incident detection, data collection and digital recording of incident video sequences. AID device works with networked video and -displays.

- **Automatic Incident Detection (AID)**

AID DEVICE is an IP based Automatic Incident detection (AID) device with feature of In-built detection system. It captures streaming video from IP cameras, support H.264 video compression and provides real-time streaming video over IP.

AID shall have a high detection rate, a short time to detect, fast incident verification and a low false alarm rate. It performs below mentioned Traffic and Non Traffic incidents detection;

Traffic Incidents are as follows;

- Stopped Vehicle
- Wrong Direction
- Speed drop

Non Traffic Incidents are as follows;

- Smoke detection
- Pedestrians
- Fallen object

Detection Performance for Coastal Tunnel Project

Below is an indication on the detection reliability that can be expected for the various algorithms in different circumstances. This data is based on both internal performance tests and field experience based on over 500 tunnels worldwide. This data assumes;

- Incidents occurring in the field of view of the camera
- Normal weather conditions
- No occlusion
- Constant lighting level

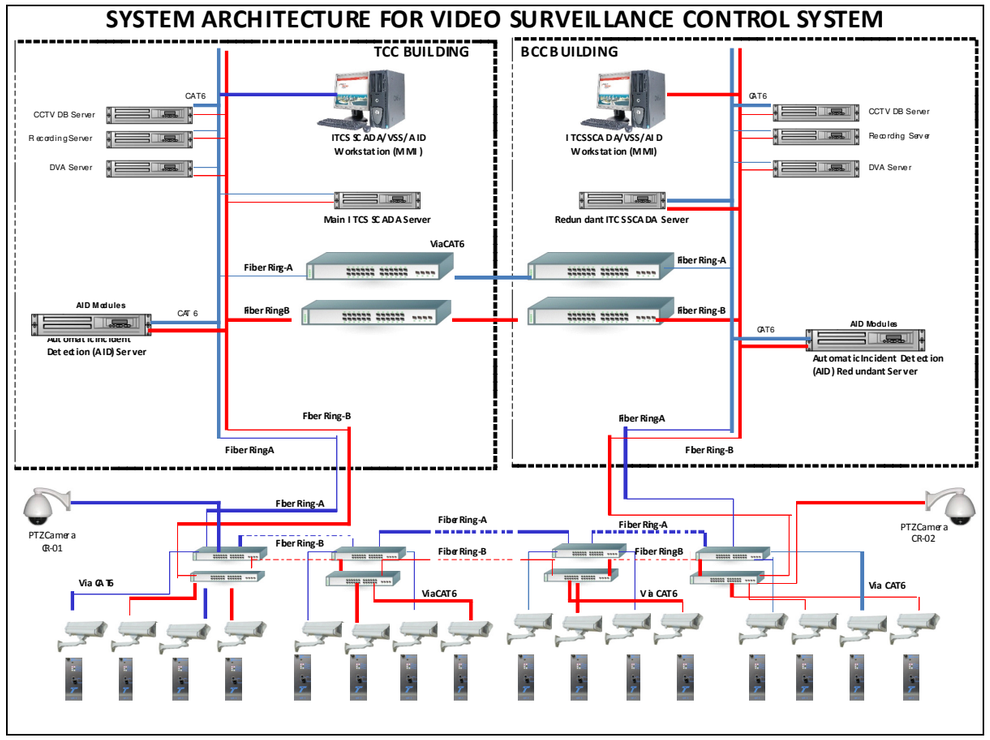
Note that camera position (height, position in the road, angle), configuration of the detection zones and camera specifications can affect detection performance. These performance specifications are valid for a detection range up to 15 times the camera mounting height except when indicated differently in table below.

Smoke detection is based on a deteriorating image quality. There is a predefined detection area over the camera image. This area is divided into a cell matrix. Each cell functions as a smoke zone.

Event	Detection Rate In %	False Alarm Rate Per Camera /Day	Time to Detect In Sec
Stopped Vehicle	>98	0.05	12
Vehicle Queue	>98	0.025	10
Wrong Way Driver	>95	0.025	10
Smoke	>99	0.025	10
Pedestrian	>90	0.05	10
Fallen Object	>90	0.05	20
Under speed	>90	0.15	10
Over speed	>90	0.15	10

Irrespective of technologies being used, Video Analytics has inherent limitation on the accuracy of detection of incidences and is highly dependent on site conditions; hence our proposal incorporates the requested technology without any assurances as to the performance or fitness for purpose of the video analytics for the applications specified.

Video Surveillance System Architecture



8.14.3 Fire Alarm System

8.14.3.1 Fire Alarm System Components

- **Fire Alarm Panel**

Fire emergency detection and evacuation are extremely critical to life safety; therefore intelligent fire alarm control panel designed for medium- to large-scale facilities shall be used in this project. The fire alarm control panel shall be of modular design that is configured per project requirements. It shall have one to ten Signaling Line Circuits (SLCs), to support up to 3,000 intelligent addressable devices.

Information is critical to fire evacuation personnel, and hence the panel shall have large 640-character Liquid Crystal Display (LCD) capable of presenting vital information to operators concerning a fire situation, fire progression, and evacuation details. The panels shall have the ability to communicate directly with one another, enabling peer to- peer communication between networked control panels. The panel shall have the ability to measure the sensitivity of each sensor and to determine its status: alarm, pre-alarm, normal and trouble.

- **Multi Criteria Intelligent Smoke Detector**

The smoke detector shall be intelligent, addressable, multi-sensing, low-profile detector. The multi criteria detector shall be capable of immunity to false alarms. Unlike traditional intelligent detectors, the Multisensor detector has a microprocessor in the detector head that processes alarm data. The multi criteria detector shall be capable of adjusting its sensitivity automatically, without needing operator intervention or control panel programming. As these are multi criteria devices, they shall have the capability of smoke as well as heat detection. It shall have both rate of rise as well as fixed temperature sensors. These detectors are proposed for the NOC building. The detectors shall have a state-of-the-art thermistor sensing circuit for fast response. These detectors shall provide open area protection with 50 foot spacing capability.

The intelligent smoke detectors shall be capable of providing two-way communication with the fire alarm systems. The fire alarm panel loop controller shall have communication protocol containing both digital and analog signals that allow each sensor to communicate its individual address, sensor type and an analog value.

- **Addressable Manual Call Point**

MCP shall have an addressable interface compatible with the intelligent control panels. Because the MCP is addressable, the control panel can display the exact location of the activated manual station. This leads fire personnel quickly to the location of the alarm.

- **Isolator Module**

This may be a part of the smoke detector, however separate fault isolator modules may also be provided. The fault isolator module shall be used with fire alarm panel SLC's to protect the system against wire-to-wire short circuits. The fault isolator modules shall be spaced between groups of sensors in a loop to protect the rest of the loop. It is used to isolate short circuit problems within a section of a loop so that other sections can continue to operate normally. It includes yellow LED indicator that pulses when normal and illuminates steady when a short is detected. If a short occurs between any two isolators, then both isolators immediately switch to an open circuit state and isolate the groups of sensors between them. The remaining units on the loop continue to fully operate.

- **Monitor Module**

This may be a part of the smoke detector, however separate monitor modules may also be provided. Monitor modules supervise a circuit of dry-contact input device. Each Monitor Module uses one of the available module addresses on an SLC loop. It responds to regular polls from the fire alarm panel

and reports its type and the status (open/normal/short) of its Initiating Device Circuit (IDC). A flashing LED indicates that the module is in communication with the control panel. The LED latches steady on alarm. Below are the deployment locations

- Break Glass at CP inside Tunnel
- Fire Extinguisher – 2 Nos inside SOS Box
- For LHS fire Zones
- Admin Building at portal

- **Control Relay Module**

This may be a part of the smoke detector, however separate control modules may also be provided. Addressable control module provides intelligent fire alarm panel a circuit for notification appliances (horns, strobes, etc.). Addressability allows the control relay module to be activated, either manually or through panel programming, on a select (zone or area of coverage) basis. This may be programmed to operate dry contacts for applications. Below are the deployment locations

- Control Module for PLC at CP inside tunnel
- Control Module for Hooter at CP inside tunnel

- **Warning Light and Warning Horn (Sounder/Flasher)**

This may be a part of the smoke detector, however separate sounder/ flasher may also be provided. Addressable indicating equipment with sounder & flasher shall get activated/sounded and will be clearly recognizable as danger signal in case of any detected fire event. They shall be externally powered. It shall be mounted on the wall outside LV room and in the local control centre.

- **Fire Alarm System Proposed for Coastal Road Tunnel Project**

FAS proposed at the site will have multi-criteria detectors including photo, smoke, heat etc placed strategically in LV rooms, and NOCs. It will also be connected to the SCADA software which can graphically represent the placement of detectors and pop up alarms as and when raised.

- **Fiber Optic Linear Heat Detection System**

The LHS SYSTEM is a linear heat detection system specifically designed for fire protection applications. It is able to measure temperature profiles at thousands of points simultaneously along a sensor cable which may be up to 6 km in length. In fire prevention, the LHS SYSTEM is able to determine not only the current position but also the progression of the fire by measuring the temperature along the sensor cable in real time.

Optical fiber offers several important advantages as a sensing medium. Signals are immune to electromagnetic interference thereby ensuring integrity of readings from electrically noisy areas, for example around power cables and transformers. As no electric current is used in the sensing fiber and the fiber is a relatively inert and dielectric (non-conducting) medium, it is a safe technology to use in hazardous environments.

The linear heat device shall be a 19" rack-mounted model, or in secure IP66 outdoor housings. It shall have up to 2/4 channels per device, so that monitoring of 2 loops redundantly with one device is possible at lower costs. It shall have a crystal-clear alphanumeric display screen showing the current status information. It shall have sufficient internal relays in a single device, so that there is no need for an external relay extension.

The linear heat detection system shall be capable of the following activities:

- Detect different fires in sufficient time with precise indication of the fire location without being influenced by high speed air currents.
- Provide functional integrity over widely extended period of time.
- Enable heat spread and size assessment at the scene of accident to activate and supervise e.g. evacuation / ventilation /suppression system adaptively.
- Give vital information's to the fire fighting forces and to control the success of countermeasures

System Sensor Cable

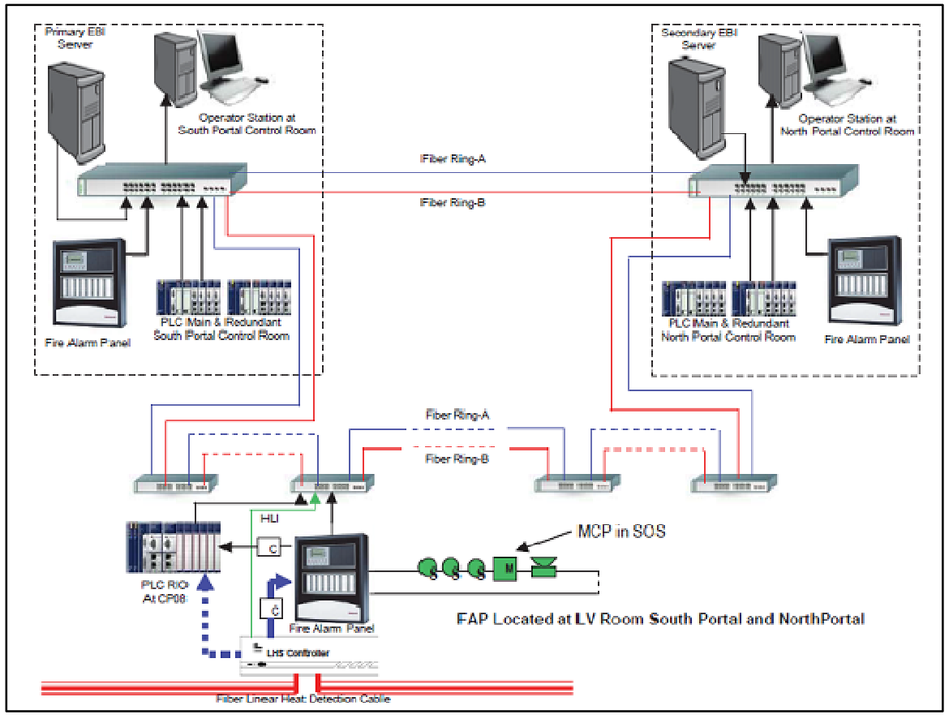
The system sensor cable shall have the following characteristics;

- Sensor Cable - Steel FRNC (m)
- Loose Steel Tube Design / Steel Armored
- Flame Retardant Non Corrosive Jacket
- 2 x MM GI 50/125 µm Fibers
- 3,8 mm Diameter / 25 kg/km
- Crush Resistance 960 N/cm
- Tensile Strength 1.100 N

8.14.3.2 LHS System Architecture

Specifications

- Range - 6 Km
- Operating temperature range: -10 to +60°C
- Power supply: 10 to 30 V DC
- Power consumption: 15 W typically
- Number of measurement channels: 1, 2
- Integrated Relay Borad:
- 4 x Opto-Coupled Reset Inputs
- Potential Free Outputs
- 1 x System Error Output
- 43 x Configurable Alarm Outputs
- 256 free definable zones per channel
- USB / Ethernet /RS232 interface, RS422 /485 external
- 19" inch rack, 2HU



Description

Fire alarm panel shall be installed in admin buildings of South portal & north portal respectively. Local fire alarm panels shall be installed inside the tunnel in LV control rooms of cross passages strategically placed at approximately a distance of 1 km from each other and in turn will be connected with main fire alarm panels over its own optical fibre network. Typical loop diagram is shown above where all addressable devices will be connected over class A wiring i.e. loop in and loop out.

Integration with SCADA system over Ethernet shall be enabled.

Linear heat sensing system comprising of evaluation unit which shall be installed inside the tunnel in LV control room no. 1, 7,16. Optical linear heat sensing cable shall be connected with respective evaluation unit. Zone alarms will be raised by evaluation unit which will be communicated to SCADA system.

Monitor module shall be connected to limit switch for monitor fire extinguisher status in SOS boxes. Monitor module with dual input shall be also being used to monitor AID devices, linear heat detection zones. Control modules shall be used to interlock with escape exit door, Evacuative broadcasting system for global announcements at south & north portals.

8.14.4 Access Control System

8.14.4.1 System Overview

Access Control System (ACS) is an integrated solution that consists of hardware and software designed to control entry into selected areas and manage movement within. The system is designed to increase security by defining access permissions based on area and time for each user and maintaining a log of all events.

ACS is used to adjust all parameters of the system, control hardware, display events related to movement of users, alarms, and operation of hardware devices. The software is also used for storing all events in the database and generating reports based on requirements defined by an operator.

Sensors shall be executed in the form of contact switches. An entry permit shall be realized by individual chip cards.

8.14.4.2 Access Control System Components

1) Reader with built-in controller for single door. IP based smart card readers for the access control inside tunnel at LV room doors, Admin Building, Ventilation Buildings. HID readers with a powerful built in controller so there is only one device to install and connected with network.

2) Electromagnetic Lock of 12/24 VDC 1200lbs to be fixed on the doors. These locks shall be controlled directly through the readers cum controllers. The electromagnetic lock shall have a magnetic switch built inside to provide NC/NO relay contacts for door sensing. To be deployed in admin building at portal and LV rooms inside tunnel.

3) Door sensors of high quality magnetic switches for door status sensing. It is a combination of a magnet and a reed-switch unit. These switches are vibration resistant. To be deployed in admin building at portal and LV rooms inside tunnel.

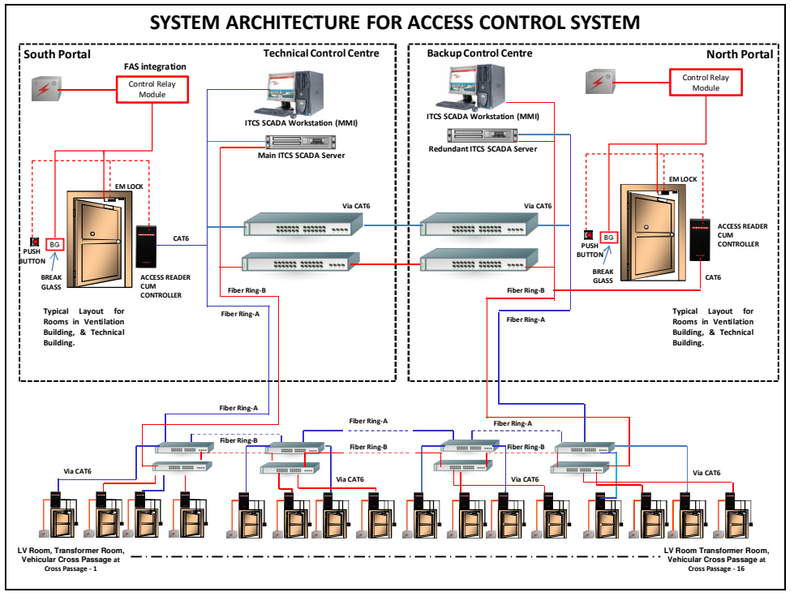
4) Emergency pull stations for emergency egress application. These pull stations can be reset with the key provide.

5) Release push button of high quality stainless steel for door release. The button comes with stainless steel faceplate and can be flush mounted on the wall. It has got a NC/NO relay contact.

6) Smart cards for access control.

7) The SCADA/ACS software for Access control application. SCADA/ACS shall be highly configurable integrated building management system providing an efficient and reliable way of ensuring the security, safety and comfort of people and the effective operation of buildings and facilities.

8.14.4.3 Access Control System Architecture



8.14.5 Traffic Control System

8.14.5.1 System Overview

The Traffic Control System consists of various traffic lights, message signs, traffic signs & etc which are all signalling devices positioned at south & north cross road round abouts portal & inside tunnel to control competing flows of traffic.

The Main aim of the system is to;

• Provide guidance to the traffic coming in and out of the tunnel in case of normal, congestion and emergency conditions.

• Provide an orderly movement of traffic;

All Traffic Lights are controlled and monitored by Programmable Logic controllers and Integrated Tunnel control system to be controlled automatically and manually as per Modes of operation defined.

Traffic Control System will have following components

1) Traffic Lights

- Traffic Lights Three Coloured - LEDs Light shall have Three colors (Red, Green, and Amber) with 300mm diameter and vertical orientation. LED kit IP65, Rear side protection IP54. TLTC Lights follows BS EN 12368 standard.
- Amber Flashing Warning Lights (AFWL) - LEDs Light shall have Amber Flashing Light, with 210mm diameter. LED kit IP65, Rear side protection IP54. AFWL Light follows BS EN 12368 standard

2) Traffic Signs

- Speed Limit Variable Message Signs - Light shall have matrix type white LED speed signs encircled in red LED circle / as per standards and shall display (30, 50, 70) km/hr. 1000mm x 1000mm. Housing material shall be of aluminum alloy with IP65 protection. Two number amber warning flashing lights of size 210mm dia shall be fitted in it. Follows EN 12966-1:2005, EN 12899.
- Tunnel Variable Lane Signals (TLS) - Light shall have matrix type LED with display of red cross and green arrow 300mm x 300mm. Housing shall be of aluminum alloy for signs with IP65. Follows EN 12966-1:2005.
- Luminous Traffic Signs (LTS 1) - LEDs sign with sign mark of “SOS Box” shall be double sided 500 x 500 mm, two traffic lights with two traffic directions, aluminum alloy housing.

- Luminous Traffic Signs (LTS 2) - LEDs sign shall sign mark of "Escape Exit" be double sided 500 x 500 mm, aluminum alloy housing.
- Luminous Traffic Signs (LTS 3 & 4) - LEDs sign shall sign mark of "Escape Exit with direction" 50 m right & left arrow, 100 m right & left arrow, 150 m right & left arrow be single sided 500 x 700 mm, aluminum alloy housing.

3) Information Panels

- Dynamic Road Information Panel (DRIP)/ Variable Message Sign Board - DRIP Cabinet size shall be 4000 mm (W) X 2000mm (H), Full Matrix, LED Display Area 3800mm (W) X 1800mm (H) with pixel pitch of 25mm and the resolution of 152 (W) x 72 (H), Enclosed in Hot Dipped Galvanised (GPSP Alloy)
- Entrance Variable Message Signs (EVS) - Light shall have Matrix Type LED Green Arrow, Red Cross, Crossover Yellow Arrow, Traffic Prohibited. 960mm x 960mm. Housing shall be of Aluminum Alloy with IP65 protection. Follows EN 12966-1:2005, standard
- Entrance Detection Control System (EDCS):
  - Entrance Height Excessive Vehicle Control System (EHD) - It shall be based on a light barrier detection principle. It shall have a Set of IR Beam Transmitter and Receiver. Transmitter shall be mounted at certain height on pole on one side of road and Receiver shall be mounted at equal height on the other side of the road on pole. In addition to it Magnetic Vehicle Loop Detector shall be installed under the road to detect vehicle physically available at particular area.

4) Barriers

- Mechanical Barrier - Electromechanical Barrier shall be provided with Boom length of 5 mtrs with IP64 protection. Boom barrier shall be connected to PLC to operate in auto mode as well in manual mode to restrict the entry of vehicles into tunnel.
- Rigid Height Barrier - Rigid Height Barrier shall be of galvanized material with height of 5mtrs and shall be gantry type to physically restrict entry of over height vehicles to tunnel.

5) Reflective signs

- Type A - Overtaking prohibited with standard font as per NHAI guidelines. It shall be pasted on galvanized sheet.
- Type B - Switch Vehicle Lights On with standard font as per NHAI guidelines. It shall be pasted on galvanized sheet.
- Type C - Switch Vehicle Lights Off with standard font as per NHAI guidelines. It shall be pasted on galvanized sheet.
- Type D - Limits Cancelled Overtaking prohibited with standard font as per NHAI guidelines. It shall be pasted on galvanized sheet.
- Information Plate (Tunnel Name Plate) - Tunnel Length and Tunnel Name shall be mentioned with reflective sign on aluminum alloy sheet size 2m x 1.5m.
- Information Traffic Sign (Radio Broadcast Frequency) - Transmitted broadcasting station frequency and name shall be mentioned with reflective foil on aluminum alloy sheet.
- Lay-bays Ahead - Lay-bays ahead shall be mentioned with reflective foil on aluminum alloy sheet.
- Fire Fighting Niche - Fire Fighting Niche sign as per mentioned in the concession agreement drawing.

8.14.5.2 Equipment & System deployment locations

1. The Traffic Lights Three Coloured shall be used for closing the tunnel traffic. The amber light of the TLTC shall serve also as flashing warning signal in exceptional traffic situations. Inside Main tunnel TLTC Lights shall be installed 2.5 mtrs above floor level towards emergency sidewalk at every 500 meter gap. Lights shall guide the road users to act as per traffic situations inside tunnel.
2. Dynamic Road Information Panels (DRIP)/ Variable Message Sign Board shall be installed near the entrance to provide necessary textual information to road users to take appropriate action accordingly.
3. Speed Limit Variable Message Signs (SL) with AFWL shall be installed inside the tunnel at every 600 meter gap to guide the road users to drive the vehicle at desired speed limits. Outside tunnel SLs shall be installed before tunnel entrance and SLs with entryway prohibited shall be installed at the cross road location to restrict the vehicle entry inside the tunnel route.
4. Entrance Variable Message Signs (EVS) with entryway prohibited" symbols shall support a tunnel closing, regular traffic operation and make possible automatic redirection of the tunnel traffic. The EVS shall be located on outside entrance road gantries of a bridge type near the tunnel portals above centres of traffic lanes.

5. Tunnel Variable Lane Signals (TLS) shall be installed inside the tunnel at every 430 meter gap above the middle of the traffic lanes.

6. Amber Flashing Warning Lights (AFWL) of the Traffic Control System shall serve as flashing warning signal in exceptional traffic situation like a vehicle breakdown, etc and shall be installed on SOS box and with Speed Limit Variable Signs (SL's).

7. Entrance Detection Control System (EDCS) - Entrance Height Excessive Vehicle Control System (EHD) – IR beam transmitter and receiver shall be mounted on pole. In addition, Induction loop cables shall be installed inside road to check physical availability of vehicle on road.

8. Mechanical barriers shall be assigned to support closing of the tunnel for traffic. Barrier shall be installed at every 500 meter gap near ECP/VCP to restrict vehicles to enter inside tunnel in case of emergency.

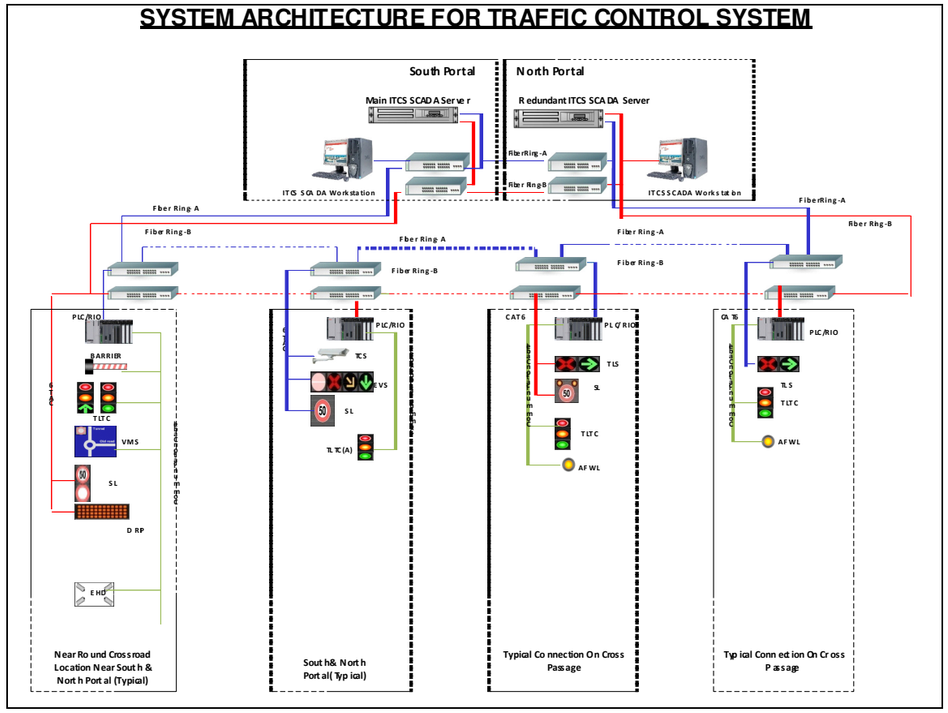
9. Rigid Height barriers shall be installed on outside entrance road gantries located in front of tunnel portals, together with TLTC, EVS's and TCS.

10. Luminous Traffic Signs shall be installed inside tunnel and mounted on one side tunnel wall to guide the road users in case of emergency condition.

11. Standing reflective traffic signs ("Overtaking Prohibition", "Switch Vehicle Lights On", "Switch Vehicle Lights Off', "Limits Cancelled", Transmitted Broadcasting Station Frequency and Name and Tunnel Name Plate, Fire fighting niche) shall be located by standard regulations on outside public lighting poles. Standing reflective traffic signs marking ECP/VCP ahead shall be installed in the tunnel tube in distance of 100 m in front of appropriate ECP/VCP. The distance shall be marked on the signs with descriptive number of individual ECP/VCP.

12. Information Sign with VMS - Information signs with VMS shall be installed at the entrance at cross road.

8.14.5.3 System Architecture of Traffic Control System



8.14.6 Emergency Call Box and PA Communication System for Tunnel

8.14.6.1 System Overview

The emergency call system consists of an emergency switch board on the workplace o operators and SOS boxes situated in front of the tunnel tube at both portals (one no. at each portal) and inside the tunnel tube installed at every 250m spacing on both sides of main tunnel. The main purpose of the system is to assure verbal communication in between operator and a traffic participant for announcement and explanation/clarification of the appropriate emergency situation. The entry of any person to some SOS box shall activate telephonic communication with using emergency speaker phone and an amber warning flashing light above the SOS box, which is signalling some traffic problem. All the emergency calls shall be recorded and archived for the time of one month (30 days).

8.14.6.2 System Components

1) SOS Box

The SOS boxes are sound-tight cabinets, made from stainless steel with degree of protection IP 65. SOS boxes shall be installed inside the main tunnel in emergency call niches located 250 m on Emergency lane side of main tunnel. SOS box cabinet shall have Emergency speakerphone, One

emergency push-button (for call of help for drivers with immobile car, health trouble and by an accident) and two manual fire extinguishers of capacity 6 kg each and tools (Axe with crow-bar) for fast extrication of persons from a stopped car. Emergency call stations contain also beside Emergency Call Speakerphone, power distribution units.

The SOS box interior is permanently alight with an orientation light. Entry to SOS box is indicated optically and acoustically on operator's workplace. In addition, main interior lighting of a SOS box & amber warning flashing lights (for both traffic directions) above box shall be activated. Emergency functions of SOS boxes, traffic signs with SOS symbols and amber warning flashing lights shall be supplied from uninterruptible power source – UPS.

The SOS boxes shall be marked by expressive numeral labelling (readable from a CCTV camera and by outstanding inscription with the following text in local and English languages: "This area does not provide protection from fire!!"

2) Main & Redundant Emergency Telephone Server

Main Emergency Telephone Server shall be installed in South Control Centre and redundant server in North Control Centre. In case of failure of one server, the other server shall take control of all Emergency Call System operations. The recording of the voice calls shall be maintained for 30 days.

SOS Box Emergency Speaker Phone's critical inputs are monitored by the Emergency Telephone Server.

The Emergency Telephone Server shall be capable of communicating with ITCS over the IP network.

3) Emergency Call System Switchboard

Emergency call system switchboard shall be used as the Master Station. They are placed at South and North Tunnel Portals and are able to control, monitor and communicate to any Intercom at the tunnel through IP backbone network. Master Station comprises of VoIP telephone console & handling desk and shall be able to receive and make emergency calls from/to SOS box Emergency Speaker Phone. Emergency calls can be recognized in the control room by special ring tone. On the handling desk panel the according lamp shall illuminate.

4) Emergency Speaker Phone (SOS Box)

The Emergency Speaker Phone located in the Emergency call box (SOS Box) shall be used by tunnel commuters to forward the information to the Master Station after an incident is detected. The operator at the Master Station shall decide the activation of a suitable control system response to the reported incident and calls in the rescue service if needed.

5) Emergency Telephone System Workstation

The workstations shall provide the graphical information about the ECS System. The visualisation software installed for Emergency call System shall display status of connected equipments.

ECS shall serve as the software for implementing the same. The workstation shall also host the Open protocol for integration to transfer alarm which shall be used to transfer alarm and event messages from ECS System to the ITCS System over the IP network.

The state of art Emergency communication system for roadways is designed to meet the communication & safety requirements for roads. System cabling is designed on redundant IP backbone to make system availability 100 % in all situations. System is built with following elements to meet the requirement,

a) IP Based Primary and redundant server.
b) Weather & Vandal proof IP Emergency Call stations at every 250 meter distance in both of tunnels at ECP/VCP side.
c) PA speakers with built in microphone for background noise sensing and intelligent volume control at every transit rooms for making announcements at individually or multiple locations from Control room.
d) Control room call Stations for answering Emergency calls, making PA announcements, monitoring & diagnostics all ECB and PA points.
e) GUI software for providing interface for SCADA system to monitoring, control the ECB & PA system through common workstation of Tunnel system. With interface it is possible to do diagnosis, keep log of events, and generate automatic system status reports, GUI representation of ECB & PA element status.
f) Audio recording for all Control station calls with time & date stamp and web interface for stored files for analysis.

8.14.6.3 System Design

All system elements are connected to each other via IP network with redundant fiber optic and copper cables. Servers are placed in two different control rooms and configured to work one as Primary and other as Secondary server. Both servers will in ON state and Emergency call stations and PA Stations are configured to work on primary server and as fall back arrangement on secondary server. Emergency call box and PA speakers are POE operated; as well it can be powered with local DC power supply.

- **Functionality**

System will provide utility to manage the harmony at roads / Tunnel by monitoring and controlling the emergency situations efficiently. In emergency, people can access the nearest Emergency call points, to get the help from the control room. For this, person needs to go and press the help button on the emergency station. After pressing the button, person will get prompt recorded audio message response from system indicating call has been connected. Call will be instantly (less than 100 mS)

connected to control room(s). Control room person will get audiovisual alerts of calls; display of control station will give details of calling station i.e. Name, Location etc. Control room attendant can select the call and communicate with person seeking help and provide the desired help. Control room station can get multiple calls simultaneously, operator will get visual display of calls and he/she can select calls as per priority.

Control room persons can make announcement to any desired Emergency call point or PA points for general announcements. There is facility to record the announcements and play it again and again from control desk, at desired time. Announcements can be broadcasted to specific location, group of stations or entire system as per selection.

IP Cameras on field can be linked with Emergency call points. When call is connected to control room, logically linked camera video will be automatically streamed to control room screen, giving live video of calling station.

All voice communication and PA announcements & events at control rooms can be recorded for later review centrally, with proper database backup.

8.14.6.4 Technical Details

Technical details of System elements are as below:

1) ECS Server

Basic Digital Central Unit which include power supply card (GEN), Processor card (GEP) and Connection Card (NET). It supports 14 plug-in slots for various functions. One ECS SERVER can support up to 112 subscribers (Paging consoles / zones), and different interfaces in accordance to user needs.

The following is a list of key benefits:

a) Digital Server for Audio, 2 Way communication, video, indication and control.
b) Integration of other systems via Ethernet and V24 interfaces with own protocol converter
c) Latest intercom technology: microprocessor-controlled, high density design, SMD production, object-orientated programming.
d) Digital networking over IP, 2 or 4-wire lines, E1, ISDN, SIP etc.
e) Expandable from 2 to 5760 subscribers (paging console / Zones channel) without restriction, and up to 30,000 subscribers with restrictions.
f) User-friendly configuration with PC Software
g) Various connection board is available to easy mounting/installation
h) All Cards, modules/paging consoles are closely monitored.
i) All cards and paging consoles are easily replaceable without re-configuration.

2) Emergency Call station

IP station with one programmable, back-lit emergency call button, electret microphone with multifunction LED, loudspeakers 2 x 8 Ω, 3 inputs for floating contacts and 2 relay outputs (connection as “make” or “break” contact), protection classification IP 65 and IK 08, material stainless steel

3) Master Control Room Station

IP station with Mono-LCD display with white backlight, backlit alphanumeric standard keypad, function buttons, electret microphone with multifunction LED, loudspeakers 2 x 8 Ω, 3 inputs for floating contacts and 2 relay outputs (connection as “make” or “break” contact), protection

classification IP 65, polycarbonate construction. Multifunctional master stations for internal and outdoor areas made in polycarbonate construction. Besides communication the stations can carry out control functions in other systems. The amplifier provides the necessary volume in areas with high ambient noise. The stations are protected against dust, dirt or water jets which may occur in industrial environments. The special foil on the front panel has a dirt-repellent effect and can be quickly and easily cleaned using normal cleaning agents and disinfectants. Large foil-type buttons make operation with protective gloves easy.

4) IP PA Speakers

a) Each loudspeaker can be addressed and configured individually

b) End-to-end monitoring of connection and loudspeaker functionality

c) High volume capacity and superior speech quality, thanks to integrated 10 watt class-D amplifier

d) IVC (Intelligent Volume Control) automatically adjusts the volume setting to the ambient noise level

e) Conversation and talk-back over integrated microphone

f) Audio Monitoring enables ambient acoustic surveillance and automatic triggering of actions such as voice announcements or emergency calls

g) Built-in inputs and outputs, e.g. for monitoring and controlling third-party sub-sections or triggering pre-defined actions

h) Power supply via PoE (Power over Ethernet) – only one Ethernet cable required

i) No need for central amplifiers – ideal also for small-sized and remote PA zones

j) Loudspeakers can be allocated to groups and zones without modifying the hardware or wiring

k) Forward compatible (unlike classic PA systems), as new functions can easily be added via software download

l) Combinable with virtual server landscapes via VirtuoSIS – provides all the benefits without the need for extra hardware

5) Central Visualization and recording software: –

ECS software is the new generation of visualisation software for control desks in client-server structure. All control desk functions of the Intercom system are displayed on one or multiple monitors.

ECS software contained modules Visualization, Video, Scheduler and the separately available ECS server applications REPORT and SDK open the path into a new dimension of Security and Communication Systems.

In standardized reporting, scheduled automation of intercom functionality, video integration and the development of professional custom applications, possibilities are nearly boundless.

8.14.7 Modes of operation & Cause & Effect Matrix for Tunnel Ventilation System

8.14.7.1 Emergency Call System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EMERGENCY CALL SYSTEM	ALARM MANUAL BUTTON	SOS Box Internal To Main Tunnel	Alarm	1) Immobile Vehicle2) Health Trouble 3) Accident	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Amber flashing lights above SOS box for both traffic direction already activated at SOS box door opening	*
					3) Intercom communication and emergency call control unit recording system at main control centre already activated at SOS box door opening	*
					4) SOS box interior lighting already activated at SOS box door opening using Occupancy sensor	*
					5) CCTV camera shall capture the image of surrounding of respective SOS box and same shall be available on operator CCTV monitors at main/redundant control centre	*
					6) Alarm confirmation/authentication by operator at main control centre from camera live pictures, on basis alarm incident operator shall activate predefined mode of operation	#
					7) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light (if vehicle breakdown occurs with vehicle stopped inside tunnel out of lay-bay), traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol (if vehicle breakdown occurs with vehicle stopped inside tunnel (out of lay-by) TLTCs inside tunnel on red light to stop traffic before arriving to stopped vehicle, and on green light after stopped vehicle (if vehicle breakdown occurs with vehicle stopped inside tunnel out of lay-by), mechanical barrier at tunnel portal at closed position (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-by)	*
					8) Activation of tunnel communication system: transmission of message from Evacuative Broadcasting system by operator	#
					9) Application of all the emergency standards procedures according with emergency response plan (ambulance, police or breakdown truck are informed in order to give assistance to involved users) by the operator at main control centre	#
					10) Operator shall reset the system based on confirmation from emergency team	#

8.14.7.2 Access Control System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
ACCESS CONTROL SYSTEM	Door Position Sensor	Cross Passage Door	Door Opening Alarm	Emergency Condition	1) Announcement / visualization and alarm transmitted to operator at main/redundant control centre	*
					2) Alarm confirmation/authentication by operator at main control centre through CCTV system, on basis alarm incident operator shall activate predefined mode of operation	#
					3) Activation of cross passage & escape tunnel emergency lighting system	*
					4) In case of Alarm: - Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light. - Signal to toll collection system to stop traffic - Traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol, message on DRIP to divert traffic to old route and SLVS for vehicle entry prohibition. Speed limit shall be reduced for SL installed inside tunnel. - TLTCs inside tunnel on red light to stop traffic before arriving to incident location, and on green light after incident location - Mechanical barrier at tunnel portal at closed position (only for entrance lanes) - Activation of tunnel communication system: alarm to be broadcast by operator in main via Evacuative Broadcasting System - Application of all the emergency standards procedures according with emergency response plan (ambulance, police or breakdown truck are informed in order to give assistance to involved users) by the operator at main control centre	*
						#
					5) If either MCP or ACS break glass is operated, emergency lighting shall be activated in escape tunnel after authentication by operator	*
					6) Operator shall reset the system based on confirmation from emergency team	#

8.14.7.3 Video Surveillance System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VIDEO SURVEILLANCE SYSTEM	AID DEVICE PER CAMERA INSIDE TUNNEL	Main tunnel (Fire zone every 75 m)	Stopped vehicle detected – Alarm	1) vehicle breakdown/ Accident	1) Alarm shall be transmitted to operator at main/redundant control centre	*
					2) alarm confirmation/authentication from operator at main control centre through CCTV system, on basis of alarm incident operator shall activate mode of operation	#
					3) speed limit reduced externally and internally to tunnel using SLV lights with amber flashing lights	*
					4)Traffic external to tunnel stopped before incident location inside tunnel, using TLTC on red light (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-bay), traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol (if vehicle breakdown occurring with vehicle stopped inside tunnel (out of lay-by). TLTCs inside tunnel on red light to stop traffic before arriving to stopped vehicle, and on green light after stopped vehicle (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-by), mechanical barrier at tunnel portal at closed position (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-by). Message shall be sent to stop the vehicle entry into tunnel and EVS both side of tunnel shall turn to red cross to stop vehicles	*
			Rise of	2) Fire incident	1) Alarm shall be transmitted to operator at main/redundant control centre	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
			smoke Alarm		2) Automatic prompt (POP-UP) of appropriate mode of operation for respective fire zone for confirmation by operator. If operator does not take any action within pre-defined time i.e. delay of 5min, system shall automatically activate the appropriate fire mode	#/*
					3) alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Activation of escape tunnel pressurization fans of respective side of tunnel automatically after 1.5 minute of incident	*
					5) Activation of second escape tunnel pressurization fan manually by operator for fire mode.	#
					6) Motorized smoke damper (MSD) - 01, 02, 03 near fire location are fully open and all others will be closed (Typical scheme is followed for different fire zones as per mode of operation)	*
					7) TVS-S-01 / TVS-S-02 / TVS-N-01 / TVS-N-02 axial fans for fresh air supply are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation.	*
					8) TVE-S-02 / TVE-N-01 / TVE-N-02 axial fans for air/smoke extraction are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation.	*
					TVE-S-01 axial fan for air/smoke extraction is activated (Typical scheme is followed for different fire zones as per mode of operation). TVE-S-01 shall operate at 100%.	*
					Jet Fan control shall be enabled in fire mode only. Please refer Mode Table & Annexure 1 provided below:	
					JF-S-01 / JF-S-02 / JF-S-03 / JF-S-04 jet fans for longitudinal air speed control not activated	*
					AN-01 to AN-05 detect the air speed velocity and direction inside tunnel	*
					10) Anemometer/Velocity sensor from S to North and N to South detect the air velocity and direction inside the tunnel. If the velocity from both side of tunnel is equal between 1.0 to 1.6 m/sec, there is no activation of Jet Fans.	*
					11) If longitudinal air velocities from S to fire site and N to Fire site are different the following operation shall be applied;	*
					a) Air velocity from S to fire site is higher than the air velocity from N to fire site;	*
					· JF-N-01 & N-02 are activated	*
					· System shall keep observing the measurement for 3 mins with defined limits i.e. above 1.6 m/sec	*
					· If air velocity from S to fire site is still higher than the air velocity from N to fire site JF-N-03 & N-04 are also activated	*
					b) Air velocity from N to fire site is higher than the air velocity from S to fire site;	*
					· JF-S-01 & S-02 are activated	*
					· System shall keep observing the measurement	*
					· If air velocity from N to fire site is higher than the air velocity from S to fire site JF-S-03 & S-04 are also activated	*
					12) JF at respective portal do not operate if fire event happen within 300m zone from the portal entrance	*
					13) JF at other portal will operate manually if needed	#
					14) traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					15) traffic external to tunnel, in correspondence at circular intersection, redirected to the old road using information sign with VMS, DRIP	*
					16) traffic external to tunnel stopped before entering inside tunnel, using EVS on red light cross	*
					17) Traffic inside the tunnel stopped before arriving to fire zone, using TLTC on red light and TLS on red light cross however the system shall allow the vehicle to move out of tunnel after fire zone using TLTC on green light and TLS on green light arrow.	*
					18) mechanical barrier at tunnel portal at closed position	*
					19) Evacuative Broadcasting system & FM radio broadcast shall make global announcement for tunnel user to leave the tunnel	*
					20) activation of escape tunnel lighting system after authentication by operator	*
					21) Activation of signal to Toll Plaza to stop vehicle tolling and entry	*
					22) ACS, open three doors in Fire condition, each side of fire zone	*
					23) Operator shall reset the system based on confirmation from emergency team	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VIDEO SURVEILLANCE SYSTEM	AID DEVICE PER CAMERA	Main tunnel (Fire zone every 75 m) Inside tunnel	Pedestrian – Alarm	Person moving in tunnel	1) Alarm transmitted to operator at main/redundant control centre. Speed sign to reduce speed of vehicles. Traffic Lights shall turn to Amber.	*
					2) Manual announcement through evacuative Broadcasting system to assist the person	#
			Wrong way vehicle – Alarm	Vehicle moving in wrong direction	1) Alarm transmitted to operator at main/redundant control center	*
					2) TLTCs inside tunnel on red light to stop traffic before arriving near to person/vehicle, and on green light after moved person/vehicle to lay-bay. After authentication by operator.	#
					3) Manual announcement through FM to warn the wrong way driver.	#
			Fallen object – Alarm	An object/ material fallen on the road	1) Alarm transmitted to operator at main/redundant control center.	*
					2) After authentication appropriate mode of operation shall be activated by operator	#
					2) TLTCs inside tunnel on red light to stop traffic before arriving near to person/vehicle, and on green light after moved person/vehicle to lay-bay. After authentication by operator. Speed reduced through SLV's before the fallen object.	*
					3) Manual announcement: operator to announce appropriate message through EBS & FM radio.	#
					4) Emergency Response team to clear the fallen object.	#
			Camera Failure alarm	Network communication /Power failure	1) Alarm transmitted to operator at main/redundant control center.	*
			AID Failure alarm	Video Loss	2) Appropriate action to be taken by operator to inform maintenance team to rectify the fault.	#
			Speed Drop	Stopped vehicle/ Slow moving vehicle	1) Announcement of appropriate message on FM radio by operator. Adjust speed limit signs.	#

8.14.7.4 Ventilation System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VENTILATION SYSTEM	NORMAL OPERATING CONDITIONS					
	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 70ppm/ OP Extinction Factor ≥ 0.006m-¹ For Duration T > 3 Min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*
					3) Opening of Non Return Damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					5) Activate FAN at 25 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					6) Fan run/stop status via air flow switch	*
					7) Opening of Non Return Damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					9) Activate FAN at 25 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					10) Fan run/stop status via air flow switch	*
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins.	*
					12) If CO level is < 50 ppm and OP < 0.0040 then all TVE & TVS FAN shall be switched off.	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VENTILATION SYSTEM	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 85 ppm/ OP Extinction Factor ≥ 0.0065m-¹ for Duration T > 3 Min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*
					3) Opening of Non Return Damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
		(Zone-5) CP's-24-26-28 (Zone-6)			5) Activate FAN at 40 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					6) Fan run/stop status via air flow switch	*
					7) Opening of Non Return Damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					9) Activate FAN at 40 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					10) Fan run/stop status via air flow switch	*
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins	*
	NORMAL OPERATING CONDITIONS - CONGESTED TRAFFIC					
	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 100 Ppm/ OP Extinction Factor ≥ 0.0070m-¹ For Duration T > 10 Min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*
					3) Opening of Non Return Damper for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					5) Activate FAN at 60 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					6) Fan Run/stop status via air flow switch	*
					7) Opening of Non Return Damper for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					9) Activate FAN at 60 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					10) Fan run/stop status via air flow switch	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins.	*
VENTILATION SYSTEM	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 115 ppm/ OP Extinction Factor ≥ 0.0075m-¹ For Duration T > 10 Min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*
					3) Opening of Non Return Damper for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					5) Activate FAN at 100 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					6) Fan run/stop status via air flow switch	*
					7) Opening of Non Return Damper for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					9) Activate FAN at 100 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					10) Fan run/stop status via air flow switch	*
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins.	*
	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5)	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 130 ppm/ OP Extinction Factor ≥ 0.0080m-¹ For Duration T > 10 Min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*
					3) Opening of Non Return Damper for TVE-S-1 & TVE-S-2 (CPs 02,04,…….14) / TVE-N-1 & TVE-N-2 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return damper (NRD) for TVE-S-1 & TVE-S-2 (CPs 02,04,…….14) / TVE-N-1 & TVE-N-2 (CPs 16,18,…….28)	*
					5) Activate FAN at 75 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
		CP's-24-26-28 (Zone-6)			16,18,…….28) and FAN at 75 % TVE-S-2 (CPs 02,04,…….14) / TVE-N-2 (CPs 16,18,…….28)	
					6) Fan run/stop status via air flow switch	*
					7) Non Return Damper for TVS-S-1 & TVS-S-2 (CPs 02,04,…….14) / TVS-N-1 & TVS-N-2 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 & TVS-S-2 (CPs 02,04,…….14) / TVS-N-1 & TVS-N-2 (CPs 16,18,…….28)	*
					9) Activate FAN at 75 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28) and FAN at 75 % TVS-S-2 (CPs 02,04,…….14) / TVS-N-2 (CPs 16,18,…….28)	*
					10) Fan run/stop status via air flow switch	*
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins.	*
	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 150 Ppm/ OP Extinction Factor ≥ 0.0090m-¹ For Duration T > 10 Min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*
					3) Opening of Non Return Damper for TVE-S-1 & TVE-S-2 (CPs 02,04,…….14) / TVE-N-1 & TVE-N-2 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return Damper (NRD) for TVE-S-1 & TVE-S-2 (CPs 02,04,…….14) / TVE-N-1 & TVE-N-2 (CPs 16,18,…….28)	*
					5) Activate FAN at 100 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28) and FAN at 100 % TVE-S-2 (CPs 02,04,…….14) / TVE-N-2 (CPs 16,18,…….28)	*
					6) Fan run/stop status via air flow switch	*
					7) Opening of Non Return Damper for TVS-S-1 & TVS-S-2 (CPs 02,04,…….14) / TVS-N-1 & TVS-N-2 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 & TVS-S-2 (CPs 02,04,…….14) / TVS-N-1 & TVE-N-2 (CPs 16,18,…….28)	*
					9) Activate FAN at 100 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28) and FAN at 100 % TVS-S-2 (CPs 02,04,…….14) / TVS-N-2 (CPs 16,18,…….28)	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					10) Fan run/stop status via air flow switch	*
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VENTILATION SYSTEM	NORMAL OPERATING CONDITIONS - STOPPED TRAFFIC (TUNNEL CLOSURE)					
	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 200ppm/ OP Extinction Factor ≥ 0.012m-¹ Duration Of Detection T ≥ 3min	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Image of spot will be captured by CCTV and will be available at operators monitor	*
					3) Alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Traffic stopped in front of tunnel portal using TLTC on red light	*
					5) Traffic stopped in front of tunnel portal using EVS on red cross symbol	*
					6) Traffic redirected to the old road using information sign with VMS at circular intersection & DRIP to divert traffic to old route	*
					7) Using of mechanical barrier for closing tunnel to traffic	*
					8) Activation of tunnel communication system: transmission of predefined phonetic messages on FM radio and EBS (users informed to shut off the vehicle engine in case of stopped traffic) via Evacuative Broadcasting system and FM Radio.	#
					9) Alarm sent to toll plaza to stop tolling and vehicle entry to tunnel	*
					10) Application of all the emergency standards procedures according with emergency response plan (ambulance, police or breakdown truck are informed in order to give assistance to involved users) by the operator at main control centre.	#
					11) Operator shall reset the system based on confirmation from emergency team	#
					12) All MT supply & Exhaust fans operate at 100% until the sensor measure lower levels & the fans can be adjusted accordingly	*

8.14.7.5 Electrical Fire Signalling System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EFSS	LINEAR HEAT DETECTOR	Main Tunnel (Fire zone at every 75 m Typical)	Heat Detection Alarm	Heat Raised Or Fire Occurred	1) Alarm shall be transmitted to operator at main/redundant control centre	*
					2) Automatic prompt(POP-UP) of appropriate mode of operation for respective fire zone for confirmation by operator. If operator does not take any action within pre-defined time i.e. delay of 5min, system shall automatically activate the appropriate fire mode	#/*
					3) Alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Activation of escape tunnel pressurization fans respective side of tunnel shall be automatically start after 1.5 minute of fire incident	*
					5) Activation of second escape tunnel pressurization fans manually by operator for fire mode	#
					6) Motorized smoke damper (MSD) - 01, 02, 03 near fire location are fully open and all others will be closed (Typical scheme is followed for different fire zones as per mode of operation)	*
					7) TVS-S-01 / TVS-S-02 / TVS-N-01 / TVS-N-02 axial fans for fresh air supply are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation	*
					8) TVE-S-02 / TVE-N-01 / TVE-N-02 axial fans for air/smoke extraction are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation	*
					9) TVE-S-01 axial fan for air/smoke extraction is activated (Typical scheme is followed for different fire zones as per mode of operation). TVE operates at 100% .	*
					Jet Fan control shall be enabled in fire mode only. Please refer Mode Table & Annexure 1 provided below:	
					· JF-S-01 / JF-S-02 / JF-S-03 / JF-S-04 jet fans for longitudinal air speed control not activated	*
					· AN-01 to AN-05 detect the air speed velocity and direction inside tunnel	*
					10) Anemometer/Velocity sensor from S to North and N to South detect the air velocity and direction inside the tunnel. If the velocity from both side of tunnel is equal between 1.0 to 1.6 m/sec, there is no activation of Jet Fans.	*
					11) If longitudinal air velocities from S to fire site and N to Fire site are different the following operation shall be applied;	*
					a) Air velocity from S to fire site is higher than the air velocity from N to fire site;	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					· JF-N-01 & N-02 are activated	*
					· System shall keep observing the measurement for 3 mins with defined limits i.e. above 1.6 m/sec	*
					· If air velocity from S to fire site is still higher than the air velocity from N to fire site JF-N-03 & N-04 are also activated	*
					b) Air velocity from N to fire site is higher than the air velocity from S to fire site;	*
					· JF-S-01 & S-02 are activated	*
					· System shall keep observing the measurement	*
					· If air velocity from N to fire site is higher than the air velocity from S to fire site JF-S-03 & S-04 are also activated	*
					12) JF at respective portal do not operate if fire event happen within 300m zone from the portal entrance	*
					13) JF at other portal will operate manually if needed	
					14) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light	*
					15) Traffic external to tunnel, in correspondence of at circular intersection, redirected to the old road using information sign with VMS, DRIP	*
					16) Traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol	*
					17) Traffic inside the tunnel stopped before arriving to fire zone, using TLTC on red light and TLS on red cross symbol however the system shall allow the vehicle to move out of tunnel after fire zone using TLTC on green light and TLS on green arrow symbol	*
					18) Mechanical barrier at tunnel portal at closed position	*
					19) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	*
					20) Activation of escape tunnel lighting system	*
					21) Activation of signal to Toll Plaza to stop vehicle tolling and entry	*
					22) ACS, open three doors in Fire condition, each side of fire zone	*
					23) Operator shall reset the system based on confirmation from emergency team	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EFSS	MANUAL CALL POINT	SOS boxes 02/03 internal to main tunnel (Typical for rest)	Manually Generated Fire Alarm	1) Fire Event	1) Alarm shall be transmitted to operator at main/redundant control centre	*
					2) Automatic prompt(POP-UP) of appropriate mode of operation for respective fire zone for confirmation by operator. If operator does not take any action within pre-defined time i.e. delay of 5min, system shall automatically activate the appropriate fire mode	#/*
					3) Alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Activation of escape tunnel pressurization fans respective side of tunnel shall be automatically start after 1.5 minute of fire incident	*
					5) Activation of second escape tunnel pressurization fans manually by operator	#
					6) Motorized smoke damper (MSD) - 01, 02, 03 near fire location are fully open and all others will be closed (Typical scheme is followed for different fire zones as per mode of operation)	*
					7) TVS-S-01 / TVS-S-02 / TVS-N-01 / TVS-N-02 axial fans for fresh air supply are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation	*
					8) TVE-S-02 / TVE-N-01 / TVE-N-02 axial fans for air/smoke extraction are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation	*
					· TVE-S-01 axial fan for air/smoke extraction is activated (Typical scheme is followed for different fire zones as per mode of operation) after 1.5min of confirmation	*
					Jet Fan control shall be enabled in fire mode only. Please refer Mode Table & Annexure 1 provided below:	
					· JF-S-01 / JF-S-02 / JF-S-03 / JF-S-04 jet fans for longitudinal air speed control not activated	*
					· AN-01 / AN-02 detect the air speed velocity and direction inside tunnel	*
					9) Anemometer/Velocity sensor from S to North and N to South detect the air velocity and direction inside the tunnel. If the velocity from both side of tunnel is equal between 1.0 to 1.6 m/sec, there is no activation of Jet Fans.	*
					10) If longitudinal air velocities from S to fire site and N to Fire site are different the following operation shall be applied;	*
					a) Air velocity from S to fire site is higher than the air velocity from N to fire site;	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					· JF-N-01 & N-02 are activated	*
					· System shall keep observing the measurement	*
	MANUAL FIRE EXTINGUISHER (LIMIT SWITCH)	SOS BOX 02/03 (Inside Main tunnel and typical for rest)			· If air velocity from S to fire site is still higher than the air velocity from N to fire site JF-N-03 & N-04 are also activated	*
					b) Air velocity from N to fire site is higher than the air velocity from S to fire site;	*
					· JF-S-01 & S-02 are activated	*
					· System shall keep observing the measurement	*
					· If air velocity from N to fire site is higher than the air velocity from S to fire site JF-S-03 & S-04 are also activated	*
					11) JF at respective portal do not operate if fire event happen within 300m zone from the portal entrance	*
					12) JF at other portal will operate manually if needed	
					13) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light	*
					14) Traffic external to tunnel, in correspondence of at circular intersection, redirected to the old road using information sign with VMS, DRIP	*
					15) Traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol	*
					16) Traffic inside the tunnel stopped before arriving to fire zone, using TLTC on red light and TLS on red cross symbol however the system shall allow the vehicle to move out of tunnel after fire zone using TLTC on green light and TLS on green arrow symbol	*
					17) Mechanical barrier at tunnel portal at closed position	*
					18) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	*
					19) Activation of escape tunnel lighting system	*
					20) Activation of signal to Toll Plaza to stop vehicle tolling and entry	*
					21 ACS, Open three doors in Fire condition, each side of fire zone.	*
					23) Operator shall reset the system based on confirmation from emergency team	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EFSS	Manual Call point	Escape door, inside Main tunnel	Manually Generated Fire Alarm	Fire event	1) Fire alarm announced in the main/redundant control centre by alarm facilities	*
					2) Alarm confirmation/authentication through emergency team visit to respective location	#
					a) EFS central resetted, in case of false alarm b) In case of real alarm, operator shall take manual action as per standard operating procedure in emergency response plan like call fire brigade	#
					c) Switch on escape tunnel lights d) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light and EVS on red cross symbol e) Traffic external to tunnel at circular intersection, redirected to the old road using information sign with VMS, DRIP f) Traffic inside the tunnel stopped before arriving to fire site, using TLTC on red light and TLS on red cross symbol, traffic after the fire site will be let out of tunnel using TLTC on green light and TLS on green arrow symbol g) Mechanical barrier at tunnel portal at closed position (only for entrance lanes) h) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	*
					i) Activation of signal to Toll Plaza to stop vehicle tolling and entry j) ACS, open three doors in Fire condition, each side of fire zone	*
					Operator shall reset the system based on confirmation from emergency team	#
EFSS	EFS DISCRETE DETECTORS	Technical Rooms, LV Rooms External/Internal To Tunnel	Automatic Fire/Smoke Alarm	Smoke Occurred	1) Fire alarm announced in the main/redundant control centre by alarm facilities	*
					2) Alarm confirmation/authentication through emergency team visit to respective location	#
					a) EFS central resetted, in case of false alarm b) In case of real alarm, operator shall take manual action as per standard operating procedure in emergency response plan like call fire brigade	#
					c) Switch on escape tunnel lights d) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light and EVS on red cross symbol e) Traffic external to tunnel at circular intersection, redirected to the old road using information sign with VMS, DRIP f) Traffic inside the tunnel stopped before arriving to fire site, using TLTC on red	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					light and TLS on red cross symbol, traffic after the fire site will be let out of tunnel using TLTC on green light and TLS on green arrow symbol g) Mechanical barrier at tunnel portal at closed position (only for entrance lanes) h) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	
					i) Activation of signal to Toll Plaza to stop vehicle tolling and entry j) ACS, open three doors in Fire condition, each side of fire zone	*
					Operator shall reset the system based on confirmation from emergency team	#
Traffic control system	ESD/EOD/EHD	In the way of the bridge road gantry at both north and south portal	Smoking vehicle detected/Excessive heated vehicle detected/Excessive height vehicle detected	Excessive Smoke generated by vehicle/ Heat generated by vehicle greater than defined value /height of vehicle greater than defined value	Alarm announced in the main/redundant control centre by alarm facilities	*
					Alarm confirmation/authentication through emergency team visit to respective location	#
					Mechanical barrier to closed position vehicle redirected to the old road using TLTC with direction symbol traffic signs shall glow and Appropriate message shall be displayed on DRIP	*
					alarm to security staff	#
					Operator shall check the authenticity of alarm and reset the system to open the Boom Barrier	#

8.14.7.6 Electrical System Cause & Effect Matrix

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
PLC inside HT Panel	HT-SS1, HT-SS2, HT-SS3, HT-SS4, HT-SS5	NORMAL			Normal Mode (Power supply from South Grid HEALTHY; North Grid HEALTHY): Power supply from South Grid feeds the entire tunnel. The Main incomer breaker at HT-SS1 CLOSE. Main-incomer breaker at HT-SS5 OPEN. All Tie-breakers CLOSE.	*
			VOLTAGE = 0 at HT-SS1 Incomer Breaker		(Power supply from South Grid FAIL; North Grid HEALTHY): Action PSS PLC: 1. Check grid-supply from South FAIL. The Main incomer breaker at HT-SS1 OPEN. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. All Tie-breakers CLOSE.	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
				Grid Supply FAIL	2. The entire tunnel re-energized from North-Grid supply. 3. Once South-Grid power supply is restored, return to Normal Mode after 1 hour	
			VOLTAGE = 0 at HT-SS1 Incomer Breaker, HT-SS5 Incomer Breaker		(Power supply from South Grid FAIL; North Grid FAIL): Action PSS: 1. Check grid-supply from South FAIL. The Main incomer breaker at HT-SS1 OPEN. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1, HT-SS2, HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure as mentioned below	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
			VOLTAGE = 0 at HT-SS2 Tie-Breaker-1	Cable damage between HT-SS1 and HT-SS2	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS1 and HT-SS2 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS2, HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS1 and HT-SS2	*
			VOLTAGE = 0 at HT-SS2		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS:	

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
			Tie-Breaker-1, HT-SS5 Incomer Breaker		1. Tie-breakers between HT-SS1 and HT-SS2 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS2, HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
			VOLTAGE = 0 at HT-SS3 Tie-Breaker-1	Cable damage between HT-SS2 and HT-SS3	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS2 and HT-SS3 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS1 and HT-SS2 CLOSE, between HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS2 and HT-SS3	*
			VOLTAGE = 0 at HT-SS3 Tie-Breaker-1, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS2 and HT-SS3 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1 and HT-SS2 CLOSE. Tie-breakers between HT-SS3, HT-SS4 and HT-SS5	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					CLOSE. 2. Follow Tunnel Close-down procedure	
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
			VOLTAGE = 0 at HT-SS4 Tie-Breaker-1	Cable damage between HT-SS3 and HT-SS4	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS3 and HT-SS4 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS1 HT-SS2 and HT-SS3 CLOSE, between HT-SS4 and HT-SS5 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS3 and HT-SS4	*
			VOLTAGE = 0 at HT-SS4 Tie-Breaker-1, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS3 and HT-SS4 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1, HT-SS2 and HT-SS3 CLOSE. Tie-breakers between HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure	*
					Action by ITCS;	

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
		9	VOLTAGE = 0 at HT-SS5 Tie-Breaker	Cable damage between HT-SS4 and HT-SS5	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS4 and HT-SS5 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS1, HT-SS2, HT-SS3 and HT-SS4 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS4 and HT-SS5	*
		10	VOLTAGE = 0 at HT-SS5 Tie-Breaker, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS4 and HT-SS5 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1, HT-SS2, HT-SS3 and HT-SS4 CLOSE. 2. Follow Tunnel Close-down procedure	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					Normal Mode (All Transformers HEALTHY at Technology Building): ACB Nos B1, B3, B5, B7, B9, B11 CLOSE; B2, B4, B6, B8, B10 OPEN	*
PLC inside LT Panel	MDB-SS1	NORMAL				
			VOLTAGE = 0 at MDB-SS1	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS1-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS1-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS1-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN. If YES, CLOSE ACB B2. 3. Power supply restored to MDB-SS1. 4. Maintenance works to be carried out at TX-SS1-1	*
			VOLTAGE = 0 at MDB-SS1	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS1-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS1-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS1-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN - if any breaker CLOSE, ACB B2 remains OPEN. 3. Follow Tunnel Close-down procedure	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					Maintenance personnel to inspect TX-SS1-1 and restore power supply to MDB-SS1	*
			VOLTAGE = 0 at MCP-AF1-VB1	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS1-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB1 (Exhaust Fan-1) 2. Check TX-SS1-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS1-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If YES, CLOSE ACB B4. 4. Power supply restored to MCP-AF1-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB1 and MCP-AF3-VB1 6. Maintenance works to be carried out at TX-SS1-3	*
			VOLTAGE = 0 at MCP-AF1-VB1	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS1-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB1 (Exhaust Fan-1) 2. Check TX-SS1-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS1-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If NO, ACB B4 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					Maintenance works to be carried out at TX-SS1-3	
			VOLTAGE = 0 at MCP-AF2-VB1	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS1-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB1 (Exhaust Fan-2) 2. Check TX-SS1-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS1-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF2-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB1 and MCP-AF4-VB1. 6. Maintenance works to be carried out at TX-SS1-4	*
			VOLTAGE = 0 at MCP-AF2-VB1	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS1-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB1 (Exhaust Fan-2) 2. Check TX-SS1-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS1-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If NO, ACB B6 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS1-4	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB1 (Supply Fan-1) 2. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF3-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB1 and MCP-AF3-VB1. 6. Maintenance works to be carried out at TX-SS1-5	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB1 (Supply Fan-1) 2. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, ACB B8 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS1-5	*
			VOLTAGE = 0 at MCP-AF4-VB1	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS1-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB1 (Supply Fan-2) 2. Check TX-SS1-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS1-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If YES, CLOSE ACB B10. 4. Power supply restored to MCP-AF4-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB1 and MCP-AF4-VB1. 6. Maintenance works to be carried out at TX-SS1-6	*
			VOLTAGE = 0 at MCP-AF4-VB1	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS1-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB1 (Supply Fan-2) 2. Check TX-SS1-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS1-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If NO, ACB B10 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS1-6	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 2. Check MCP-AF4-VB1 ACB B11 HEALTHY. If YES, Turn ON MCP-AF4-VB1. 3. Maintenance works to be carried out at TX-SS1-5	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 2. Check MCP-AF4-VB1 ACB B11 HEALTHY. If NO, check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, OPEN the CLOSED Breaker. CLOSE ACB B8. 4. Power supply to MCP-AF3-VB1 restored 5. Turn-on MCP-AF3-VB1 and run Exhaust Fan-1 to 100% speed. 6. Maintenance works to be carried out at TX-SS1-5	*
PLC inside LT Panel	MDB-SS5	NORMAL			Normal Mode (All Transformers HEALTHY at Technology Building): ACB Nos B1, B3, B5, B7, B9, B11 CLOSE; B2, B4, B6, B8, B10 OPEN	*
			VOLTAGE = 0 at MDB-SS5	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS5-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS5-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS5-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN. If YES, CLOSE ACB B2.	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					3. Power supply restored to MDB-SS5. 4. Maintenance works to be carried out at TX-SS5-1	
			VOLTAGE = 0 at MDB-SS5	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS5-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS5-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS5-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN - if any breaker CLOSE, ACB B2 remains OPEN. 3. Follow Tunnel Close-down procedure	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance personnel to inspect TX-SS5-1 and restore power supply to MDB-SS5	*
			VOLTAGE = 0 at MCP-AF1-VB2	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS5-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB2 (Exhaust Fan-1) 2. Check TX-SS5-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS5-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If YES, CLOSE ACB B4. 4. Power supply restored to MCP-AF1-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB2 and MCP-AF3-VB2	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					6. Maintenance works to be carried out at TX-SS5-3	
			VOLTAGE = 0 at MCP-AF1-VB2	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS5-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB2 (Exhaust Fan-1) 2. Check TX-SS5-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS5-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If NO, ACB B4 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-3	*
			VOLTAGE = 0 at MCP-AF2-VB2	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS5-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB2 (Exhaust Fan-2) 2. Check TX-SS5-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS5-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF2-VB2.	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB2 and MCP-AF4-VB2. 6. Maintenance works to be carried out at TX-SS5-4	
			VOLTAGE = 0 at MCP-AF2-VB2	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS5-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB2 (Exhaust Fan-2) 2. Check TX-SS5-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS5-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If NO, ACB B6 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-4	*
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB2 (Supply Fan-1) 2. Check TX-SS5-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If YES, CLOSE ACB B6.	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					4. Power supply restored to MCP-AF3-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB2 and MCP-AF3-VB2. 6. Maintenance works to be carried out at TX-SS5-5	
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB2 (Supply Fan-1) 2. Check TX-SS5-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, ACB B8 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-5	*
			VOLTAGE = 0 at MCP-AF4-VB2	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS5-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB2 (Supply Fan-2) 2. Check TX-SS5-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS5-7 OPEN.	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If YES, CLOSE ACB B10. 4. Power supply restored to MCP-AF4-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB2 and MCP-AF4-VB2. 6. Maintenance works to be carried out at TX-SS5-6	
			VOLTAGE = 0 at MCP-AF4-VB2	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS5-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB2 (Supply Fan-2) 2. Check TX-SS5-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS5-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If NO, ACB B10 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-6	*
			VOLTAGE = 0 at MCP-AF3-	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC:	*

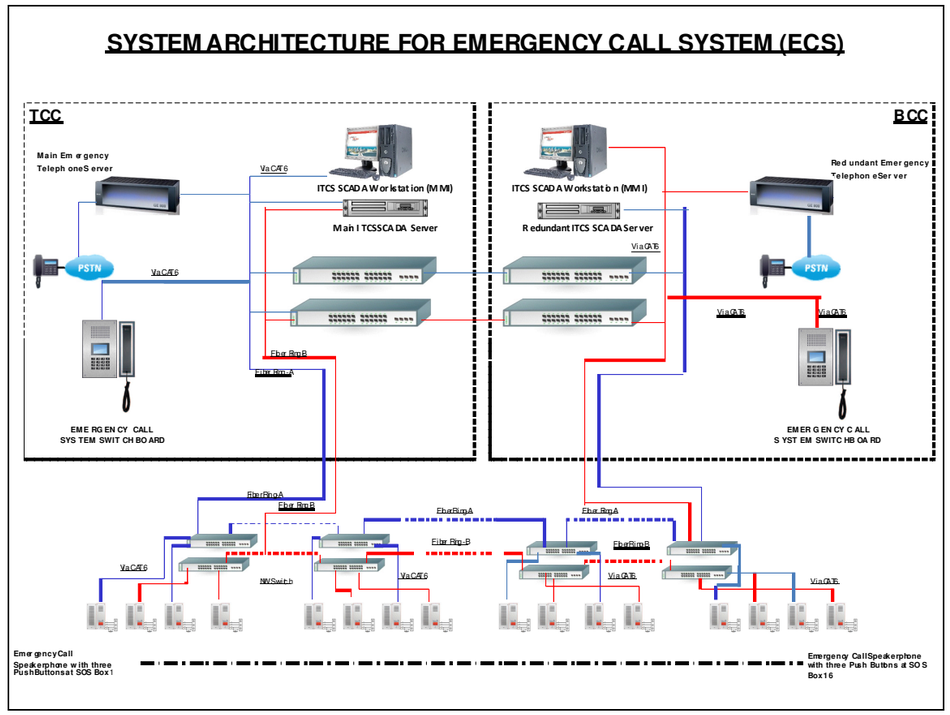
DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
			VB2		1. Check TX-SS5-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 2. Check MCP-AF4-VB2 ACB B11 HEALTHY. If YES, Turn ON MCP-AF4-VB2. 3. Follow TUNNEL FIRE MODE PROCEDURE 4. Maintenance works to be carried out at TX-SS5-5	
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS5-5 parameters TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 2. Check MCP-AF4-VB2 ACB B11 HEALTHY. If NO, check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, OPEN the CLOSED Breaker. CLOSE ACB B8. 4. Power supply to MCP-AF3-VB2 restored 5. Turn-on MCP-AF3-VB2 and run Exhaust Fan-1 to 100% speed. 6. Follow TUNNEL FIRE MODE PROCEDURE 7. Maintenance works to be carried out at TX-SS5-5	*
PLC inside LT Panel	MDB-SS2	NORMAL			Normal Mode (All Transformers HEALTHY at Sub-station 2 @ CP-08): MCCB Nos B1 CLOSED, B2 OPEN	*
			VOLTAGE = 0 at MDB-SS2	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS2-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS2-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS2-1 OPEN. 2. Check power supply at MCCB B2 - HEALTHY. CLOSE MCCB B2. 3. Power supply restored to MDB-SS2. 4. Maintenance works to be carried out at TX-SS2-1	*
			VOLTAGE = 0 at MDB-SS2	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS2-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS2-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS2-1 OPEN. 2. Check power supply at MCCB B2 - FAIL. Check Transformer TX-SS2-2 parameters, TRIP. MCCB B2 REMAINS OPEN. 3. Follow TUNNEL CLOSE-DOWN PROCEDURE.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance works to be carried out at TX-SS2-1	*
PLC inside LT Panel	MDB-SS3	NORMAL			Normal Mode (All Transformers HEALTHY at Sub-station 2 @ CP-08): MCCB Nos B1 CLOSED, B2 OPEN	*
			VOLTAGE = 0 at MDB-SS3	MCCB-B1 TRIP/ OPEN	Mode-1 (TRANSFORMER TX-SS3-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS3-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS3-1 OPEN. 2. Check power supply at MCCB B2 - HEALTHY. CLOSE MCCB B2. 3. Power supply restored to MDB-SS3. 4. Maintenance works to be carried out at TX-SS3-1	*
			VOLTAGE = 0 at MDB-SS3	MCCB-B1 TRIP/ OPEN	Mode-2 (TRANSFORMER TX-SS3-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS3-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS3-1 OPEN. 2. Check power supply at MCCB B2 - FAIL. Check Transformer TX-SS3-2 parameters, TRIP. MCCB B2 REMAINS OPEN. 3. Follow TUNNEL CLOSE-DOWN PROCEDURE.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance works to be carried out at TX-SS3-1	*
PLC inside LT Panel	MDB-SS4	NORMAL			Normal Mode (All Transformers HEALTHY at Sub-station 2 @ CP-08): MCCB Nos B1 CLOSED, B2 OPEN	*
			VOLTAGE = 0 at MDB-SS4	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS4-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS4-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS4-1 OPEN. 2. Check power supply at MCCB B2 - HEALTHY. CLOSE MCCB B2. 3. Power supply restored to MDB-SS4. 4. Maintenance works to be carried out at TX-SS4-1	*
			VOLTAGE = 0 at MDB-SS4	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS4-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS4-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS4-1 OPEN. 2. Check power supply at MCCB B2 - FAIL. Check Transformer TX-SS4-2 parameters, TRIP. MCCB B2 REMAINS OPEN. 3. Follow TUNNEL CLOSE-DOWN PROCEDURE.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance works to be carried out at TX-SS4-1	*

8.14.8 System Architecture of Emergency Call System



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 a 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 the 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.

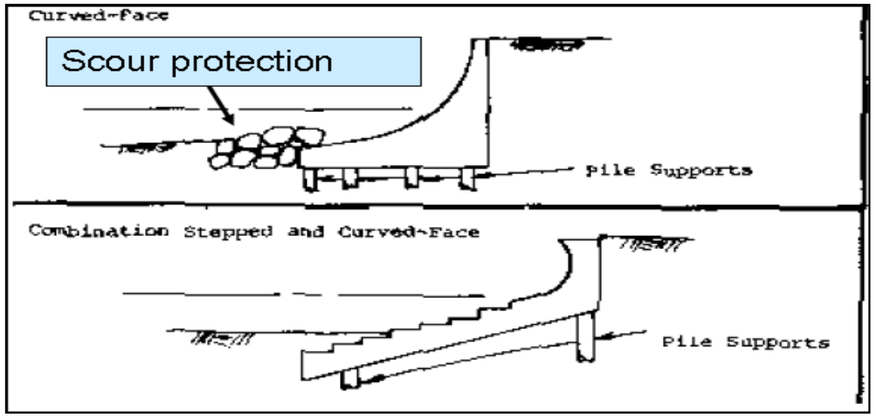


Figure 9.1: Typical Sections of Seawalls

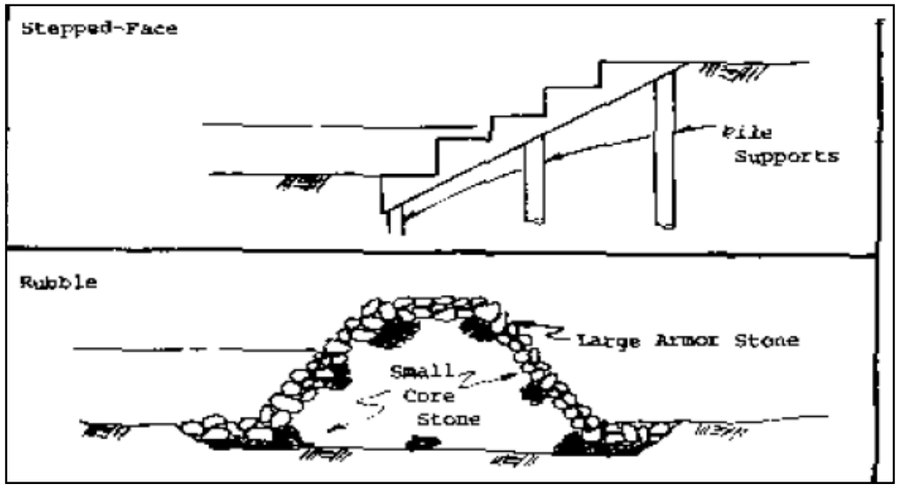


Figure 9.2: Typical Sections of Seawalls

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 methods 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 mm / 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

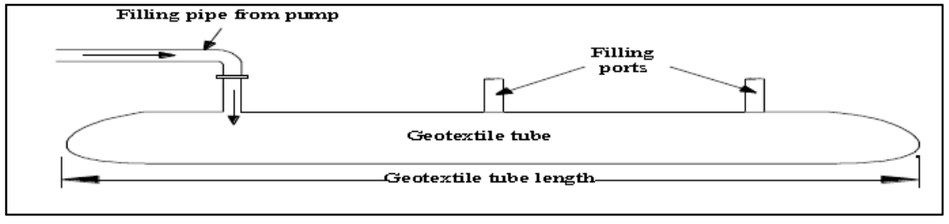
9.4 Modern Methods of Reclamation

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

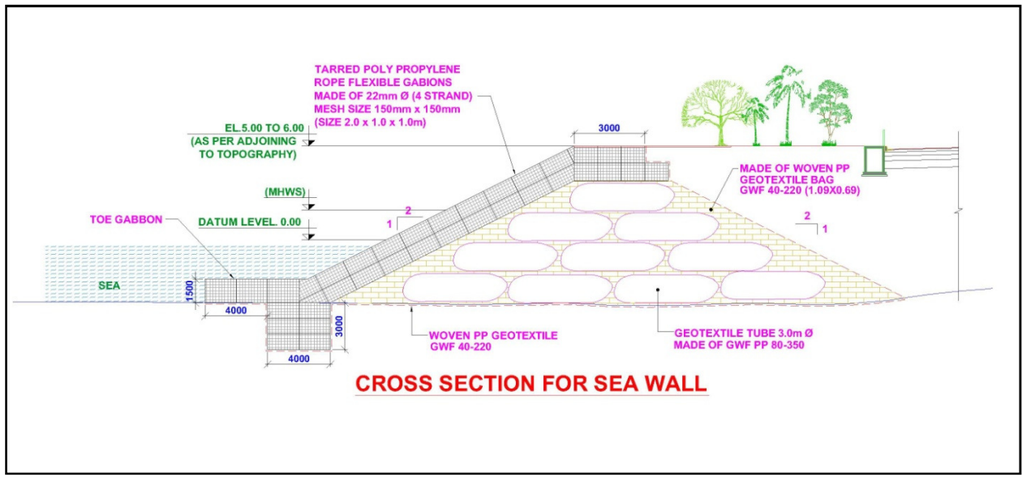
Geotextile tubes are tubular containers that are formed in situ on land or in water. Geotextile tubes are laid out and filled on site to their required geometrical form. The tubes are filled by hydraulically pumping fill into the tube. Geotextile tubes range in size from 1m to 5m in diameter, and up 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 standard 600 micron sieve, 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.

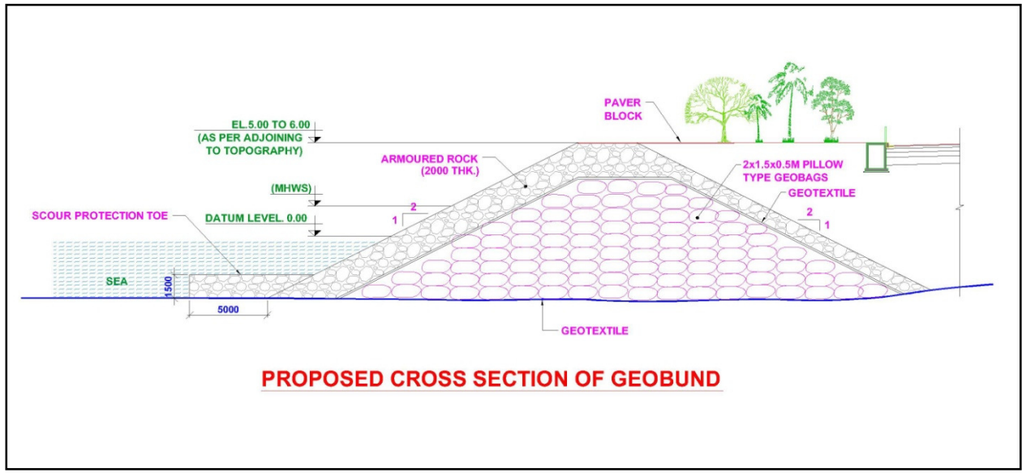
The typical section considering the Geotubes is shown below.



Use of Geobags or Geotextile bags

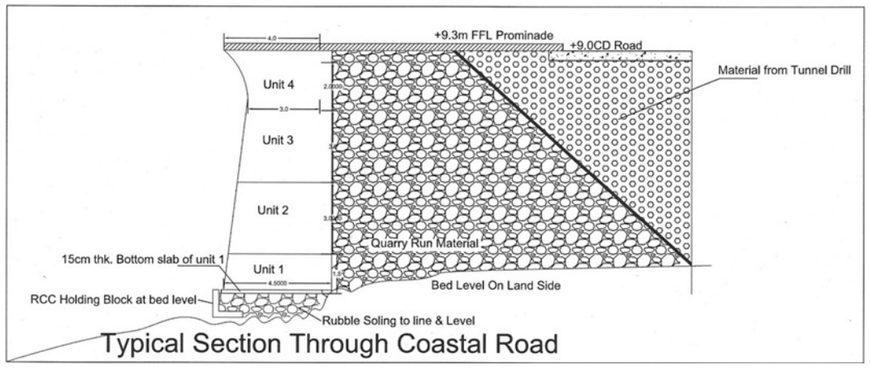
Geotextile bags are small volume containers that are filled on land or above water and then pattern-placed either near water or below water level. The function of these bags is similar to Geotextile tubes but the smaller size makes the ease in handling, placing and anchoring.

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-3 and phase 4 shall be used to back fill behind the walls. The quantity of tunnel muck expected from Coastal Road is 3.0 million 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-3 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.



Based on the geotechnical investigations, for majority of the area hard rock is available at surface, over which the proposed sea wall can be constructed.

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 up to 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 up to 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 up to 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
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

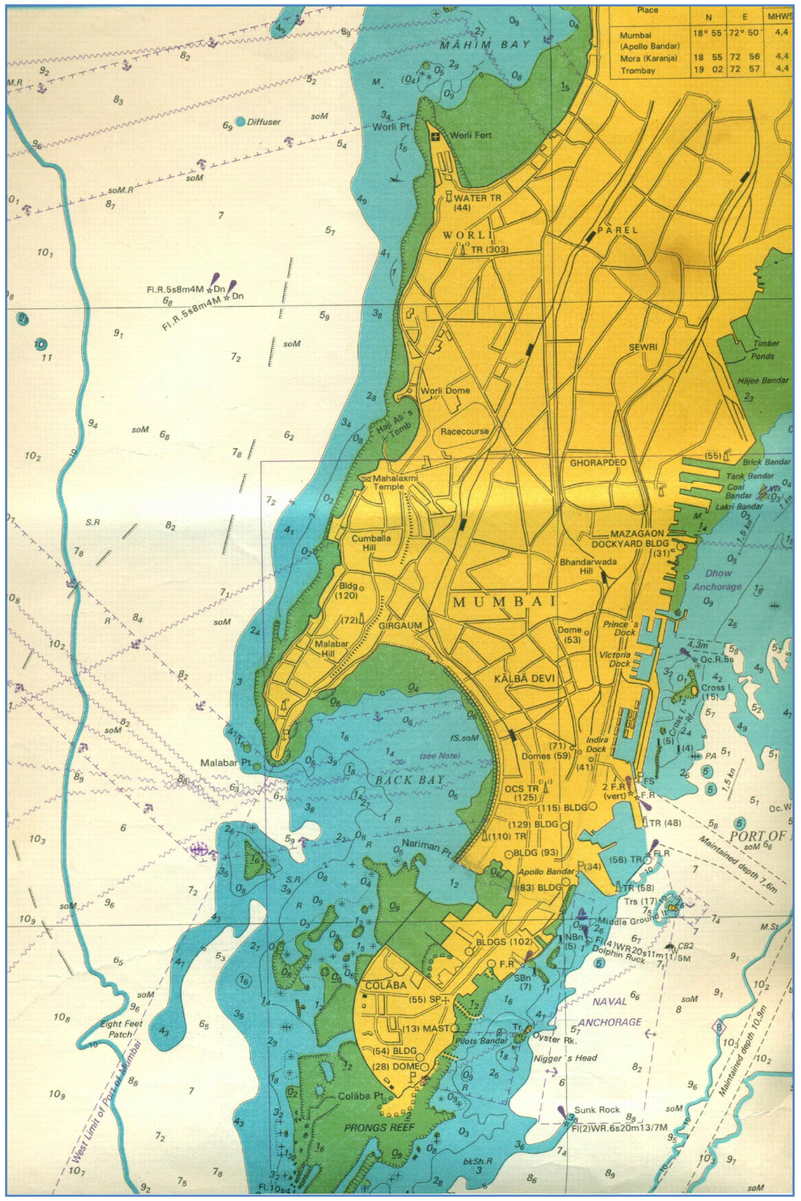
Month	Rainfall (mm)
January	15.1
February	1
March	0.1
April	0.5
May	20.6
June	504.2
July	819.4
August	546.8
September	325.2
October	81.1
November	113.2
December	4.1

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 the NE direction.

Oceanographic Condition:

Admiralty chart:



Tides:

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. Indan Journal of Marine Sciences Issue: June 1991).

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.

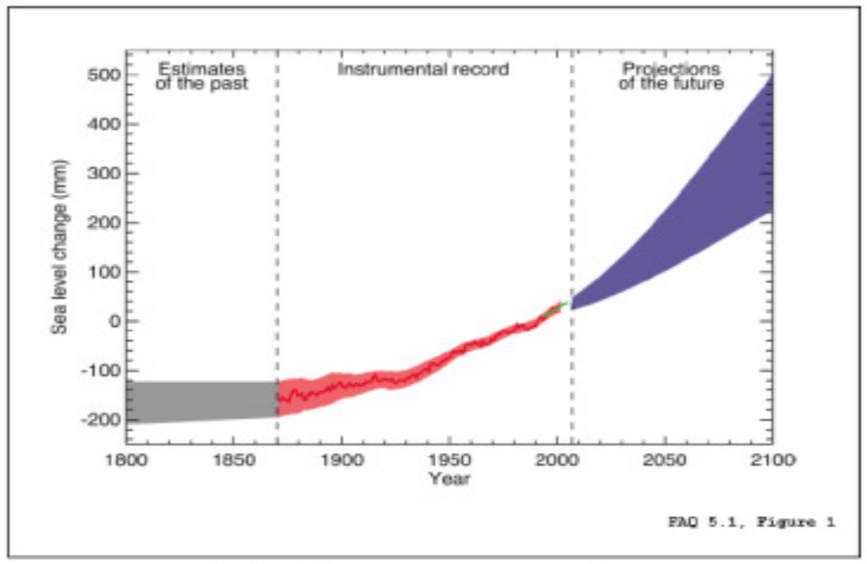
Littoral Drift

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:

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

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 9.6: 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 alignment

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.

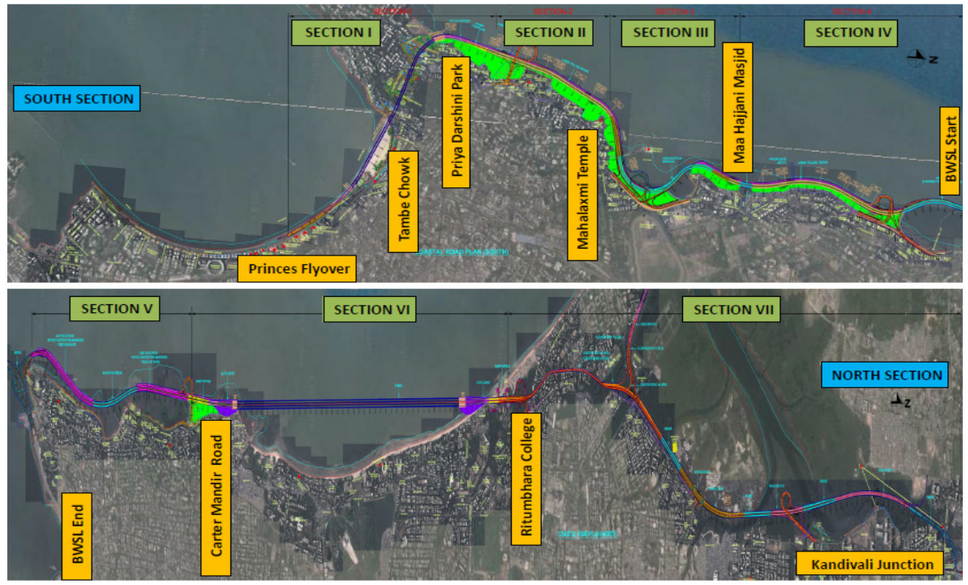
The environmental screening has made with the use of available information from official and non-official (e.g. Consultation with local people, NGOs etc.) sources concerning the location, type and sensitivity of all critical natural habitats (such as conservation areas, wildlife sanctuaries, sacred groves, , 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

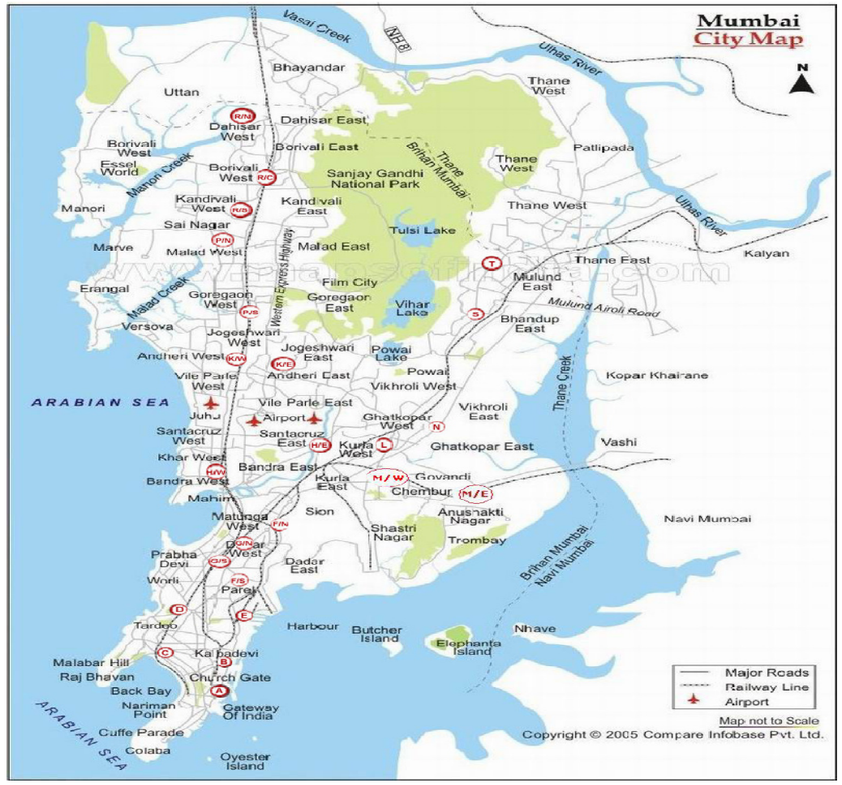
10.8.1 Location

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 Princess street flyover and ends at Kandivali. 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

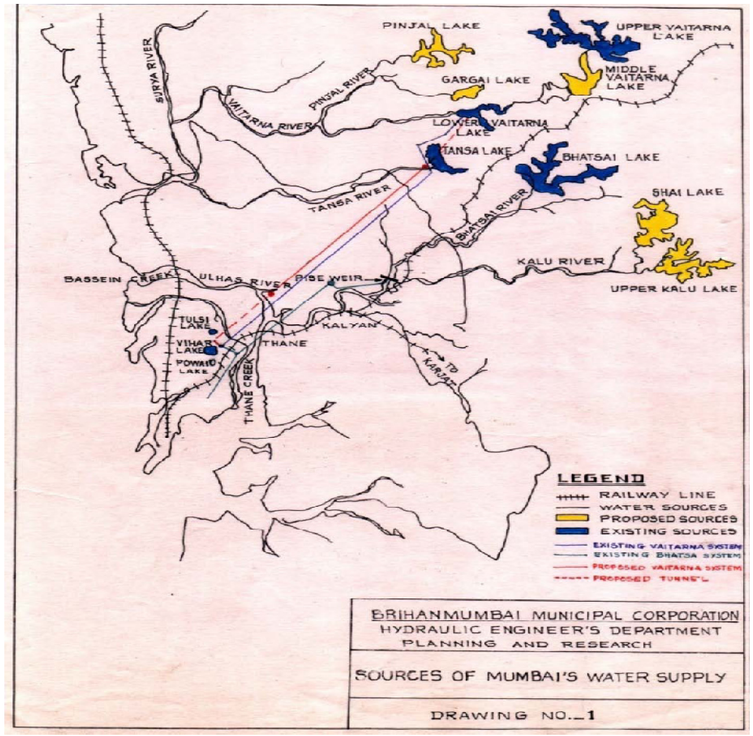
Mumbai, being on the seacoast, experiences a tropical savanna climate with a heavy southwest monsoon rainfall of more than 2100 millimeters a year. Mumbai experiences three seasons– summer from March to May, monsoon between June and September and winter during October to February. The city receives heavy 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 at 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 Powai lake, 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. The City is prone 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 ranges, extending in the eastern and central part running NNE – SSW. The maximum elevation of the area is 450 m above mean sea level (MSL) 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 (MSL). Malabar, 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 protrude into the main land and give rise to mudflats and swamps. The area is drained by Mahim, Mithi, Dahisar and Poisar 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.

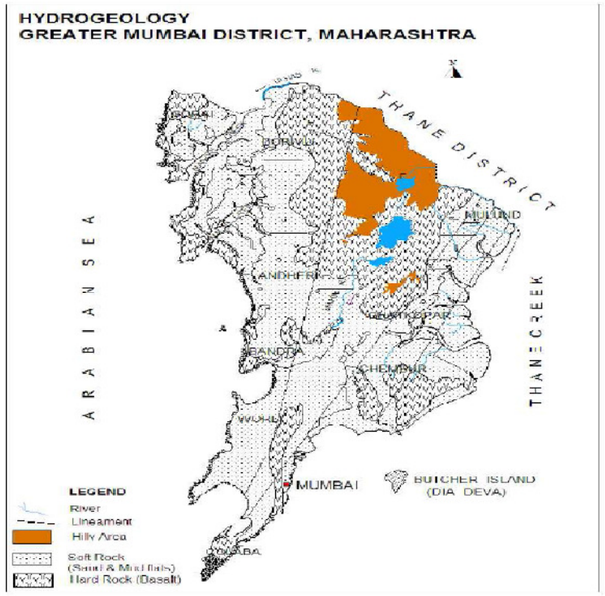
Mumbai Island has ridges along its western and eastern side. The city of Mumbai is built on central low-lying part of the Island. The western ridges comprise stratified ash beds.

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 occurs 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 ranges 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 dug wells varies from 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, the and Marine Alluvium in the coastal area are highly potential aquifers 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

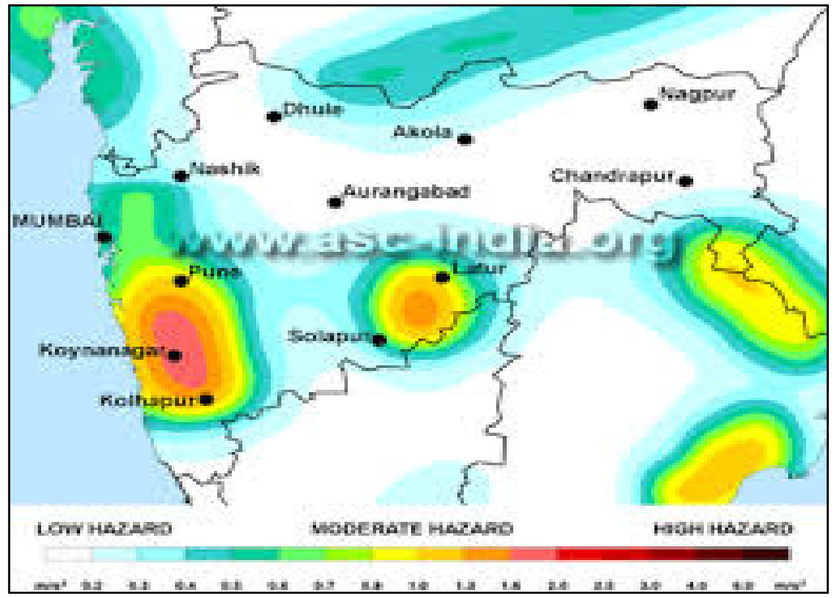
The pollution of ground water as well as surface water is the major problem in the area. The creeks in the region have become the dumping ground of sewage and industrial effluents. In addition to this, various industrial effluents from oil refineries, reactors, fertilizers plants at Chembur have polluted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

The data of Maharashtra Pollution Control Board (MPCB) indicate higher 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

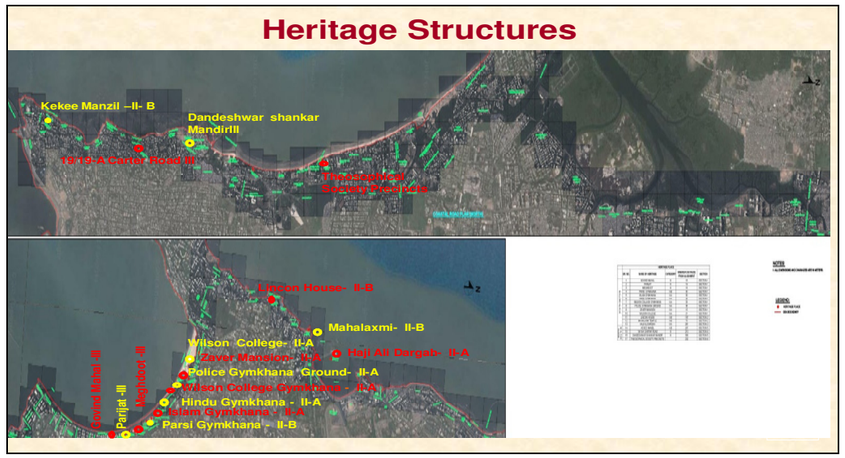
Details of 17 nos. of religious and heritage structures along the entire project stretch are given below.

Table 10.2: Details of Religious and Heritage 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	Lincoln House	II-B	187
12	Mahalaxmi Temple	II-B	78
13	Haji Ali Dargah	II-A	281
14	Keki 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 precincts 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 buildings 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

Mithi river 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, increased rainfall, decline in crop productivity and health issues stare at Maharashtra in the next 100 years.

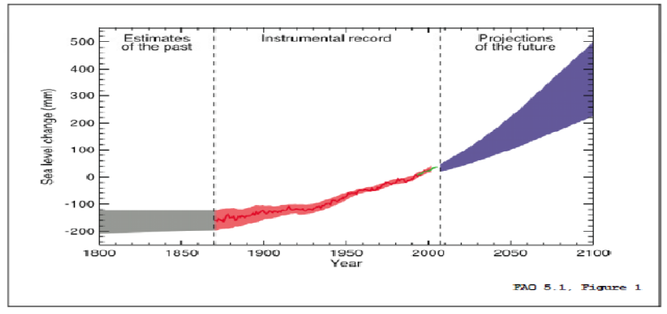
Study conducted by TERI showed that coastal flooding could lead to reduction in availability of fresh water due to saltwater intrusion as well as contamination of water supply through pollutants from submerged waste dumps. The temperature of Mumbai and Maharashtra is likely to increase by 1-3 degrees 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 Maharashtra 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 strengthening and protection.

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

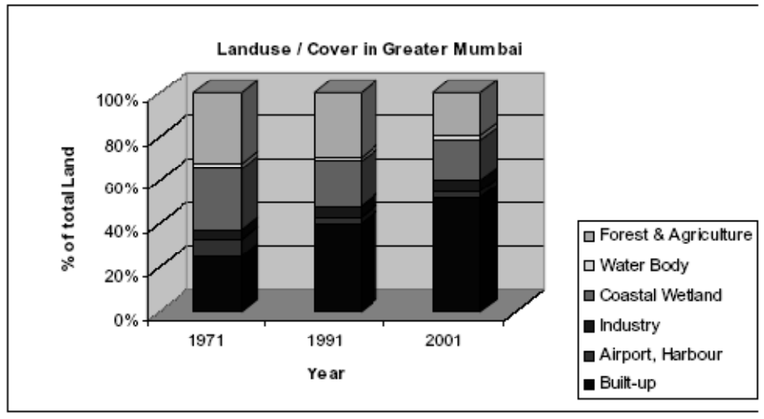
According to the 2011 census, the population of Mumbai was 12,479,608. The population density is estimated to be about 20,482 persons per square kilometre. The living space is 4.5sq metre per person. As Per 2011 census, Greater Mumbai, the area under the administration of the MCGM, has a literacy rate 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 auto rickshaws.

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 creeks that are ecologically sensitive.

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

Other sensitive issues identified along the proposed road are

- fisherman route,
- drain outfall 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 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 mangroves 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 of 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 the 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 mitigation 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 of 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 records.
- Disbursement of compensation to the title holders
- Identification of sites for relocation of Mangroves

10.10.3 Generic Structure of EIA report

This EIA report will be organized 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 continuously instrumental in strengthening existing policies for protecting and improving the quality of the coastal environment. The legal formal? 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 bodie,s 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 are required to 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 work 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 of the road alignment.

11.3 Estimation of Quantities and Cost

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

Table 111.1 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.

Table11.2 Cost Estimate of the Alignments Options 1 to 3

		OPTION 1			OPTION 2			OPTION 3		
Section.No	Section Wise	Length of Alignment (m)	Reclamation Area (Hectare)	Project Cost (Crores)	Length of Alignment (m)	Reclamation Area (Hectare)	Project Cost (Crores)	Length of Alignment (m)	Reclamation Area (Hectare)	Project Cost (Crores)
1	Jagannath Bhosale Road to Priyadarshini Park	6600	14.15	1525.5	6600	14.15	1526	7000	62.09	1978
2	Priyadarshini Park to Mahalaxmi	2400	35.77	739.2	2400	35.77	739	1500	38.42	462
3	Mahalaxmi to Baroda Palace	1800	19.90	522.45	1800	19.90	522	1400	0.00	332
4	Baroda Palace to BWSL (Start)	3000	37.00	895.6	3000	37.00	896	2950	30.07	877
5	BWSL(End) to Juhu Sea Side Garden (Start of Tunnel)	5825	64.06	1588.1	5800	22.88	1598	5850	47.24	1575
6	Juhu Sea Side Garden (Start of Tunnel) to Ritumbhara College (End of Tunnel)	4400	3.00	1909.6	4400	3.00	1910	4700.	62.14	1401
7	Ritumbhara College (End of Tunnel) to Kandivali	12575	54.15	3842.3	12625	18.60	3993	12200 .00	52.14	3722
	Interchanges 18no's	18		1350	18		1350	18		1350
	TOTAL	36600	228	12373	36625	151	12533	35600	292	11695

Table 11.3 Cost Estimate of the Alignments Options 4 to 6

Section.No	Section Wise	OPTION 4			OPTION 5			OPTION 6		
		Length of Alignment (m)	Reclamation Area (Hectare)	Project Cost (Crores)	Length of Alignment (m)	Reclamation Area (Hectare)	Project Cost (Crores)	Length of Alignment (m)	Reclamation Area (Hectare)	Project Cost (Crores)
1	Jagannath Bhosale Road to Priyadarshini Park	7000	7.9	1555	5810	7.9	1309	6770	14.2	1519
2	Priyadarshini Park to Mahalaxmi	1500	38.5	462	1490	36.6	459	1490	36.6	459
3	Mahalaxmi to Baroda Palace	1400	0.0	332	2000	0.0	474	2000	0.0	474
4	Baroda Palace to BWSL (Start)	2950	27.0	877	2900	10.3	846	2900	10.3	846
5	BWSL(End) to Juhu Sea Side Garden (Start of Tunnel)	5850	45.8	1699	4590	10.9	1255	4590	10.9	1255
6	Juhu Sea Side Garden (Start of Tunnel) to Ritumbhara College (End of Tunnel)	4700	9.4	2040	5150	8.0	2235	5150	8.0	2235
7	Ritumbhara College (End of Tunnel) to Kandivali	12200	52.2	3716	12210	52.0	3747	12210	52.0	3747
	Interchanges 18no's	18		1350	18		1350	18		1350
	TOTAL	35600	180	12030	34150	126	11674	35110	132	11884

Table 11.4 Cost Estimate of the Alignments Options 7 (Package Wwise)

Package-1(Priyadarshini Park to Markandershwar Temple)(CH.5+900 TO 9+720)		
ABSTRACT SHEET FOR (Package-1)of Coastal Road Project USING THANE DSR 2013-14 & M.C.G.M DSR (ESCALATION @ 5% PER YEAR OVER & ABOVE DSR OF YEAR 2013-2014)		
Sl. No	**Description of Item**	**Amount (Rs. In Crore)** **Package 1**
1	Estimated Civil Construction Cost (Year 2016-17)	**1515.10**
2	Contingency @ 2.8% of (2)	42.42
3	**Sub Total (1+2)**	**1557.52**
4	Construction Supervision Charges @ 2 % of (3)	31.15
5	Administrative Charges @ 1 % of (3)	15.58
6	Quality Control charges @ 1% of (3)	15.58
7	Road Safety cell audit Charges @ 0.5 % of (3)	7.79
8	Maintenance during DLP payable to Concessionaire @ 7.5% of (3)	116.81
9	Escalation @ 5 % per annum for 2 years i.e. 10% of (3) during construction payable to Contractor.	85.66
10	**Total Estimated Project Cost**	**1830.09**

Package-2(Markandershwar Temple to Bridge Connecting worli end)(CH.9+720 TO 12+430)		
ABSTRACT SHEET FOR (Package-2)of Coastal Road Project USING THANE DSR 2013-14 & M.C.G.M DSR (ESCALATION @ 5% PER YEAR OVER & ABOVE DSR OF YEAR 2013-2014)		
Sl. No	**Description of Item**	**Amount (Rs. In Crore)** **Package 2**
1	Estimated Civil Construction Cost (Year 2016-17)	**831.40**
2	Contingency @ 2.8% of (1)	23.28
3	**Sub Total (1+2)**	**854.68**
4	Construction Supervision Charges @ 2 % of (3)	17.09
5	Administrative Charges @ 1 % of (3)	8.55
6	Quality Control charges @ 1% of (3)	8.55
7	Road Safety cell audit Charges @ 0.5 % of (3)	4.27
8	Maintenance during DLP payable to Concessionaire @ 7.5% of (3)	64.10
9	Escalation @ 5 % per annum for 2 years i.e. 10% of (3) during construction payable to Contractor.	47.01
10	**Total Estimated Project Cost**	**1004.25**

Package-3(BWSL(End) to Start of Tunnel (Carter Road Mandir)(CH.0+000 To CH.4+325)		
ABSTRACT SHEET FOR (Package-3)of Coastal Road Project USING THANE DSR 2013-14 & M.C.G.M DSR (ESCALATION @ 5% PER YEAR OVER & ABOVE DSR OF YEAR 2013-2014)		
Sl. No	**Description of Item**	**Amount (Rs. In Crore)** **Section-5**
1	Estimated Civil Construction Cost (Year 2016-17)	**1490.97**
2	Contingency @ 2.8% of (1)	41.75
3	**Sub Total (1+2)**	**1532.71**
4	Construction Supervision Charges @ 2 % of (3)	30.65
5	Administrative Charges @ 1 % of (3)	15.33
6	Quality Control charges @ 1% of (3)	15.33
7	Road Safety cell audit Charges @ 0.5 % of (3)	7.66
8	Maintenance during DLP payable to Concessionaire @ 7.5% of (3)	114.95
9	Escalation @ 5 % per annum for 2 years i.e. 10% of (3) during construction payable to Contractor.	84.30
10	**Total Estimated Project Cost**	**1800.94**

Package-6(Bharat Nagar (End of Tunnel) to Kandivali Interchange)(CH.10+200 TO 19+330)		
ABSTRACT SHEET FOR (Package-6)of Coastal Road Project USING THANE DSR 2013-14 & M.C.G.M DSR (ESCALATION @ 5% PER YEAR OVER & ABOVE DSR OF YEAR 2013-2014)		
Sl. No	**Description of Item**	**Amount (Rs. In Crore)** **Package 6**
1	Estimated Civil Construction Cost (Year 2016-17)	**3535.40**
2	Contingency @ 2.8% of (1)	98.99
3	**Sub Total (1+2)**	**3634.39**
4	Construction Supervision Charges @ 2 % of (3)	72.69
5	Administrative Charges @ 1 % of (3)	36.34
6	Quality Control charges @ 1% of (3)	36.34
7	Road Safety cell audit Charges @ 0.5 % of (3)	18.17
8	Maintenance during DLP payable to Concessionaire @ 7.5% of (3)	272.58
9	Escalation @ 5 % per annum for 2 years i.e. 10% of (3) during construction payable to Contractor.	199.89
10	**Total Estimated Project Cost**	**4270.41**

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 Traffic Forecast

The overall growth rate for various categories of traffic along the Coastal Road has been taken as 2% per annum upto 2043, as discussed in the projection of traffic. Due to abutting land use and limited

access to the facility, the growth rate will be lower along this proposed road, while traffic along existing roads will grow at 5.5% per annum (10% higher). It has been assumed that the road will be mainly used by cars and taxis, hence other vehicles in the assignment have been ignored. The estimated projected traffic in three different alternatives as described earlier is presented in **Table 12.3** to **Table 12.8**.

Table 12.3: Traffic Projection for the Proposed Coastal Road-Southern Part–Alternative I: Existing Road through above mentioned roads – without Coastal Road (Do Nothing situation)

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2014	50,201	19,476	1,588	2,536	72	5
2015	51,205	19,866	1,620	2,587	73	5
2016	52,229	20,263	1,652	2,638	75	5
2017	53,274	20,668	1,685	2,691	76	5
2018	54,339	21,081	1,719	2,745	78	5
2019	55,426	21,503	1,753	2,800	79	6
2020	56,534	21,933	1,788	2,856	81	6
2021	57,665	22,372	1,824	2,913	83	6
2022	58,818	22,819	1,861	2,971	84	6
2023	59,995	23,276	1,898	3,031	86	6
2024	61,195	23,741	1,936	3,091	88	6
2025	62,419	24,216	1,974	3,153	90	6
2026	63,667	24,700	2,014	3,216	91	6
2027	64,940	25,194	2,054	3,281	93	6
2028	66,239	25,698	2,095	3,346	95	7
2029	67,564	26,212	2,137	3,413	97	7
2030	68,915	26,736	2,180	3,481	99	7
2031	70,294	27,271	2,224	3,551	101	7
2032	71,699	27,817	2,268	3,622	103	7
2033	73,133	28,373	2,313	3,694	105	7
2034	74,596	28,940	2,360	3,768	107	7
2035	76,088	29,519	2,407	3,844	109	8
2036	77,610	30,110	2,455	3,921	111	8
2037	79,162	30,712	2,504	3,999	114	8
2038	80,745	31,326	2,554	4,079	116	8
2039	82,360	31,952	2,605	4,161	118	8
2040	84,007	32,591	2,657	4,244	120	8
2041	85,687	33,243	2,711	4,329	123	9
2042	87,401	33,908	2,765	4,415	125	9
2043	89,149	34,586	2,820	4,504	128	9
2043	90,932	35,278	2,876	4,594	130	9

Table 12.4: Traffic Projection for the Proposed Coastal Road-Southern Part–Alternative II: Existing Road through above mentioned roads – with Coastal Road (With Project)

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2014	25,602	19,476	1,588	2,536	72	5
2015	26,114	19,866	1,620	2,587	73	5
2016	26,636	20,263	1,652	2,638	75	5
2017	27,169	20,668	1,685	2,691	76	5
2018	27,712	21,081	1,719	2,745	78	5
2019	28,267	21,503	1,753	2,800	79	6
2020	28,832	21,933	1,788	2,856	81	6
2021	29,409	22,372	1,824	2,913	83	6
2022	29,997	22,819	1,861	2,971	84	6
2023	30,597	23,276	1,898	3,031	86	6
2024	31,209	23,741	1,936	3,091	88	6
2025	31,833	24,216	1,974	3,153	90	6
2026	32,470	24,700	2,014	3,216	91	6
2027	33,119	25,194	2,054	3,281	93	6
2028	33,781	25,698	2,095	3,346	95	7
2029	34,457	26,212	2,137	3,413	97	7
2030	35,146	26,736	2,180	3,481	99	7
2031	35,849	27,271	2,224	3,551	101	7
2032	36,566	27,817	2,268	3,622	103	7
2033	37,297	28,373	2,313	3,694	105	7
2034	38,043	28,940	2,360	3,768	107	7
2035	38,804	29,519	2,407	3,844	109	8
2036	39,580	30,110	2,455	3,921	111	8
2037	40,372	30,712	2,504	3,999	114	8
2038	41,179	31,326	2,554	4,079	116	8
2039	42,003	31,952	2,605	4,161	118	8
2040	42,843	32,591	2,657	4,244	120	8
2041	43,700	33,243	2,711	4,329	123	9
2042	44,574	33,908	2,765	4,415	125	9
2043	45,465	34,586	2,820	4,504	128	9
2043	46,374	35,278	2,876	4,594	130	9

Table 12.5: Traffic Projection for the Proposed Coastal Road-Southern Part–Alternative III: Construction of Coastal Road (With Project)

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2014	24,598	0	0	0	0	0
2015	25,090	0	0	0	0	0

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2016	25,592	0	0	0	0	0
2017	26,104	0	0	0	0	0
2018	26,626	0	0	0	0	0
2019	27,158	0	0	0	0	0
2020	27,701	0	0	0	0	0
2021	28,255	0	0	0	0	0
2022	28,820	0	0	0	0	0
2023	29,397	0	0	0	0	0
2024	29,985	0	0	0	0	0
2025	30,585	0	0	0	0	0
2026	31,196	0	0	0	0	0
2027	31,820	0	0	0	0	0
2028	32,457	0	0	0	0	0
2029	33,106	0	0	0	0	0
2030	33,768	0	0	0	0	0
2031	34,443	0	0	0	0	0
2032	35,132	0	0	0	0	0
2033	35,835	0	0	0	0	0
2034	36,551	0	0	0	0	0
2035	37,282	0	0	0	0	0
2036	38,028	0	0	0	0	0
2037	38,789	0	0	0	0	0
2038	39,564	0	0	0	0	0
2039	40,356	0	0	0	0	0
2040	41,163	0	0	0	0	0
2041	41,986	0	0	0	0	0
2042	42,826	0	0	0	0	0
2043	43,682	0	0	0	0	0
2043	44,556	0	0	0	0	0

Table 12.6: Traffic Projection for the Proposed Coastal Road-Northern Part–Alternative I: Existing Road through above mentioned roads – without Coastal Road (Do Nothing situation)

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2014	56,250	10,309	861	3,371	571	183
2015	57,375	10,515	878	3,438	582	187
2016	58,523	10,725	896	3,507	594	190
2017	59,693	10,940	914	3,577	606	194
2018	60,887	11,159	932	3,649	618	198
2019	62,105	11,382	951	3,722	630	202
2020	63,347	11,610	970	3,796	643	206
2021	64,614	11,842	989	3,872	656	210
2022	65,906	12,079	1,009	3,950	669	214
2023	67,224	12,320	1,029	4,029	682	219
2024	68,568	12,567	1,050	4,109	696	223
2025	69,940	12,818	1,071	4,191	710	228
2026	71,339	13,074	1,092	4,275	724	232
2027	72,765	13,336	1,114	4,361	739	237
2028	74,221	13,603	1,136	4,448	753	241
2029	75,705	13,875	1,159	4,537	768	246
2030	77,219	14,152	1,182	4,628	784	251
2031	78,764	14,435	1,206	4,720	800	256
2032	80,339	14,724	1,230	4,815	816	261
2033	81,946	15,018	1,254	4,911	832	267
2034	83,585	15,319	1,279	5,009	848	272
2035	85,256	15,625	1,305	5,109	865	277
2036	86,961	15,938	1,331	5,211	883	283
2037	88,701	16,256	1,358	5,316	900	289
2038	90,475	16,581	1,385	5,422	918	294
2039	92,284	16,913	1,413	5,530	937	300
2040	94,130	17,251	1,441	5,641	956	306
2041	96,012	17,596	1,470	5,754	975	312
2042	97,933	17,948	1,499	5,869	994	319
2043	99,891	18,307	1,529	5,986	1,014	325
2043	1,01,889	18,673	1,560	6,106	1,034	331

Table 12.7: Traffic Projection for the Proposed Coastal Road-Northern Part–Alternative II : Existing Road through above mentioned roads – with Coastal Road (With Project)

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2014	29,250	10,309	861	3,371	571	183
2015	29,835	10,515	878	3,438	582	187
2016	30,432	10,725	896	3,507	594	190
2017	31,040	10,940	914	3,577	606	194
2018	31,661	11,159	932	3,649	618	198
2019	32,294	11,382	951	3,722	630	202
2020	32,940	11,610	970	3,796	643	206
2021	33,599	11,842	989	3,872	656	210
2022	34,271	12,079	1,009	3,950	669	214

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2023	34,956	12,320	1,029	4,029	682	219
2024	35,656	12,567	1,050	4,109	696	223
2025	36,369	12,818	1,071	4,191	710	228
2026	37,096	13,074	1,092	4,275	724	232
2027	37,838	13,336	1,114	4,361	739	237
2028	38,595	13,603	1,136	4,448	753	241
2029	39,367	13,875	1,159	4,537	768	246
2030	40,154	14,152	1,182	4,628	784	251
2031	40,957	14,435	1,206	4,720	800	256
2032	41,776	14,724	1,230	4,815	816	261
2033	42,612	15,018	1,254	4,911	832	267
2034	43,464	15,319	1,279	5,009	848	272
2035	44,333	15,625	1,305	5,109	865	277
2036	45,220	15,938	1,331	5,211	883	283
2037	46,124	16,256	1,358	5,316	900	289
2038	47,047	16,581	1,385	5,422	918	294
2039	47,988	16,913	1,413	5,530	937	300
2040	48,947	17,251	1,441	5,641	956	306
2041	49,926	17,596	1,470	5,754	975	312
2042	50,925	17,948	1,499	5,869	994	319
2043	51,943	18,307	1,529	5,986	1,014	325
2043	52,982	18,673	1,560	6,106	1,034	331

Table 12.8: Traffic Projection for the Proposed Coastal Road-Northern Part–Alternative III: Construction of Coastal Road (With Project)

Year	Car	2-Wheeler	Bus	LCV	2/3- Axle Truck	MAV
2014	27,000	0	0	0	0	0
2015	27,540	0	0	0	0	0
2016	28,091	0	0	0	0	0
2017	28,653	0	0	0	0	0
2018	29,226	0	0	0	0	0
2019	29,810	0	0	0	0	0
2020	30,406	0	0	0	0	0
2021	31,015	0	0	0	0	0
2022	31,635	0	0	0	0	0
2023	32,267	0	0	0	0	0
2024	32,913	0	0	0	0	0
2025	33,571	0	0	0	0	0
2026	34,243	0	0	0	0	0
2027	34,927	0	0	0	0	0
2028	35,626	0	0	0	0	0
2029	36,338	0	0	0	0	0
2030	37,065	0	0	0	0	0
2031	37,807	0	0	0	0	0
2032	38,563	0	0	0	0	0
2033	39,334	0	0	0	0	0
2034	40,121	0	0	0	0	0
2035	40,923	0	0	0	0	0
2036	41,741	0	0	0	0	0
2037	42,576	0	0	0	0	0
2038	43,428	0	0	0	0	0
2039	44,296	0	0	0	0	0
2040	45,182	0	0	0	0	0
2041	46,086	0	0	0	0	0
2042	47,008	0	0	0	0	0
2043	47,948	0	0	0	0	0
2043	48,907	0	0	0	0	0

12.3 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%.

12.4 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

12.5 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	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	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

12.6 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

12.7 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	-	-	-

Year		Amount in Cr.		
		Routine Maintenance including tolling	Periodic Maintenance	Total
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
Moratorium 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.

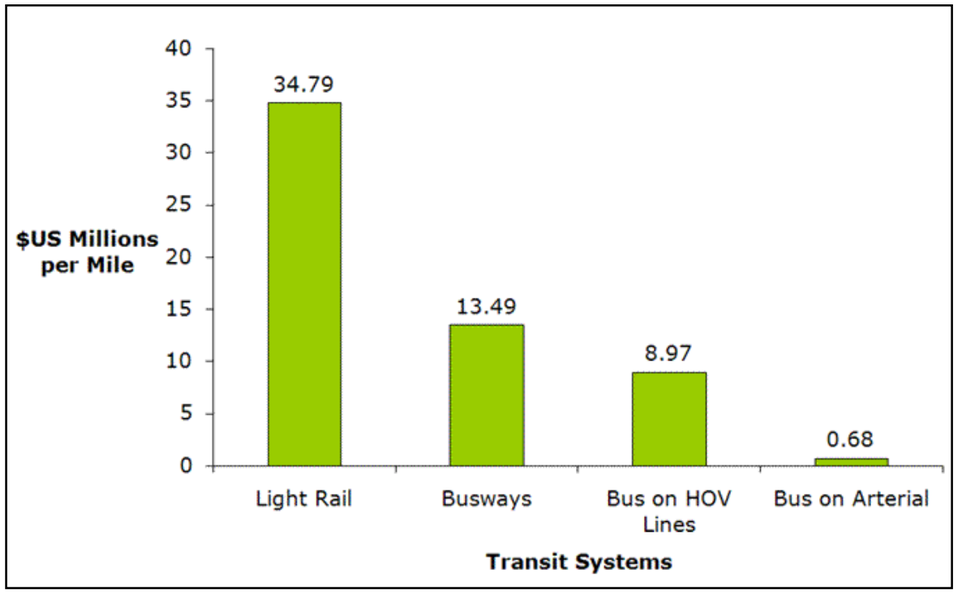


Figure 14:1 Capital costs per mile of Light Rail versus BRT systems

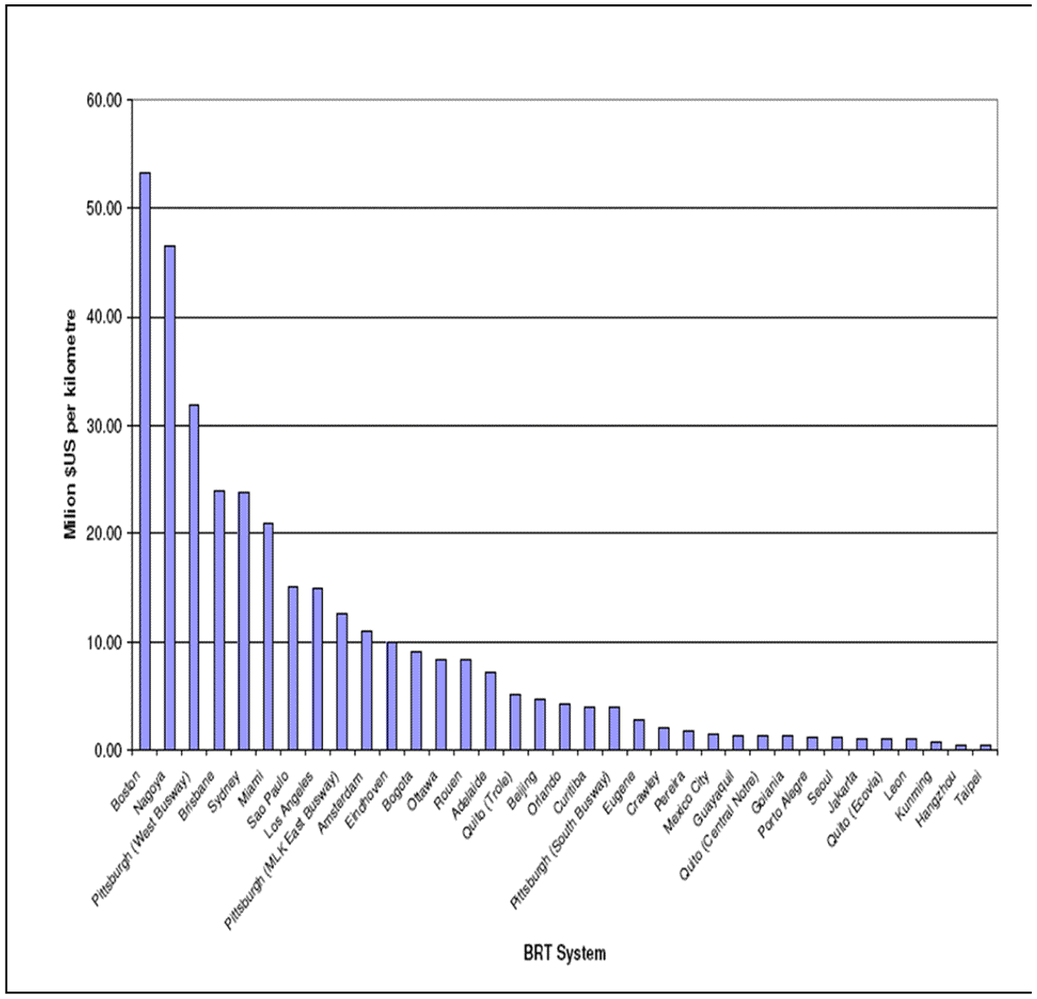


Figure 14.2: Total infrastructure costs per kilometre of BRT systems

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.

Table 14.1: Documentation of Transit Priority Mode Shift Impact Evidence (Currie and Sarvi, 2011)

Documentation of Transit Priority Mode Shift Impact Evidence

Context	Travel Time Impact	Mode Shift Impact
Adelaide North East Busway	Before =40min After =25 min (-15) % Reduction=38% Source: [12]	Ridership Growth= 24% % Pax Previously Drove=40% Source: [13]
Sydney Liverpool Parramatta Transitway	Up to 60 mins tt saving [12] Current timetable is 58 min run time. Implies a 51% notional saving in run time	Ridership Growth= 56% 47% new journeys % Pax Previously Drove=9% Source: [13] Note : % Pax Previously Drove=41% Source: [14]
Brisbane SE Busway	Before =60min After =18 min (-42) % Reduction=-70% Source: (Currie 2006)	Ridership Growth= 56% 17% new journeys % Pax Previously Drove=26% Source: [13]
SmartBus Route 901	Before =57min After =43 min (-14) % Reduction=-14% Source: Analysis Rte 665/830 vs 901 route sections[2]	Ridership Growth[1]= 42% % Pax Previously Drove=34% Source: [15]
SmartBus Route 902	Before =87min After =68 min (-32) % Reduction=-37% Source: Analysis Rte 888/889 vs 902 route sections[2]	Ridership Growth[1]= 47% % Pax Previously Drove=29% Source: [16]
SmartBus Route 903	Before =98min After=74min (-24) % Reduction=-24% Source: Analysis Rte 700 vs 903 route sections[2]	Ridership Growth[1]= 26% % Pax Previously Drove=21% Source: [17]
Transit Link 2 West Lakes Adelaide	Before =47min After =38.5 min (-8.5) % Reduction=-18% Source: Adelaide Network Study – North West	Ridership Growth[1]= 21% % Pax Previously Drove=10% Source: [18]
Transit Link 3 Elizabeth Adelaide	Before =71min After =62 min (-9) % Reduction=-13% Source: Adelaide Network Study – North	Ridership Growth[1]= 27% % Pax Previously Drove=10% Source: [18]
Transit Link 4 Port Road Adelaide	Before =45min After =39.5 min (-5.5) % Reduction=-12% Source: Adelaide Network Study – North West	Ridership Growth[1]= 16.5% % Pax Previously Drove=7% Source: [18]
Transit Link 5 Grange Adelaide	Before =43min After =39.5 min (-3.5) % Reduction=-8% Source: Adelaide Network Study – North West	Ridership Growth[1]= 12% % Pax Previously Drove=4% Source: [18]
Euclid Avenue Cleveland USA	Before =41min After =33 min (-8) % Reduction=-20% Source: [19]	Ridership Growth[1]= 13% % Pax Previously Drove=D/K% Source:[19]
New Britain-Hartford Busway, USA	Before =35min After =20 min (-15) % Reduction=-42% Source: [19]	Ridership Growth[1]= D/K% % Pax Previously Drove=50% Source:[19]
HOV System 1 Huston USA	Before =45min After =24 min (-21) % Reduction=-47% Source: [19]	Ridership Growth[1]= D/K% % Pax Previously Drove=72% Source:[19]
HOV System 2 Huston USA	Before =50min After =30 min (-20) % Reduction=-40% Source: [19]	Ridership Growth[1]= D/K% % Pax Previously Drove=72% Source:[19]
Vancouver Broadway B Line, Canada	Before =D/K After = D/K min (-3-10) % Reduction=- D/K Source: [19]	Ridership Growth[1]= D/K% % Pax Previously Drove=20% Source:[19]
Aalborg, Demark	Before =D/K After = D/K min (DK) % Reduction=- 7% Source: [20] EU Jupiter Project	Ridership Growth[1]= D/K% % Pax Previously Drove=8% Source:[20] EU Jupiter Project
Florence, Italy	Before =D/K After = D/K min (DK) % Reduction=- 12% Source: [20] EU Jupiter Project	Ridership Growth[1]= D/K% % Pax Previously Drove=15% Source:[20] EU Jupiter Project
Ipswich, UK	Before =D/K After = D/K min (-4-5 mins) % Reduction=D/K Source: [20] EU Jupiter Project	Ridership Growth[1]= 43% % Pax Previously Drove=25% Source:[20] EU Jupiter Project
Leeds, UK	Before =D/K After = D/K min (D/K) % Reduction=-33% Source: [20] EU Jupiter Project	Ridership Growth[1]= 40% % Pax Previously Drove=11% Source:[20] EU Jupiter Project
London Rte 220, UK	Before =D/K After = D/K min (D/K) % Reduction=-14-23% Source: [20] EU Jupiter Project	Ridership Growth[1]= 7-15% % Pax Previously Drove=D/K Source:[20] EU Jupiter Project
Helsinki, Finland	Before =D/K After = D/K min (D/K) % Reduction=-11% Source: [21]	Ridership Growth[1]= 11% % Pax Previously Drove=D/K Source: [21]

Note: [1]This is previous modes which were not public transport after accounting for those new to services who didn't have a previous mode prior to services commencing. Note this is like total mode shift and is only loosely associated with corridor ridership growth.
[2]Analysis of before and after services where route sections are shared. Before based on printed (old) timetables and after using June 2011 timetables.

In measuring land use impacts of BRT the employment generation benefits of BRT has been investigated, in a limited capacity.

The predominant focus of research into the employment impacts of BRT is in spatial planning for employment dispersion and the maintenance of low density housing in city areas.

In Ottawa, Ontario, decision makers and planners have developed a multi-centered regional structure for the area.

Ottawa, the dominant center, is surrounded by primary and secondary employment centers. Under the Official Plan, downtown Ottawa is to remain the dominant employment center for the region. (Today, the downtown accounts for 28 percent of regional employment.) Nine primary employment centers will incorporate 5,000 or more jobs; each of these employment centers must be within 400 m of existing or future transit way stations.

Secondary employment centers will provide 2,000 to 5,000 jobs. These centers can be off the transit way but must have access to efficient transit services. The cornerstone for achieving this vision is Ottawa's exclusive busway system—the most extensive in North America—which captures 70 percent of CBD work-related trips.

The most comprehensive examination of the employment generation impacts of BRT presents an analysis of construction phase and operational phase of systems and the quality of employment stemming from the project.

A new BRT system will likely represent a dramatic transformation of the proposed corridors. As with any project of this magnitude, the system will generate a considerable amount of employment through the construction process.

Due to the emphasis on high-quality infrastructure and services, BRT employment can range from artisan work on stations to the direct labour applied to road work. A BRT system also generally brings with it significant improvements in the quality of the employment as well. The improved efficiency and lower operating costs in the new system will improve overall profitability. A primary difference between the BRT and non-BRT scenario in congested corridors would be that for the non-BRT scenario, after a certain numbser of years, population and employment growth in the corridor would stop, whereas in the BRT corridor it would continue at historical growth rates.

How does BRT Perform as Mass Transit

- BRT has been very successful in attracting ridership growth on operating corridors throughout the world and has demonstrated great success in moving existing public transport users and motor vehicle users on to mass transit in Brisbane and Adelaide.
- High performance BRT systems have the capacity to move around 40,000 passengers per hour in one direction.
- BRT offers operational flexibility by giving operators the opportunity to offer all-stop and express services in urban corridors.
- BRT roadways can be shared with high occupancy vehicles, taxis, off-peak freight vehicles and emergency vehicles to help ease urban congestion and improve road safety.

- By presenting the opportunity for a "Rail- Like" look and feel at a significantly lower vehicle cost BRT can attract users who normally avoid bus-based public transport.

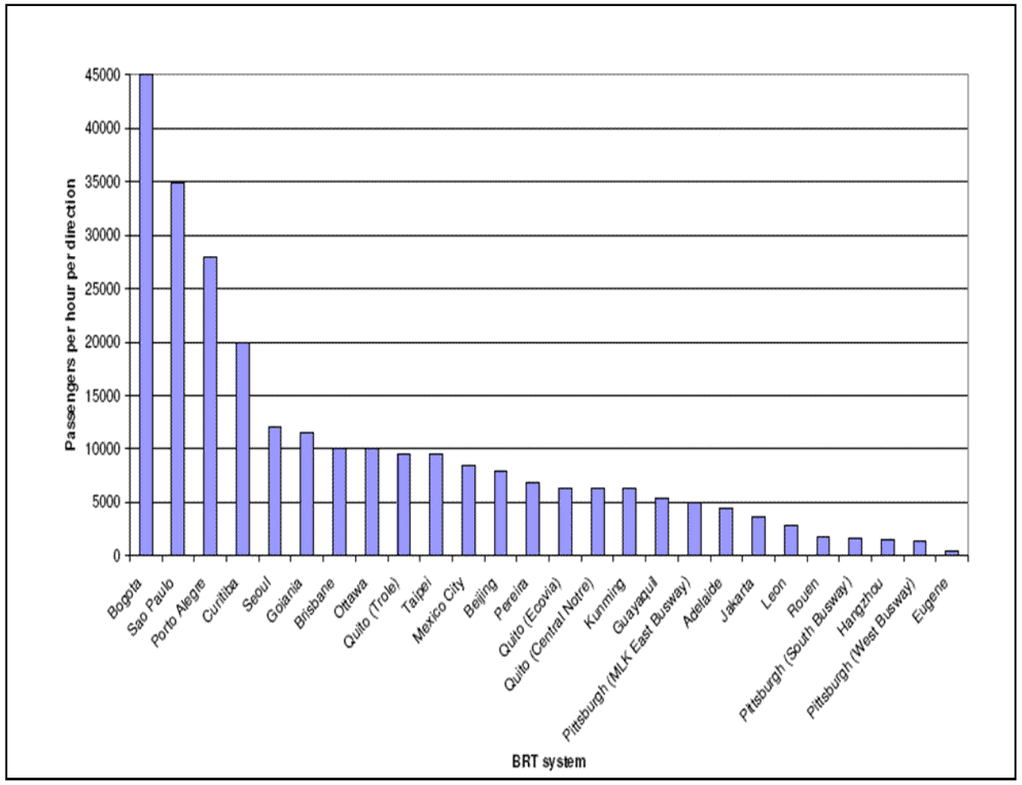


Figure 14.3: Passengers per hour in one direction of BRT systems

The Environmental Performance of BRT

- BRT can produce significantly greater Carbon Dioxide (CO2) reductions than LRT systems
- The electricity used in LRT generated from fossil fuels produces a large amount of CO2 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 CO2 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.

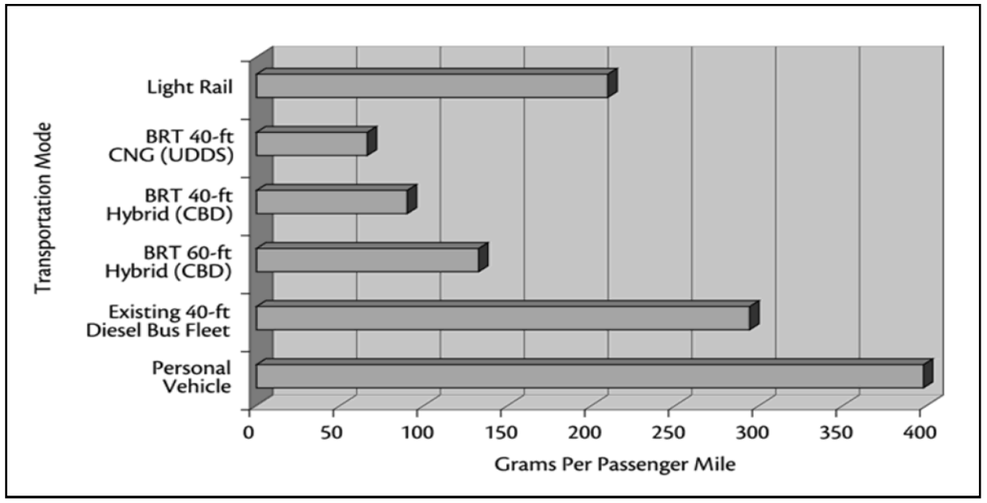


Figure 14.4: Comparative analysis of the environmental performance of LRT and BRT systems with different fuel technologies

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.

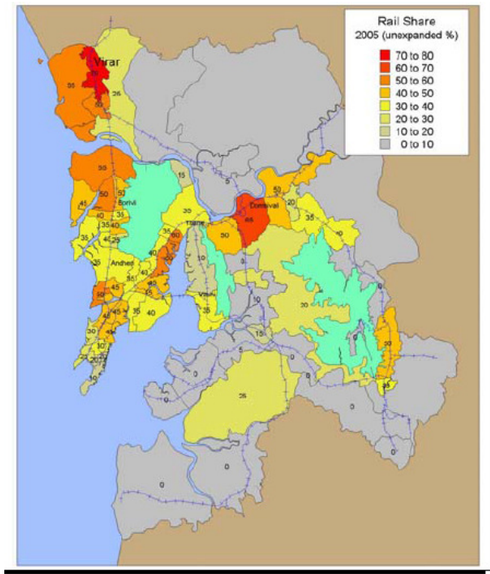


Figure 4-20: Rail Share by Areas (Morning Peak Period – Work Purpose)

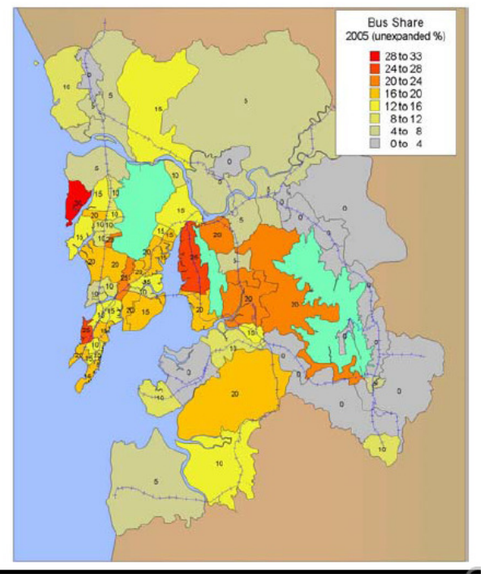
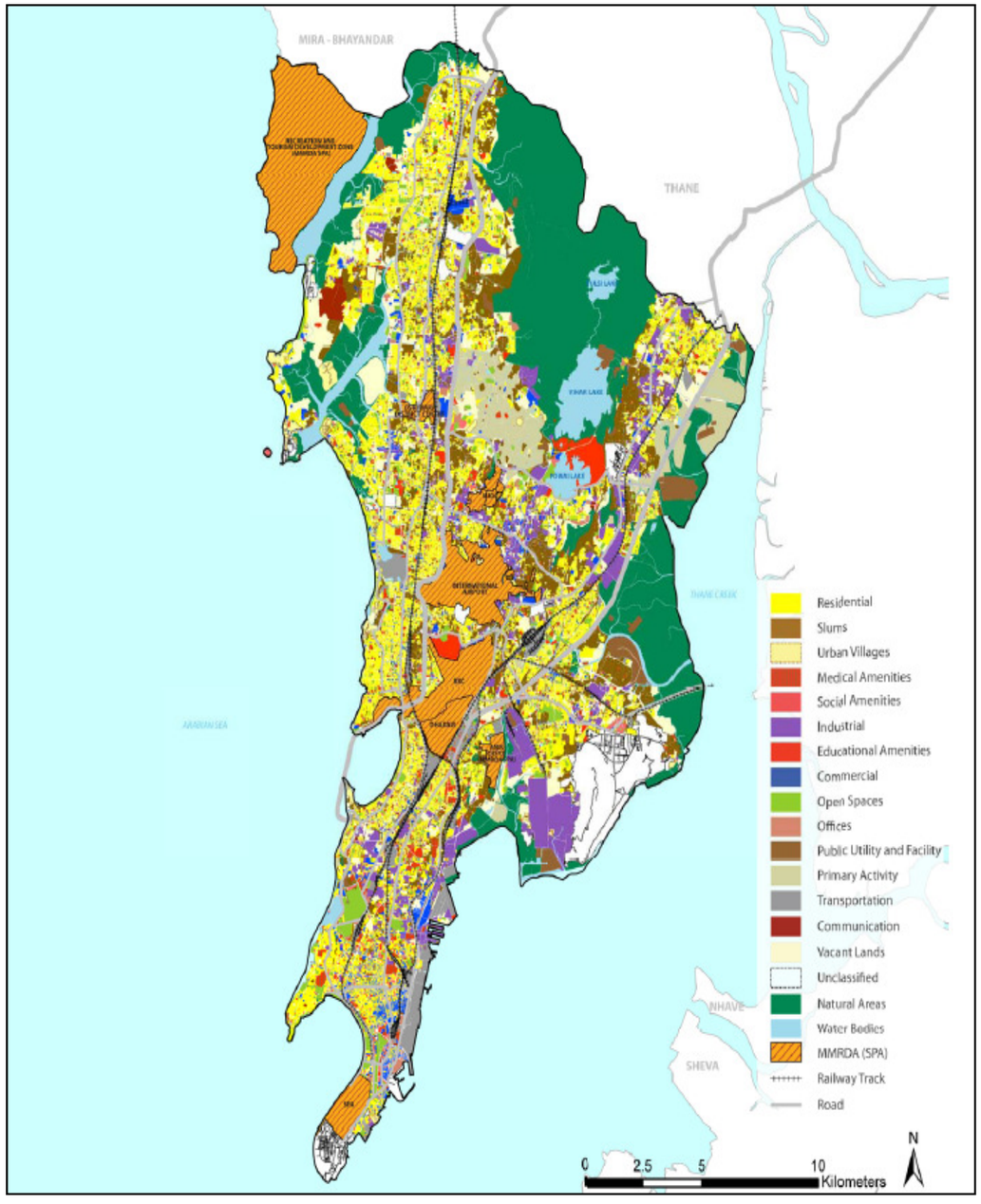
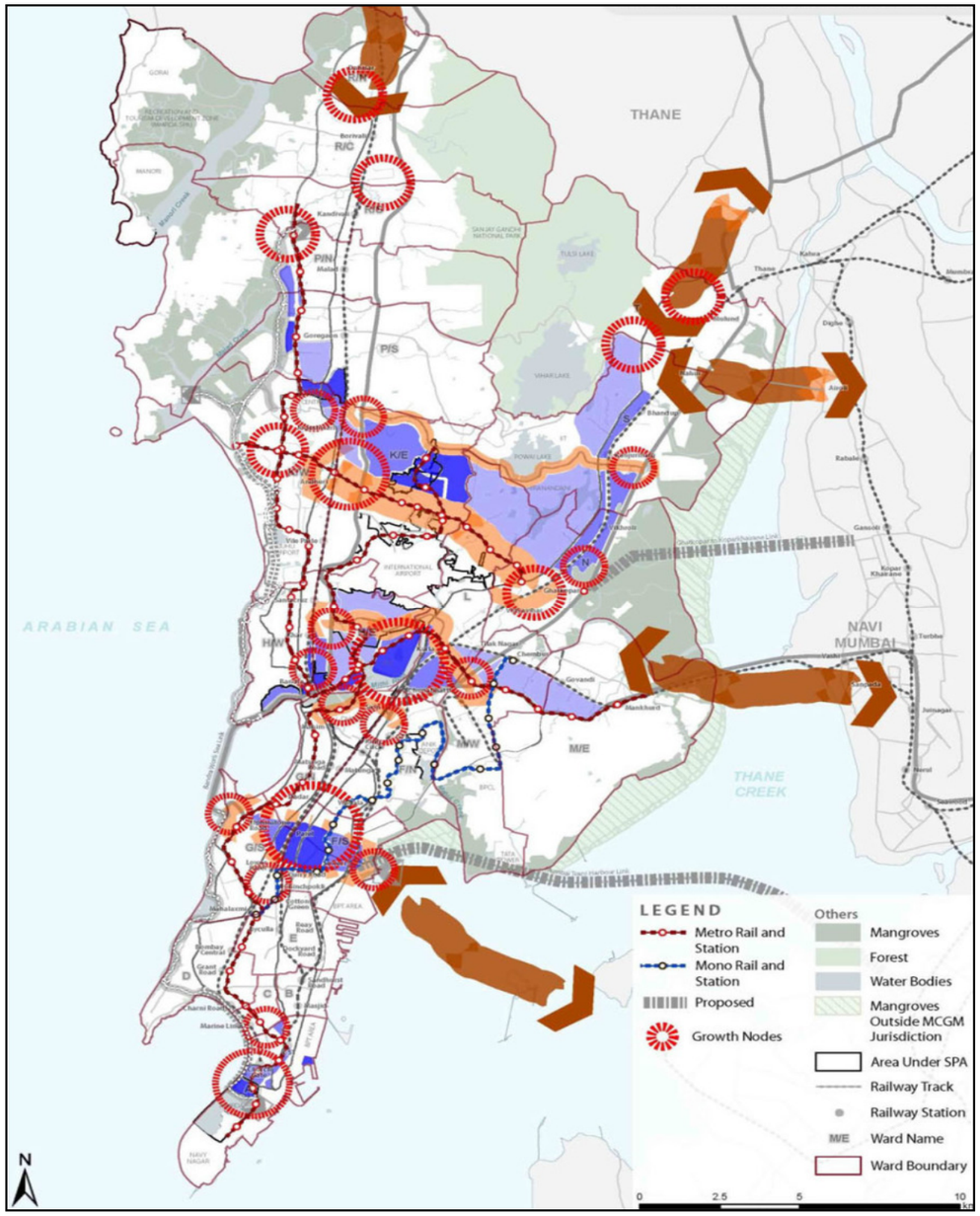


Figure 4-21: Bus Share by areas (Morning Peak Period – Work Purpose)

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 Taxi.



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.

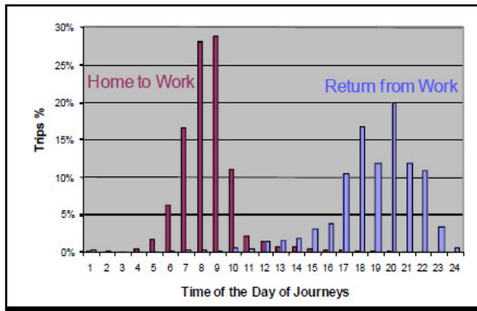


Figure 4-35: Time of the Day of Journeys to Work (and back)

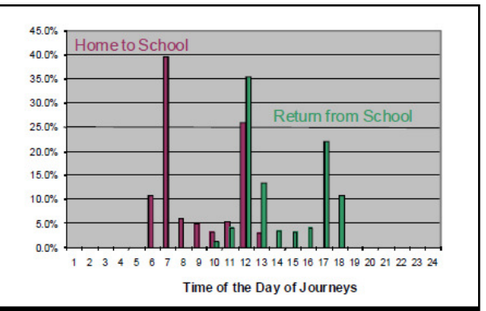
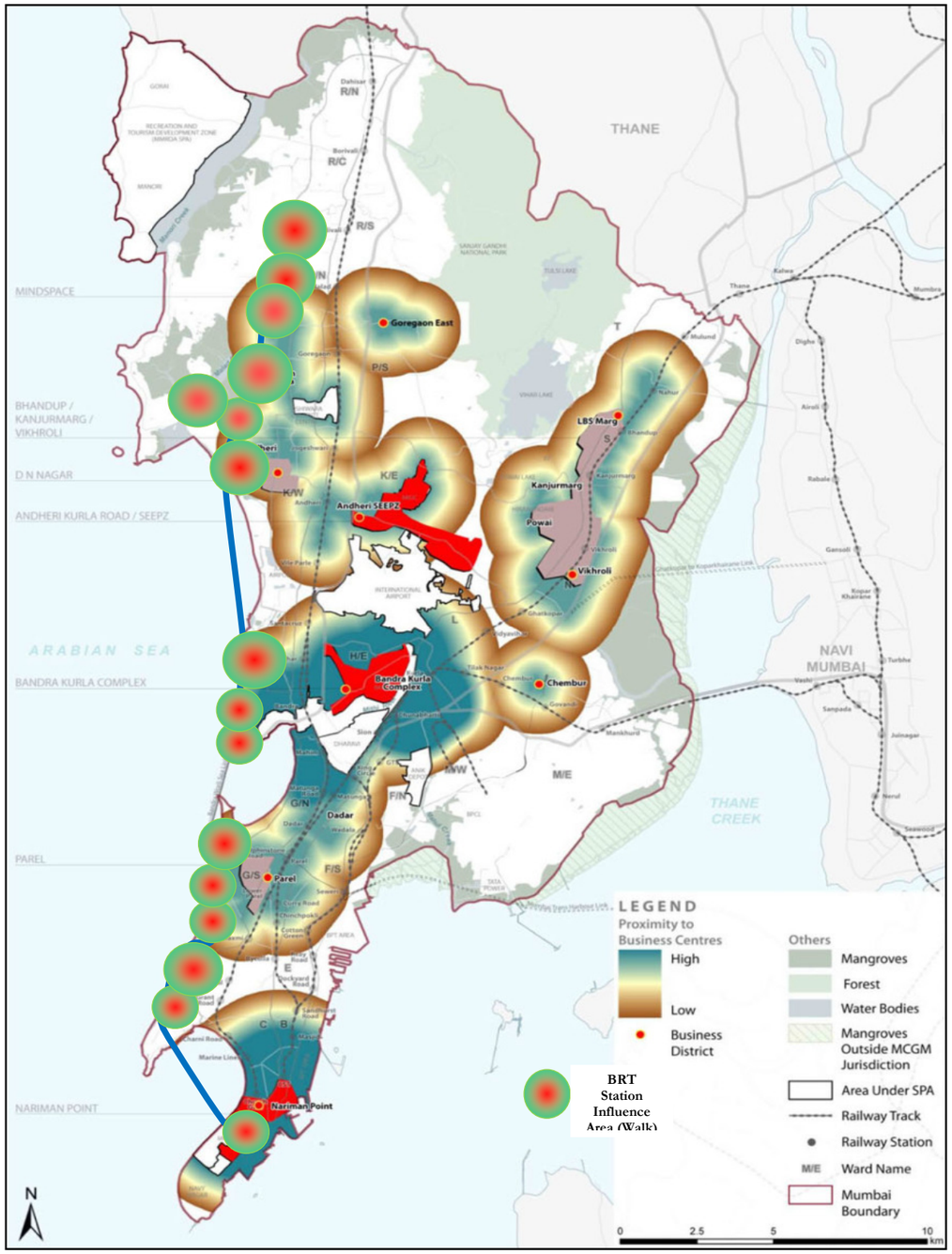


Figure 4-36: Time of the Day of Journeys to School (and back)

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 0.4million passengers with 32,000 passengers during peak hour.

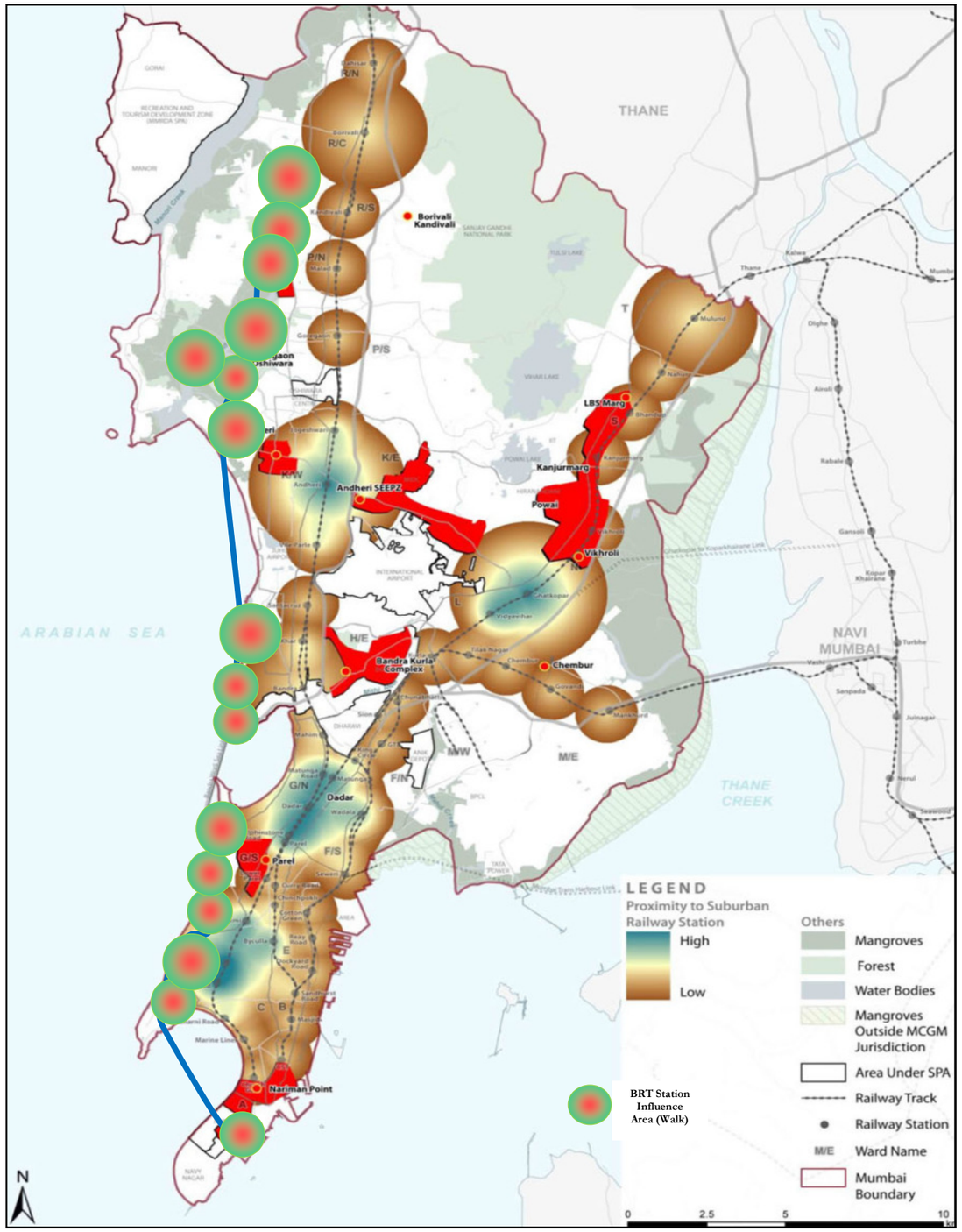
Reference is drawn from various existing successful bus services around the world

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



- 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

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


THANE
ARABIAN SEA
NAVI MUMBAI
THANE CREEK
Borivali Kandivali
Andheri SEEPZ
Kanjurmarg
Powai
Vikhroli
Chembur
Bandra Kurla Complex
Dadar
Parel
Nariman Point
LBS Marg
R/N
R/C
R/S
P/N
P/S
K/W
K/E
H/E
MW
M/E
F/N
G/N
F/S
G/S
LEGEND
Proximity to Suburban Railway Station
High
Low
Others
Mangroves
Forest
Water Bodies
Mangroves Outside MCGM Jurisdiction
Area Under SPA
Railway Track
Railway Station
M/E
Ward Name
Mumbai Boundary
BRT Station Influence Area (Walk)
0
2.5
5
10
N

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 Princess Street Flyover 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 Chapter 6

Based on traffic pattern and various Engineering and Environmental constraints following broad sections were identified for construction phasing:

Part 1: South (Princess Street Flyover to Worli end of Sea Link)

- Section 1: Princess Street Flyover 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 analyzed 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, approval of Alignment Option 7 is recommendedl.

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 legalFormal 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.