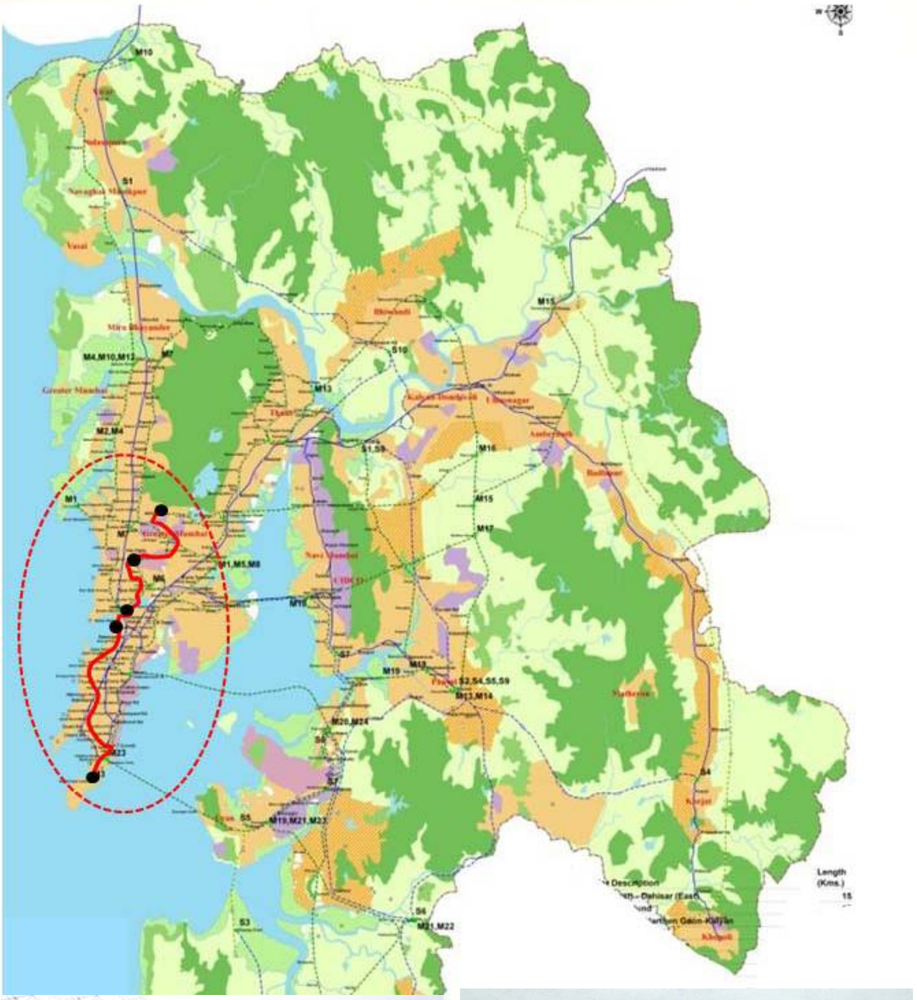
Mumbai Metro Rail Corporation Limited

DETAILED PROJECT REPORT FOR THROUGH METRO CORRIDOR

COLABA – BANDRA – SEEPZ



FINAL REPORT

November, 2011

RITES
THE INFRASTRUCTURE PEOPLE
(A Government of India Enterprise)

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EXECUTIVE SUMMARY

0.1 INTRODUCTION

Mumbai, the financial capital of India, has witnessed phenomenal growth in population and employment. The trend is expected to continue in the future. The job opportunities it offers have served as a major attraction for immigration from hinterland of Maharashtra as well as from all parts of the Country. Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. It comprises of 7 municipal corporations, 13 municipal councils and 996 villages and extends over an area of 4,355 sq.km. MMR is projected to have population and employment (both in terms of formal and informal) as 34.0 million and 15.3 million respectively in the year 2031.

Four-fold growth of population since 1951 has been largely accommodated in the suburbs while the highest concentration of jobs has remained in the Island City. The physical characteristics of the City are such that the suburbs have been constrained to spread northwards only, and all transport facilities are concentrated within three narrow corridors. Today's major challenge is to provide connectivity and promote growth by providing additional infrastructure which would improve the quality of life of the residents.

A Master Plan for Mumbai Metro was prepared in 2004 which proposed implementation of metro corridors in three phases i.e. Phase 1: 2005-2011, Phase II: 2011- 2016 and Phase III: 2016-2021. MMRDA has carried out DPR studies for all the three Phase I metro corridors during the period 2005-2009 (Line 1: Versova - Andheri - Ghatkopar, Line 2: Mankhurd - Bandra - Charkop and Line III: Colaba - Bandra). In 2010, MMRDA also carried out the DPRs of four lines of Phase II & III. Among these, RITES carried out the DPR for BKC - Kanjur Marg (via Air port) with extension from BKC to Mahim (Total Length - 23.5 km).

Table 0.1: Phasing of Mumbai Metro Master Plan

Sr. No.	Corridor	Length of the Corridor (km)	Capital Cost @ 2003 prices (Rs in Crores)	Peak Hour Peak Direction Flow (PHPDT)	Phasing	Phase wise length (km)	Proposed Period of Implementation
1	Versova – Andheri – Ghatkopar	15.0	1500	31421	I	63.8	2005-2011
2	Colaba (Backbay) – Mahim – Charkop	36.0	5085	43356			
3	Mahim – Mankhurd	12.8	1595	28022			
4	Charkop – Dahisar (East)	7.5	750	19094	II	19.9	2011-2016
5	Ghatkopar – Mulund	12.4	1540	32698			
6	BKC to Kanjurmarg via Airport	19.5	3225	21441	III	62.8	2016-2021
7	Andheri (East) – Dahisar (East)	18.0	1800	25504			
8	Hutatma Chowk – Ghatkopar	21.8	3455	18354			
9	Sewri – Prabhadevi	3.5	875	4446			

To provide multimodal access to the airport passengers at CSIA, (being developed as a world class airport), it has long been considered necessary to provide metro connectivity to/ from major parts of the City. Initially this was contemplated via Line I (Versova – Andheri – Ghatkopar), but the spur line connection was not found feasible.

The National Facilitation Committee (NFC), decided that the metro connectivity to the CSIA be expedited and put in the phase 1, rather than in the phase 3 as per Metro Master Plan. This was decided to be achieved by merging Line 6 of Phase 3, named BKC – Kanjur Marg via Airport with the Line 3 of Phase I, i.e. Colaba – Mahim – Bandra and run through services from Colaba till SEEPZ.

With this background, MMRDA through MMRC commissioned the services of RITES to update both the studies ; viz. the first conducted by DMRC for Colaba – Mahim – Bandra Metro Line (2007) and the second by RITES for Mahim – BKC – Kanjur Marg (2010); and prepare a combined DPR for the running of through services on the fully underground Colaba – Bandra – SEEPZ corridor (**Figure 0.1**)

0.2 RIDERSHIP ESTIMATION

The ridership figures for the Colaba – Bandra – SEEPZ Metro corridor are provided by MMRDA based on the results of its CTS Transport Demand Model.

The proposed Metro Corridor is expected to have a daily ridership of 16.99 Lakh and Max. PHPDT of 42000 by 2031. The daily ridership and PHPD on the corridor are shown in **Table 0.2**.

Table 0.2: PHPDT and Daily Ridership for 2016, 2025 and 2031

Corridor	2016		2025		2031	
	Max. PHPDT	Daily Ridership (in Lakh)	Max. PHPDT	Daily Ridership (in Lakh)	Max. PHPDT	Daily Ridership (in Lakh)
Colaba-Bandra - SEEPZ	25700	10.06	39000	13.87	42000	16.99

0.3 SYSTEM DESIGN

0.3.1 Permanent Way

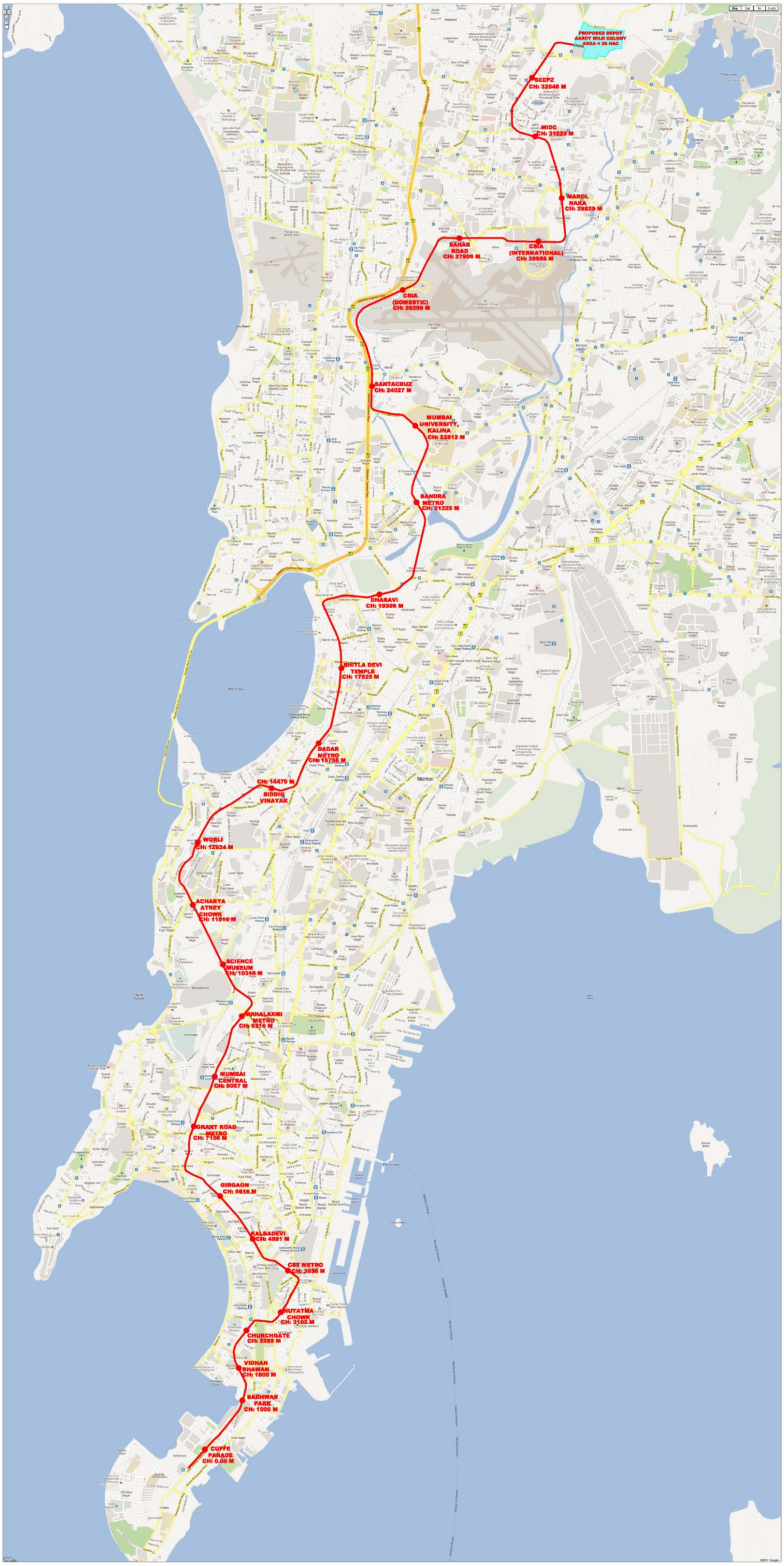
Choice of Gauge

Mumbai Metro Corridors I and II are being implemented with standard gauge and with the objective of uniformity, this corridor is also proposed to be on Standard Gauge(1435mm).

a) Track Structure

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro Systems is long lasting and requires minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The ballastless track structure has been proposed keeping the above philosophy in view.

Figure 0.1: Proposed Colaba – Bandra – SEEPZ Metro Corridor



b) Rail Structure Interaction

Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) also. REJ in ballasted track will be for a maximum gap of 120 mm, whereas on ballastless track for a maximum gap of 180 mm.

c) Welding

Flash Butt Welding Technique is to be used for welding of rails. Alumino-Thermit Welding is to be done only for those joints which cannot be welded by Flash Butt Welding Technique, such as joints at destressing locations and approach welds of switches & crossings. For minimising the population of Thermit welds, mobile (rail-cum-road or portable) Flash Butt Welding Plant will have to be deployed.

The track will conform to standards as laid down by Railway Board vide their letter no. 2010/ Proj./Genl/3/3 dated 23/12/2011.

0.3.2 Traction System

Keeping in view the ultimate traffic requirements, uniformity, standardization and other techno-economic considerations, 25kV ac traction system is considered to be the best solution and hence, proposed for adoption. Suitable measures will be required for mitigation of EMI & EMC caused by 25 kV single-phase traction currents.

0.3.3 Signalling and Train Control

Metro carries a large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting ‘Distance to go’ ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems.

Signalling & Train Control system on the line is planned for a design headway of 2.5 minutes so as to meet sustained train operation at 3 minutes interval during peak periods.

0.3.4 Telecommunication

The standards proposed to be adopted for telecommunication systems are presented in **Table 0.3.**

Table 0.3 Standards Proposed for Telecommunication Systems

System	Standards
Transmission System	SDH and GE based for the entire telecom network.
Transmission Media	Optical Fibre system as the main bearer for bulk of the telecommunication network,
Telephone Exchange	EPABX of minimum 128 ports is to be provided at all Stations and an Exchange of 256 Ports to be provided at Terminal Station & OCC.
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel and central control.

System	Standards
Train Destination Indicator System	LED/LCD based boards with adequate visibility to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and also special messages in emergencies. Provision for display of information for other public transport modes will be made at interchange stations.
Centralized clock system	Accurate display of time through a synchronisation system of slave clocks driven from a master clock at the OCC and sub – master clock in station. This shall also be used for synchronisation other systems.
Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement. Provision for announcements for other public transport modes will be made at interchange stations.
Redundancy (Major System)	Redundancy on Radio base station equipment. Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.
Environmental Conditions	All equipment rooms to be air-conditioned.
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

0.3.5 Automatic Fare Collection

Ticketing system shall be simple, easy to use/operate and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. A computer based automatic fare collection system is proposed.

0.3.6 Rolling Stock

Rolling Stock proposed for Colaba – Bandra – SEEPZ Metro will be similar to Rolling Stock of Line - I of Mumbai Metro. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed for the Corridor are presented in **Table 0.4**.

Table 0.4: Broad Features of Rolling Stock

S. No.	Parameter	Colaba – Bandra - SEEPZ Corridor
1	Vehicle dimensions	
	Length (including coupler)	DT-M-T-M-T-M-M-DT : 178360 mm
	Width	3200mm
	Height	DTC : 4118mm over panto in down position TC/MC : 3898mm over AC portion of roof
2	Coach construction	Lightweight stainless steel body
3	Tare Weight	DT (42.0T), T (42.0T), M (42.0T)
4	Axle load	17 T
5	Propulsion system	3 phase drive system with VVVF control
6	Type of traction supply	25KV AC Overhead collection
7	Acceleration/ Deceleration	Maximum 1.1 m/s^2 and 1.3 m/s^2 respectively

0.4 CIVIL ENGINEERING

0.4.1 Alignment Planning

- The consultants developed various alignment options between Colaba - Mahim and presented to MMRC during the course of various discussions/meetings as well as in "Options Report" submitted in Aug'11.
- The corridor is proposed to have double line track, with a capacity to run 8 coach trains.
- The corridor is planned fully underground either on the edge of the existing road or along the median of the road and care has to be taken to cause least disruption to existing services/ traffic movement. Underground structures are planned keeping in view Mumbai's aggressive marine environment and high corrosion proneness - with suitable anti-corrosive treatment to reinforcement/ structural steel, concrete surface in contact with earth as well as exposed to atmosphere.

0.4.2 Engineering Survey

Topographical survey has been carried out along the proposed alignment not less than 80 m wide or built up lines whichever is more as well as 100 m on station areas. The detailed Topographical Survey between Colaba to Mahim has been carried out afresh along the proposed alignment whereas duly updated survey data for Mahim - SEEPZ has been used from line – 6 DPR.

0.4.3 Geometric Design Norms

Horizontal Alignment

As far as possible, the alignment follows the existing roads. On consideration of maximum allowable cant of 125 mm and cant deficiency of 100 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. However, in the underground section, desirable minimum radius of curve is taken as 300 m for ease of working of Tunnel Boring Machine.

Vertical Alignment

Rail level at stations and in tunneling portion has been kept at least 15 m below the ground level. Since rock has been encountered at shallow depths from the existing ground level, in the range of 2.10 m to 10.0 m, underground tunneling is proposed for construction. The rail level is kept such that, the entire tunnel is encased in the rock and a minimum of 6 m rock cushion is available over the tunnel. This will also avoid the underground utilities (except station areas) and building foundations.

Gradients

The stations are proposed to be on level stretch. Between stations, generally the grades may not be steeper than 3.0%. However, where existing road gradients are steeper than 3%, gradients up to 4% (compensated) are provided in short stretches on the main line.

Design Speed

The maximum sectional speed will be 80 km/h. However, the applied cant and length of transitions will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations. Computerized train simulation studies need to be conducted with proposed gradients at the time of detailed design stage. This is with the objective of keeping down the wear on rails on curves to the minimum.

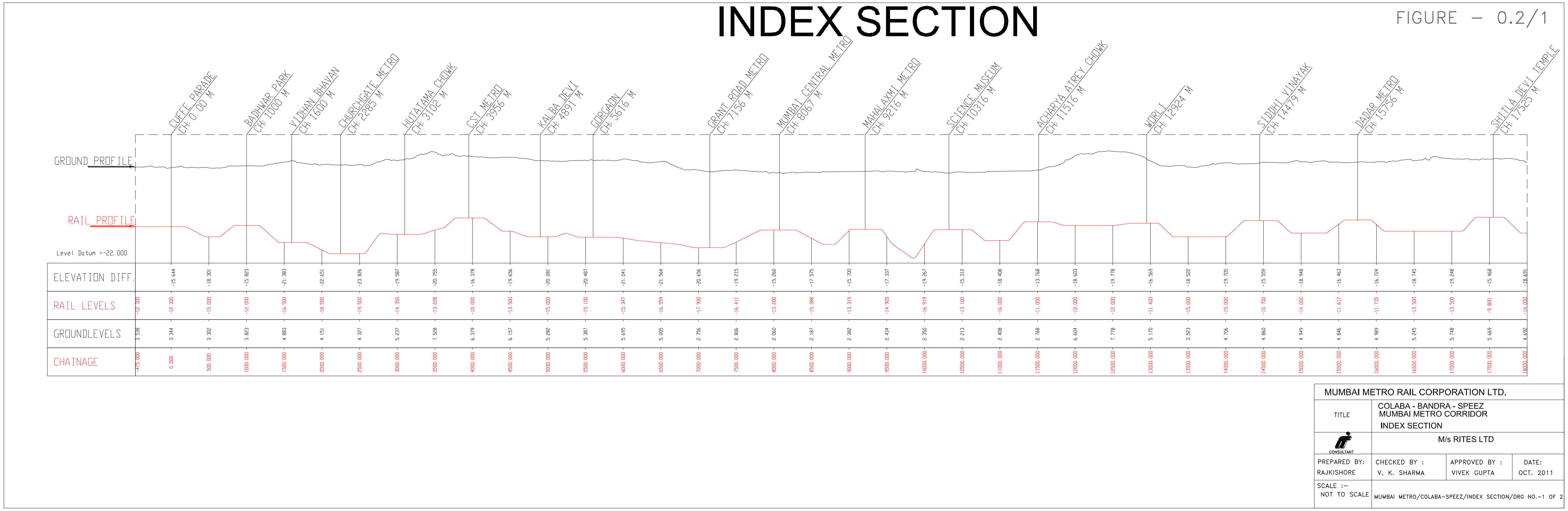
0.4.4 Alignment Description

The alignment starts from the southern tip of Mumbai City at Colaba/ Cuffe Parade near the WTC junction on Captain Prashant Pethe Marg and moves northwards. After crossing Badhwar Park, it turns left along Jagannath Bhosle Road, moves off the road and runs under the police baracks at Nariman point to connect Vidhan Bhawan and Mantralaya. Further, it aligns along Jamshedji Tata Road to connect with Churchgate Station.

After crossing Oval Maidan along Veer Nariman Road, the alignment further runs along Dr. D.N. Road upto west of CST Rly Station along Mahapalika Marg. Further, the alignment runs along JSS Road, Lamington Road and Dr. Anandrao Nair Marg. After crossing the WR tracks at Mahalaxmi, the alignment runs along Dr. E Moses Marg, Dr. Annie Basant Road, N. Gokhale Road and Lady Jamshedji Road. At Mahim, the alignment turns right along R. Hospital Road, moves along Mahim-Sion Link/ Station Road, crosses Mahim creek (Mithi River) just east of the Sion-Bandra Link Road and further crosses Metro line II (Charkop – Bandra – Mankhurd corridor) at Bandra Metro Station (ITO). The alignment passes through Bandra-Kurla Complex, Bharat Nagar and Valmiki Nagar slums and Kalina University.

Further North, the alignment passes parallel to Santacruz – Chembur Link Road and eastern service road of Western Express Highway. The alignment enters into Mumbai Airport's premises and covers Domestic terminal, Sahar Road and International terminal. The alignment crosses metro line I (Versova – Andheri – Ghatkopar corridor) at Marol Naka. Further, the alignment passes through MIDC and SEEPZ area along Krantiveer Lakhuji Salve Marg with terminal station at SEEPZ opposite the SEEPZ Bus Depot. The alignment terminates north of Jogeshwari – Vikhroli Link Road at Aarey Milk Colony, where depot is located. **The, index section and schematic plan is enclosed as Figures 0.2/1, 0.2/2 & 0.3**.

The total length of the alignment between C/L of Cuffe parade station to SEEPZ station is 32.546 km and the total alignment length is 33.508 km. A total of 27 underground stations have been proposed along the entire length of alignment. 3 underground stations are proposed in Mumbai Airport's premises. List of stations along with their chainage and interstation distance (ISD) is presented in **Table 0.5.**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BADHWAR PARK CH: 1000 M
VIDHAN BHAVAN CH: 1600 M
CHURCHGATE METRO CH: 2285 M
HUTATAMA CHOWK CH: 3102 M
CST METRO CH: 3956 M
KALBA DEVI CH: 4891 M
GORGAON CH: 5616 M
GRANT ROAD METRO CH: 7156 M
MUMBAI CENTRAL METRO CH: 8067 M
MAHALAXMI METRO CH: 9216 M
SCIENCE MUSEUM CH: 10316 M
ACHARYA ATREY CHOWK CH: 11516 M
WORLI CH: 12924 M
SIDDHI VINAYAK CH: 14479 M
DADAR METRO CH: 15756 M
SHITLA DEVI TEMPLE CH: 17525 M
GROUND PROFILE
RAIL PROFILE
Level Datum =-22.000
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RAIL LEVELS
GROUNDLEVELS
CHAINAGE
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TITLE
COLABA - BANDRA - SPEEZ
MUMBAI METRO CORRIDOR
INDEX SECTION
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CHECKED BY : V. K. SHARMA
APPROVED BY : VIVEK GUPTA
DATE: OCT. 2011
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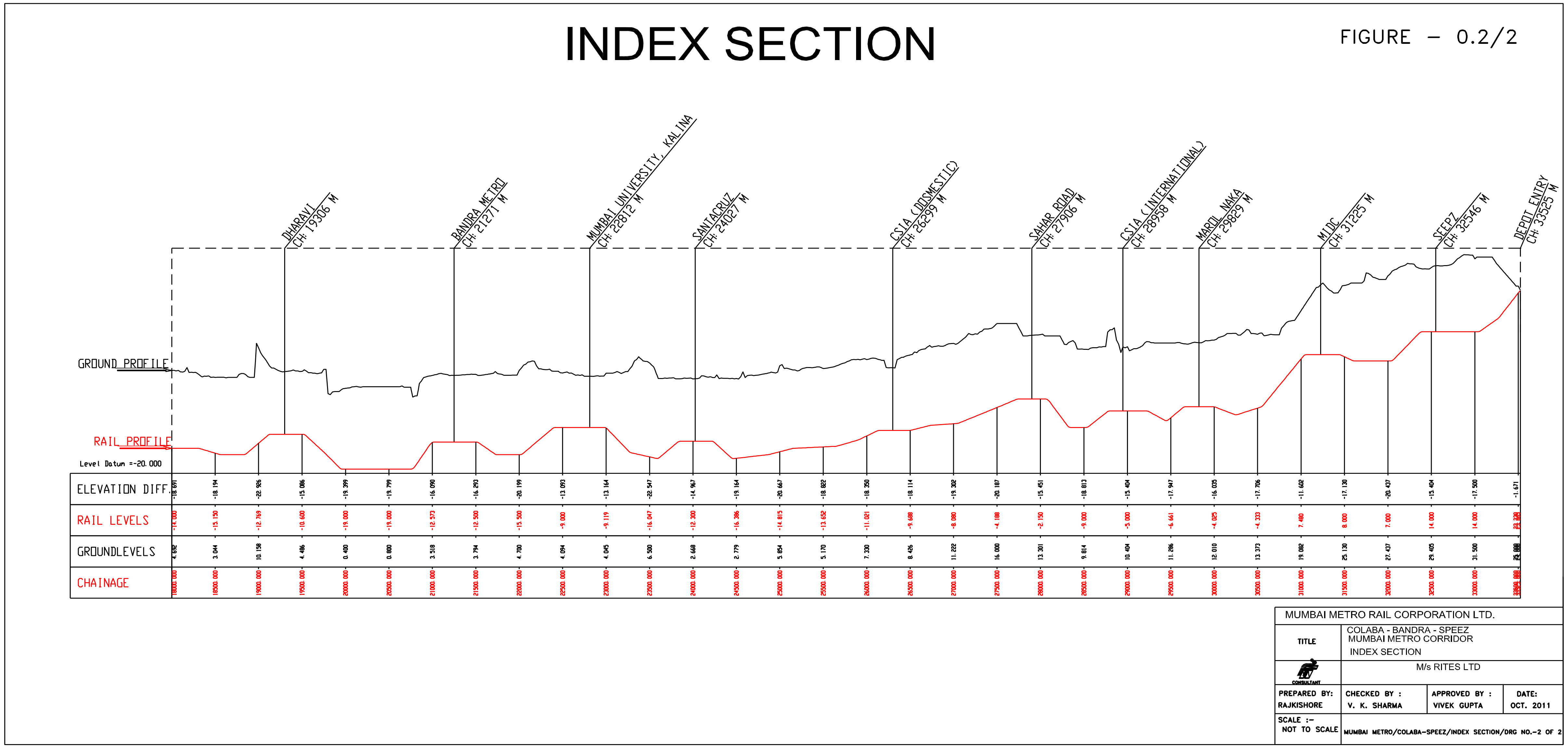
MUMBAI METRO/COLABA-SPEEZ/INDEX SECTION/DRG NO.-1 OF 2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MUMBAI UNIVERSITY, KALINA CH: 22812 M
SANTACRUZ CH: 24027 M
CSIA (DOMESTIC) CH: 26299 M
SAHAR ROAD CH: 27906 M
CSIA (INTERNATIONAL) CH: 28958 M
MAROL NAKA CH: 29829 M
MIDC CH: 31225 M
SEEPZ CH: 32546 M
DEPOT ENTRY CH: 33525 M
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RAIL PROFILE
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MUMBAI METRO CORRIDOR
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CHECKED BY : V. K. SHARMA
APPROVED BY : VIVEK GUPTA
DATE: OCT. 2011
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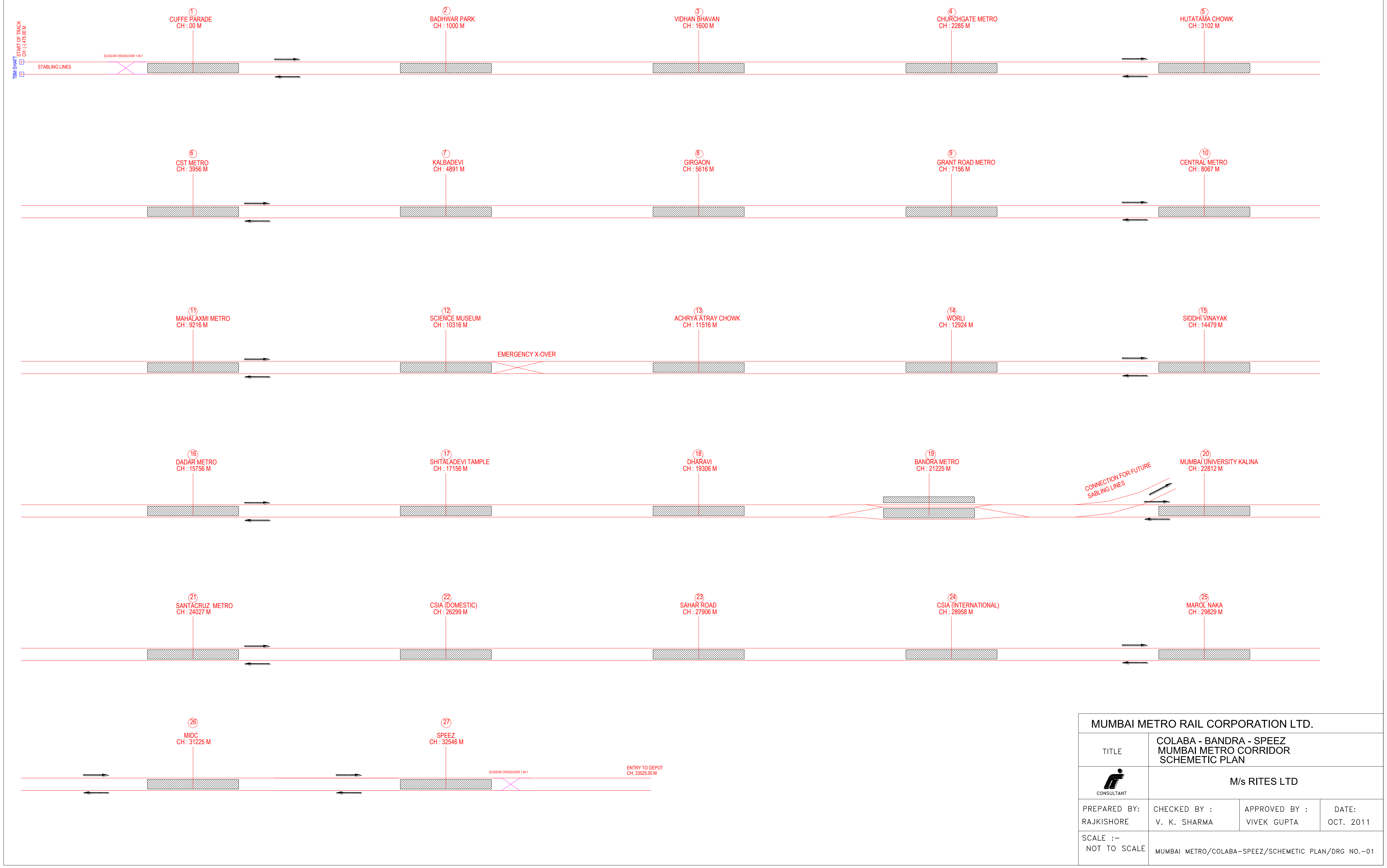
FIGURE – 0.3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CH : 00 M
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CH : 1000 M
3 VIDHAN BHAVAN
CH : 1600 M
4 CHURCHGATE METRO
CH : 2285 M
5 HUTATAMA CHOWK
CH : 3102 M
6 CST METRO
CH : 3956 M
7 KALBADEVI
CH : 4891 M
8 GIRGAON
CH : 5616 M
9 GRANT ROAD METRO
CH : 7156 M
10 CENTRAL METRO
CH : 8067 M
11 MAHALAXMI METRO
CH : 9216 M
12 SCIENCE MUSEUM
CH : 10316 M
EMERGENCY X-OVER
13 ACHRYA ATRAY CHOWK
CH : 11516 M
14 WORLI
CH : 12924 M
15 SIDDHI VINAYAK
CH : 14479 M
16 DADAR METRO
CH : 15756 M
17 SHITALADEVI TAMPLE
CH : 17156 M
18 DHARAVI
CH : 19306 M
19 BANDRA METRO
CH : 21225 M
CONNECTION FOR FUTURE
SABLING LINES
20 MUMBAI UNIVERSITY KALINA
CH : 22812 M
21 SANTACRUZ METRO
CH : 24027 M
22 CSIA (DOMESTIC)
CH : 26299 M
23 SAHAR ROAD
CH : 27906 M
24 CSIA (INTERNATIONAL)
CH : 28958 M
25 MAROL NAKA
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26 MIDC
CH : 31225 M
27 SPEEZ
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ENTRY TO DEPOT
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CONSULTANT
M/s RITES LTD
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CHECKED BY : V. K. SHARMA
APPROVED BY : VIVEK GUPTA
DATE: OCT. 2011
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Table 0.5: List of Stations

Sr No.	Station Name	Chainage (M)	INTER STATION DISTANCE (M)	GL/RL (M)	Proposed RL (M)	Level Difference (M)
1	Cuffe Parade	0	-	3.43	-12.30	-15.73
2	Badhwar Park	1000	1000	3.44	-12.00	-15.44
3	Vidhan Bhavan	1600	600	5.14	-16.50	-21.64
4	Churchgate Metro	2285	685	4.00	-19.50	-23.50
5	Hutatma Chowk	3102	817	6.65	-14.35	-21.00
6	CST Metro	3956	854	6.68	-10.00	-16.68
7	Kalbadevi	4891	935	5.15	-15.00	-20.15
8	Girgaon	5616	725	5.50	-15.10	-20.60
9	Grant Road Metro	7156	1540	2.41	-17.90	-20.31
10	Mumbai Central Metro	8067	911	1.95	-13.20	-15.15
11	Mahalakshmi Metro	9216	1149	2.35	-13.00	-15.35
12	Science Museum	10316	1100	2.16	-13.10	-15.26
13	Acharya Atrey Chowk	11516	1200	5.89	-11.00	-16.89
14	Worli	12924	1408	4.52	-11.40	-15.92
15	Siddhi Vinayak	14479	1555	4.70	-10.70	-15.40
16	Dadar Metro	15756	1277	4.85	-10.50	-15.35
17	Shitla Devi Temple	17525	1769	5.71	-9.60	-15.31
18	Dharavi	19306	1781	4.46	-10.60	-15.06
19	Bandra Metro	21271	1965	3.56	-11.60	-15.16
20	Mumbai University, Kalina	22812	1541	3.31	-9.00	-12.31
21	Santacruz	24027	1215	2.74	-12.30	-15.04
22	CSIA (Domestic)	26299	2272	5.35	-9.70	-15.05
23	Sahar Road	27906	1607	13.15	-2.15	-15.30
24	CSIA (International)	28958	1052	10.37	-5.00	-15.37
25	Marol Naka	29829	871	11.35	-5.00	-16.35
26	MIDC	31225	1396	25.72	8.50	-17.22
27	SEEPZ	32546	1321	29.81	14.00	-15.81

Note: Station names are tentative and subject to change

0.4.5 Terminals

i. Cuffe Parade Station (South terminal station)

The Southernmost station on the Metro corridor is Cuffe Parade station. The rail level for Cuffe Parade station is kept 15.00 m (minimum) below the ground level. A passage has also been proposed to provide passenger dispersal facilities to World trade Centre. Reversal facilities have also been planned at Cuffe Parade station with stabling facilities.

ii. ITO Station (Mid Terminal)

ITO station will serve as the Mid Terminal station for the proposed corridor. This station will have one island and one side platform with provision of reversal facilities. Passenger interchange with Metro Line 2 (Charkop – Bandra – Mankhurd) has been planned at this station.

iii. SEEPZ Station (North Terminal station)

Northern Terminal of the corridor will be SEEPZ. Reversal/stabling facility has also been planned at this station. The depot is proposed at Aarey Milk Colony, after the SEEPZ station - north of Jogeshwari – Vikhroli Link Road.

0.4.6 Geo Technical Investigation

Geological site investigation were carried out from Colaba to Mahim for about 18.475 km and Mahim to SEEPZ for about 15.033 Km during preparation of DPR for Colaba – Bandra Metro (line – 3) and Mahim – Kanjur Marg Metro (line – 6). The data available from both the DRR's has been used for finalisation of construction methodology.

0.4.7 Utilities

The proposed metro alignment is passing along major arterial roads which are serving Institutional, commercial and residential areas. A large number of surface and sub-surface utilities viz. sewers, water mains, storm water drains, telephone cables, electric poles, traffic signals, etc. exist along the proposed alignment. Details of the existing utility services along the proposed alignment have been collected from the concerned authorities. The affected portions of the services with reference to the proposed alignment have been identified and temporary diversion and/ or permanent relocation proposals have been indicated.

0.4.8 Archaeological/ Heritage issues

In the Maharashtra region, there are 118 listed Archaeological sites out of which only eight lie in MMR. Out of these eight sites, six are in the Borivili area and beyond. Two sites, i.e. Sion and Parel are in the city limits but lie far from the proposed Corridor . Hence the Corridor does not fall within the purview of the Ancient Monuments and Archaeological Sites and Remains (Monuments and Validation) Act, 2011.

The proposed Corridor is fully underground and does not affect any Listed Heritage Structure so as to seek approval for the execution and operation of Metro Corridor. However, as the Corridor is passing through/along the Heritage Precincts and Hutatma Chowk and CST Metro stations are located in these Precincts, approval of Commissioner, MCGM through MHCC (Maharashtra Heritage Conservation Committee) will have to be obtained. Archaeological sites along corridor are as follows:

1. Worli Fort
2. Dharavi Fort
3. Mahim Fort

0.4.9 Land Requirement

Land is mainly required for;

- MRTS Structure (including Route Alignment), Station Buildings, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub - Stations
- Radio Towers
- Temporary Construction Depots and work sites for segment casting for underground construction

The abstract of land requirements for different components is given in **Tables 0.6** and **0.7.**

Table 0.6: Summary of Permanent Land Requirement

(Area in m^2)

	Stations		TSS		Depot	Total
	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ		
Pvt Land	16200	16060	2000	0	0	**34260**
Govt Land	8268	6688	2000	2000	264070	**283026**
Total	**24468**	**22748**	**4000**	**2000**	**264070**	**317286**

Table 0.7: Summary of Temporary Land Requirement

	Stations		Construction Depot		Total
	Colaba - Mahim	Mahim – SEEPZ	Colaba - Mahim	Mahim - SEEPZ	
Pvt Land	0	627	0	12370	**12997**
Govt Land	5999	12407	40298	69237	**127941**
Total	**5999**	**13034**	**40298**	**81607**	**140938**

0.5 STATION PLANNING AND INTERMODAL INTEGRATION FACILITIES

0.5.1 Stations have been located so as to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, interchange requirements with other modes of transport, station spacing, alignment, utilities, road and pedestrian requirements, etc. (**Table 0.8**).

Table 0.8: Station Planning Details

Stations	Development Density	Integration With Other Modes	No. of Entries/ Exits proposed
Cuffe Parade	High	Terminal station, interchange with Colaba bus Depot/Terminal	4
Badhwar Park	High	Inter-modal integration with buses, IPT and private pick/drop	4
Vidhan Bhavan	Medium	Inter-modal integration with buses, IPT and private pick/drop	5
Churchgate Metro	High	Interchange station with existing suburban/ proposed elevated corridor	4*
Hutatma Chowk	High	inter-modal integration with buses, IPT and private pick/drop	4
CST Metro	High	Interchange station with existing suburban corridor	4*
Kalbadevi	High	Inter-Modal integration with buses, IPT and private pick/drop	4
Girgaon	High	Charni road Suburban Railway Station about 400m away	4
Grant Road Metro	High	Grant Road Suburban Railway Station about 600m away	4
Mumbai Central Metro	High	Interchange station with existing suburban/ proposed elevated corridor. Suburban Railway Station about 600m away	4*
Mahalakshmi Metro	High	Interchange station with existing suburban/ proposed elevated corridor and upcoming monorail corridor. Mahalaxmi suburban Railway Station about 400m away	4*
Science Museum	Medium	Inter-modal integration with buses, IPT and private pick/drop	4
Acharya Atrey Chowk	Medium	Inter-modal integration with buses, IPT and private pick/drop	4

Stations	Development Density	Integration With Other Modes	No. of Entries/ Exits proposed
Worli	High	Inter-modal integration with buses, IPT and private pick/drop	4
Siddhi Vinayak	High	Interchange station with proposed MTHL corridor	4*
Dadar Metro	High	Interchange station with existing suburban / proposed elevated corridor Dadar Western Railway Station approximately at a distance of 1000 m	5*
Shitla Devi Temple	High	Mahim Western Railway Station approximately at a distance of 600 m	4*
Dharavi	High	Inter-modal integration with buses, IPT and private pick/drop	5
Bandra Metro	High	Changeover terminal station of Metro Phase I Line II i.e. Charkop-Bandra-Mankhurd,	3*
Mumbai University, Kalina	Low	Inter-modal integration with buses, IPT and private pick/drop	4
Santacruz	High	Suburban Railway Station about 700m away	4
CSIA (Domestic)	Low	Adjacent to Domestic Airport Terminal	4
Sahar Road	Medium	Inter-modal integration with buses, IPT and private pick/drop	4
CSIA (International)	Low	Adjacent to upcoming International Airport Terminal	4
Marol Naka	High	Interchange station with Upcoming Metro Line I (Versova–Andheri-Ghat Kopar Corridor)	3*
MIDC	High	Inter-modal integration with buses, IPT and private pick/drop	4
SEEPZ	Medium	Terminal Station, interchange with SEEPZ Bus Stand	4

* Additional access and traffic dispersal arrangements at interchange stations.

0.5.2 Planning Norms & Standards

The typical size of the proposed underground stations would be nearly 27 m wide and 290 m long. Important criteria that have been applied in Station Planning include:

- Sizing of Station Passenger facilities
- Stipulated Design standards
- Emergency Evacuation
- Passenger circulation, comfort, ease of use, safety and security
- Operational accommodation (Back of House Areas)
- Electrical and mechanical plant and Equipment space requirements
- Platform Screen Doors

Stations are planned assuming a train operation frequency of 2 minutes 30 seconds in 2031. The station layout accommodates the worst case scenario at each station.

The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the next level does not exceed 4.5 minutes (as per NFPA 130)

Entrances to stations have adequate capacity to satisfy predicted passenger flows and emergency evacuation requirement.

The position of entrances is determined by the juxtaposition of building location of roadways footpaths width, space availability and flow directions of passenger traffic.

The widths of entrances take into account the predicted passenger flows and available space.

All entrances extending to street level are protected against flooding. This protection is done by the provision of a minimum of 3 steps up to a landing (+450 mm minimum).

Minimum Corridor width

- Unidirectional movement: 1.8 m
- Bi-directional movement: 2.0 m
- Where length of the corridor is more than 30 m: 3.0 m
- For staff: 1.2 m

Ramps

- Preferred gradient: 1:20
- Maximum gradient: 1:12
- Minimum width:
  - Unidirectional movement: 1.2 m
  - Bi-directional movement: 1.5 m
- For ramp exceeding 10 m, rest platform: 1.8m long

The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation. The space planning requirement for each of the stations with respect to the number of AFC gates, ticket windows, stair width, number of escalators, platform width etc in normal and emergency conditions are based on peak hour passenger traffic. These calculations not only accommodate the normal and delayed operation but also satisfy NFPA 130.

0.5.2 Typical Station Design

Bandra Metro (BKC/ ITO)

The Bandrta Metro station at Bandra Kurla Complex is proposed as a Mid Terminal Station. The BKC station is a major interchange station between the Metro Line II (CBM corridor) and the proposed Colaba – Bandra - SEEPZ corridor. To enable seamless transfer of passengers between one line and another, it is proposed to connect the paid area of the proposed mid terminal station with the paid area of the ITO station of the Charkhop - Bandra - Mankhurd Metro corridor.

The proposed station has a triple platform configuration with ticketing counters at the concourse level on both sides of the station. Auxiliary substations for Power Supply and Traction facilities is placed at the platform level, where as the requirement of System Rooms, Staff facilities, Tunnel Ventilation System and Operations is contained at the Concourse Level. DG set, Fuel Tank, Water Tank and Chiller Plant are placed at the Ground Level.

Island platform is 180 m long and 11.6 m wide, whilst side platform is 180m long and 6.6 m wide. Vertical circulation, in the form of four sets of, adequately sized, stairs and escalators have been provided in the centre of the island platform, and side platform to cater to normal and emergency passenger movement for the projected year 2031.

The Metro Station is also accessible for the disabled with the provision of one lift to connect the ground level to the concourse level (unpaid public area) and another lift to connect the concourse level (paid public area) to the platform level. Separate firemen access stairs and passenger escape stairs have also been provided at each end of the station.

Retail space of about 240 sq mt is proposed at the Concourse level for small kiosks, automatic vending machines, retail shops etc. **Figure 0.4** shows the Concourse Level and Platform Level Plans of the Bandra (BKC) Metro Station.

0.5.3 Inter-modal Integration And Dispersal Facilities

With the increase in passenger traffic dispersing via the road network for the feeder trips, it is vital that adequate traffic dispersal facilities be planned for horizon year traffic and capacity of roads, footpaths/pedestrian facilities, bus stops, IPT stands, Pick / Drop areas to cater to the projected requirements for the proposed metro stations, considering the following objectives:

- To facilitate efficient transfer and dispersal of passengers from/ to the proposed system
- To provide for effective inter-modal interchange of the passengers with the feeder modes including walk, IPT and buses.
- To integrate the proposed system's entry/ exits with those of existing system and upcoming transport infrastructure

This issue become more important for stations involving major interchanges with other existing/proposed/upcoming mass transit modes. The approach followed to achieve these objectives involves the analysis of the present issues, concerns and the potentials in order to facilitate the future traffic demand levels. The same for the typical Bandra Metro station and proposals for achieving the desired efficiency of inter-modal integration and passenger dispersal in view of the overall traffic volume in horizon year is discussed in the **Tables 0.9** and **0.10**.

Table 0.9: Issues, Concerns and Potentials of the Bandra Metro Station Area

Issues	Concerns	Potentials
• Interchange with Charkop-Bandra –Mankhurd Metro Line needs to be suitably addressed	• The immediate surroundings have marshy land wherein the facilities like parking cannot be planned because of Environment concerns and clearances	• Large employment base in the catchment area • Wide footpaths which can accommodate the passenger dispersal • Will cater to the ridership from the proposed Metro Line II i.e. Charkop – Bandra – Mankhurd • Future possibilities of high density as large chunk of land is still vacant which will add to the metro ridership

Table 0.10: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Bandra Metro Station

	Existing Carriagewaywidth	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Bandra Kurla Complex Road	30.5	15250	8960 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	15250	13310 PCU
Bharat Nagar Road	23.5	11750	5235 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	11750	7710 PCU
Pedestrian Facilities							
Bandra Kurla Complex Road	6	6000	1210 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Widening of footpath in front of station Entry/Exits.	6000	7700 Persons
Bharat Nagar Road	6	6000	1010 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Station Entry/ Exits provided across all directions for facilitating convenient access • Strengthening of footpath area, removal of parking • Widening of footpath in front of station Entry/Exits.	6000	7420 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	Minimum 1 Bus bay to handle a total of at least 2 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	• 1 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	Minimum 1 Taxi bay to handle a total of at least 3 Taxi / minute in peak hour per direction	2 Taxi / minute
						Parking	
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Planned off-street parking facilities with defined parking bays (about 50) is suggested near the station		

The street level inter-modal integration plan indicating the traffic circulation and proposed road infrastructure / argumentation in the station precinct area is also presented at **Figure 0.5**.

Figure 0.4: Concourse & Platform Level Plans – Bandra Metro (BKC)

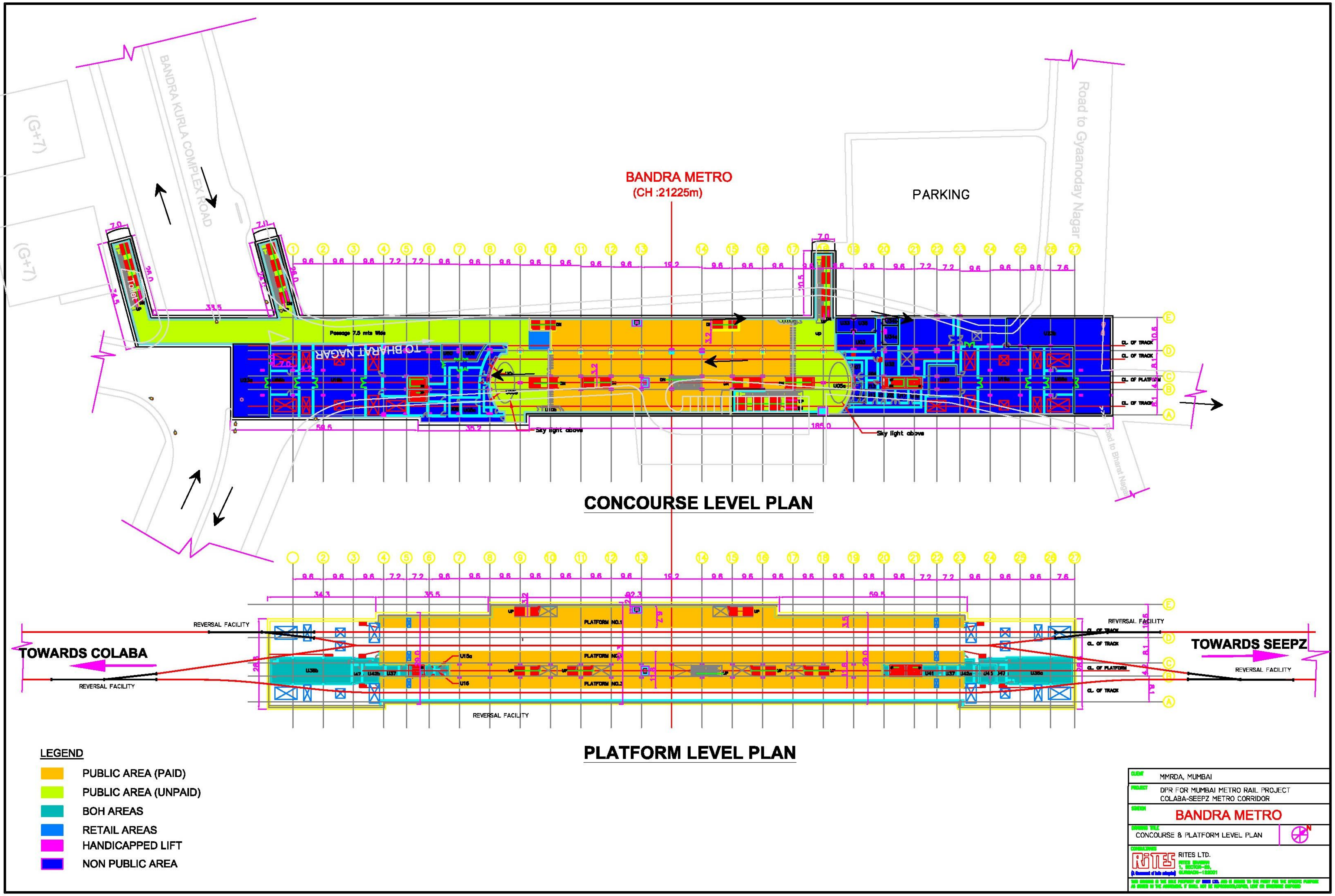
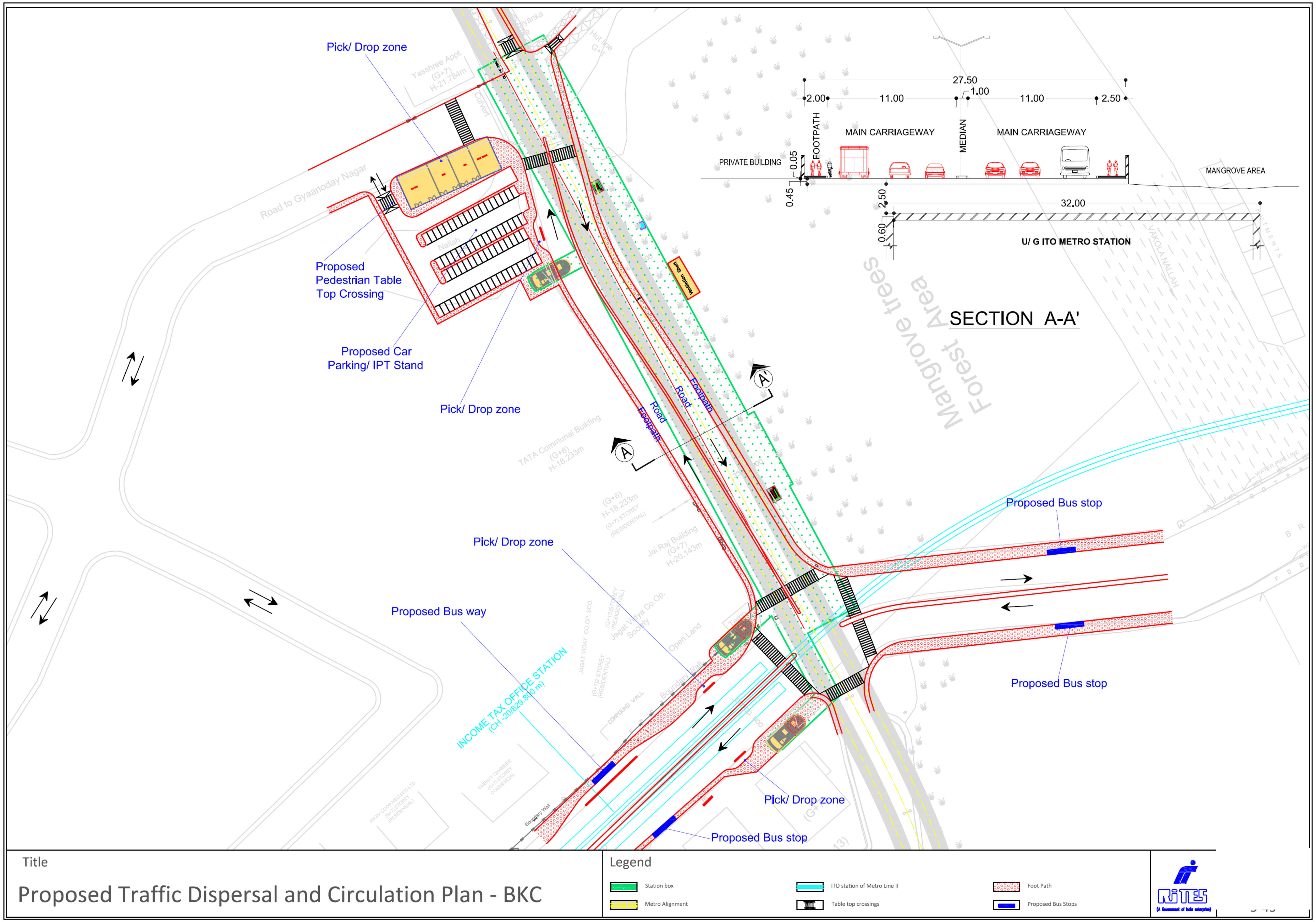


Figure 0.5 : Proposed Traffic Dispersal and Circulation Plan – Bandra Metro (BKC)



0.6 TRAIN OPERATION PLAN

- The salient features of the proposed train operation plan are:

  a) Train operation considers mid-terminal at Bandra.

  b) Running of normal services for 19 hours of the day (5 AM to 12 PM, i.e. midnight) with average station dwell time of 30 seconds,

  c) Airport traffic will be served with a frequency of 20-30 minutes during midnight to 2 AM.

  d) Make up time of 5-10% (on the tangent track) with 8-12% coasting.

  e) Scheduled average speed for Corridor shall be 30 kmph.

Train operation plan with train carrying **capacity @ 6 persons per square meter of standee area** is considered (**Table 0.11**).

Table 0.11: Transport Capacity Provided on the Corridor

Year	Colaba – Bandra			Bandra – SEEPZ		
Section	2016	2025	2031	2016	2025	2031
Cars per train/ Trains Per Hour	6/ 14	6/ 20	6/ 24	6/ 9	6/ 10	6/ 12
Avg. Head way (seconds)	260	180	150	400	360	300
Avg. PHPDT Demand	25000	36000	40000	16000	18000	20000
PHPDT Capacity Available	25088	35840	43008	16128	17920	21504

Selection of Train Length

The peak hour peak direction trips (PHPDT) for Colaba-Bandra section are estimated to be 42000 during the horizon year 2031.

The proposed train operation with 6 car and 150 seconds headway will provide Peak Hour Peak Direction Capacity of **54720** with standee density @ 8 persons /m^2. The capacity provided is more than the peak hour peak direction trips for both the sections and will therefore, ensure comfortable journey for the commuters. With eight car trains the capacity will be in excess of **72000 and can be increased further by improving headway**.

All the systems and infrastructure on the corridor have been provided for 8 car trains having passenger carrying capacity of 3000 (Sitting-386, Standing – 2614 @ 8 persons /m^2). The proposed infrastructure for 8 car rake having capacity of 72000 plus is, therefore, considered adequate. Provision of infrastructure for 9 car rake length will require additional expenditure on longer platforms at each station, in maintenance depot and stabling sidings. Moreover, for the given traffic volume energy requirement for traction will also increase. In view of these techno-economic considerations and requirement to cater to the projected traffic volume, the system design with 8 car trains has advantage over design based on 9 car trains.

- Based on Train formation and headway to meet Peak Hour Peak Direction Traffic Demand in different years, rake requirement has been calculated separately for Colaba – Bandra and Bandra - SEEPZ sections (**Table 0.12**).

Table 0.12: Year Wise Car and Rake Requirement

Time horizon	Section Length		Bare Rake Requirement		Total Bare Rake Reqd.	Maint. Spare	Traffic spare	Total rake Reqd.	Total coach Reqd.
	Colaba-Bandra	Bandra-SEEPZ	Colaba-Bandra	Bandra-SEEPZ					
2016	21.75	11.76	22	8	30	3	2	35	**210**
2025	21.75	11.76	31	9	40	4	3	47	**282**
2031	21.75	11.76	35	11	46	5	4	55	**330**

0.7 MAINTENANCE FACILITIES

The Colaba – Bandra - SEEPZ Corridor would require a dedicated Depot cum workshop facility for the maintenance of the rakes in the inception year 2016. A minor depot for stabling and inspection of about 20 rakes would be required to cater to the maintenance requirement of increased rolling stock holding during the year 2025. Apart from necessary facilities viz. stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning, etc. for the rolling stock operational on the corridor, Depot cum Workshop will also house Operation Control Centre (OCC), Administrative Building, maintenance facilities for Civil – track, buildings, water supply; Electrical – traction, E&M; Signaling & Telecom.; Automatic Fare Collection, etc.

For starting the morning services, some rakes will have to be kept at terminal stations and stabling facilities for the remaining rakes will have to be provided at the depot.

0.8 POWER SUPPLY

The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following assumptions:-

a) Specific energy consumption of rolling stock – 70 KWh/1000 GTKM

b) Train operation :

Normal - 6 car at 260 to 150 seconds headway on Colaba-Bandra & 400 to 300 seconds headway on Bandra – SEEPZ section

Designed - 8 car at 2.5 minutes headway on Colaba-Bandra & 5.0 minutes headway on Bandra – SEEPZ section

c) Underground station load – initially 2000kW, which will increase to 2500kW in the year 2031 (Designed load – 3000kW)

d) Depot auxiliary load - initially 2000kW, which will increase to 2500 KW in the year 2031 (Designed load – 3000kW)

e) Power factor of load – 0.9 & Transmission losses @5%

Keeping in view the above norms, designed load and power requirement projected for the year 2016, 2021 and 2031 are summarized in **Table 0.13.**

Table 0.13: Power Demand Estimation (MVA) for Colaba – Bandra – SEEPZ

Year	2016	2025	2031	Designed Load
Traction	24.13	32.49	37.71	55.88
Auxiliary	49.00	65.33	81.67	98.00
Total	**73.13**	**97.82**	**119.38**	**153.88**
Total Traction	**24.13**	**32.49**	**37.71**	**55.88**
Total Auxiliary	**65.33**	**73.50**	**81.67**	**98.00**
G.TOTAL(A+B+C)	**89.46**	**105.99**	**119.38**	**153.88**

Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in detail. The City has 220kV, 100kV, 33/22kV and 11kV network to cater to various types of demand in vicinity of the proposed corridor. Discussions were held with M/s Tata Power Company Ltd. (Licensee of the area) to finalize the Input Power Supply sources and Supply Voltage.

M/s Tata Power Company Ltd. indicated during discussions that their 33kV and 100kV network is highly reliable and stable to meet 33kV and 25kV power requirements of the proposed corridor. Keeping in view the reliability requirements and considering the complete corridor of 33.508 km length with all underground stations, three Receiving Sub-stations are proposed to avail power supply for traction as well as auxiliary services.

Table 0.14: Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of 100 kV cables
Colaba – Bandra – SEEPZ	Receiving Sub Station of Tata Power (100 kV)	Colaba (100/ 33/ 25 kV)	2 km. 100kV (Double Circuit cables).
	Mahalakshmi Receiving Sub Station of Tata Power (100 kV)	Race Course (100/ 33/25 kV)	1 km. 100kV (Double Circuit cables).
	Dharavi Receiving Sub Station of Tata Power (100 kV)	Dharavi (100/ 33/ 25 kV)	1 km. 100kV (Double Circuit cables).

0.9 ENVIRONMENT IMPACT ASSESSMENT

0.9.1 Water Environment (Water Quality)

To ascertain the water quality, representative water samples from six locations were collected for the analysis of physical and chemical parameters.

Surface water collected from Mithi River has high dissolved solids, high hardness, high chloride content, etc. - hence requires treatment for any use. Out of four ground water samples, three are almost within permissible limit which may be used after filtration followed by disinfection.

0.9.2 Air Environment

In order to establish the base line data, Ambient Air Quality Monitoring (AAQM) has been carried out by setting up ambient air quality monitoring stations through High Volume Sampler (HVS) at five locations, i.e. Churchgate, Grant Road, Mahim (Nr. Bus Depot), Mumbai University, Sahar Road (Nr.IOC) and SEEPZ for the parameters like RSPM, SPM, SO_2, NOx, CO and HC. The results so obtained are reported in **Table 0.15**. The SPM and RSPM level has been observed on higher side as compared with National Ambient Air Quality (NAAQ) standards while parameters like SO_2, NOx and CO are within the permissible limits.

Table 0.15: Air Quality at Project Site

S.No.	Location	RSPM $\mu g/m^3$	SPM $\mu g/m^3$	SO_2 $\mu g/m^3$	NOx $\mu g/m^3$	CO mg/m^3
1	Churchgate	196	351	33	50	2.19
	Permissible limit	60	100	80	80	4.00
2	Grant Road	161	235	29	38.5	2.65
	Permissible limit	60	100	80	80	4.00
3	Mahim	120	321	10.3	29.0	1.05
	Permissible limit	60	100	80	80	4.00
4	Mumbai University[2]	86	236	7.0	18	1.00
	Permissible limit	60	100	80	80	4.00
5	Sahar Road(Nr.IOC)[3]	130	338	15	41.3	1.20
	Permissible limit	60	100	80	80	4.00
6	SEEPZ	140	363	16	55	1.27
	Permissible limit	60	100	80	80	4.00

0.9.3 Noise Level Quality

Noise levels were measured at six locations, i.e. World Trade Centre, Churchgate, Mahim, Mumbai University, Sahar Road (Nr. IOC) and SEEPZ along the project alignment. It is observed that the noise level at World Trade Centre, Churchgate, Mahim and Mumbai University are beyond permissible limits while noise level at Sahar Road and SEEPZ are within permissible limits. Predominant source of noise is the vehicular movement.

0.9.4 Social and Economic Assessment

A sample Socio-Economic Survey (SES) was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed corridor on these conditions. On the basis of alignment drawings and field visits it was noted that approximately 1520 families would be affected as the dwellings of these families are touching the proposed metro corridor.

During the social survey, it was observed that approximately 57% families are squatters, which need relocation/compensation. The social survey in these affected areas was conducted by using random sampling method. More than 10 % (152 families) of total affected families from major locations along the alignment which represent the whole stretch of proposed corridor were randomly selected for analysing their socio-economic conditions. The primary data for the study was collected through interviews with the project-affected people by using structured household questionnaire.

0.9.5 Checklist of Impacts

A typical checklist identifying anticipated environmental impacts is presented in **Table 0.16.**

Table 0.16: Evaluation of Environmental Impacts

Proposed activity	Potential impact	Nature of potential impact	Rating of impact		
		Beneficial or adverse	Direct or indirect	Significance of impact	Magnitude of impact
Construction of Metro Rail Corridor	Demand/ Supply Infrastructure Employment	Beneficial Beneficial Beneficial	Direct Indirect Direct	Medium Medium Medium	Medium Medium Low
Raw Materials Consumption	Stone	Adverse	Indirect	Medium	Low
Water consumption	Surface Water Ground Water	Adverse Adverse	Direct Direct	Medium Low	Low Low
Transportation of materials	Ambient noise Public health and safety	Adverse Adverse	Direct Indirect	Low High	Low Low
Atmospheric emission	Ambient air quality, Ambient odor	Adverse Adverse	Direct Direct	Medium Medium	Low Low
Waste water discharge	Land/Water	Adverse	Direct	Low	Insignificant
Solid Waste disposal	Ground water Soil quality	Adverse Adverse	Indirect Indirect	Medium Low	Insignificant Insignificant
Noise generation	Ambient noise	Adverse	Direct	Low	Inignificant
Vibration	Public health	Adverse	Direct	Medium	Insignificant
Construction spoils disposal	Land Water	Adverse Adverse	Direct Direct	Low Medium	Low Low

Note: (Impact) High – Irreversible; Medium – Mitigated through measures; Low – Mitigation required

0.10 COST ESTIMATES

0.10.1 Capital Cost Estimates

The cost estimate has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, traffic integration facilities, security at stations, environmental protection, rehabilitation, etc. at September, 2011 price level.

The rates are taken as per DPRs of DMRC Phase – III Corridors, which was at Jan ’2011 price level. These rates have been enhanced by 10% to arrive at Sept’2011 price level and also due to difficult working conditions and different subsoil conditions of Mumbai.

The element of central and state taxes and duties (including customs duty, excise duty,VAT), octroi and insurance has been excluded for working out the base project cost. However, these details are tabulated separately for use in financial appraisal of project. The rates of the taxes, duties, octroi and insurance have been adopted as per the Mahim – Kanjur Marg Metro DPR.

Base capital cost of project at September, 2011 price level, works out to be **Rs. 150551 Million** excluding land cost and **Rs. 166416 Million** including land cost. Central and state taxes and duties (customs, Excise and VAT) have been worked out to **Rs. 25467 Million**. The component towards octroi and insurance has been worked out as **Rs. 2951.50 Million.** The abstract capital cost estimate is presented in **Table 0.17.**

Table 0.17: Abstract of Cost Estimate

Sr. No	Item	Amount (Rs Cr)
1	Underground alignment and formation (tunnel by TBM)	4,241
2	Station Building (11 NATM and 16 cut and cover)	5,947
3	Aarey Milk Colony Depot	244
4	P-Way (Track work)	244
5	Traction & power supply incl. OHE, ASS etc.	564
6	Signalling and Telecommunication	615
7	R & R incl. hutments etc.	91
8	Misc. Utilities, road works, other civil works such as signages environmental protection and traffic management	217
9	Rolling Stock	1,764
10	***Total of all items except Land***	***13,927***
11	General Charges incl. design charges @ 5% on all items except land	692
12	***Total of all items including General Charges***	***14,619***
13	Contingencies at 3 % on all items except land	436
14	**Total excluding land**	**15,055**
15	Land (Private)	485
16	Land (Government)	1,056
17	Contingencies at 3 % on land	46
18	***Total land cost***	***1,586***
19	**Total including pvt & govt. land and excluding taxes**	**16,641**
19	Central taxes	2,043
20	State taxes	504
21	Octoroi & insurance	295
22	***Total taxes***	***2,842***
	Total including taxes and excluding land	**17,897**
	Total including taxes and private land	**18,396**
	Total including pvt & govt land and taxes	**19,483**

0.10.2 O&M Estimate

The total Operation and Maintenance cost in the years 2016-17, 2025-26 and 2031-32 is estimated at about Rs. 4407 Million, Rs. 8152 Million and Rs. 12407 Million respectively (**Table 0.18**).

Table 0.18: Operation and Maintenance Costs

(Rs. in Million)

Year	Staff Cost (A)	Maintenance Expenses (B)	Energy Charges (C.)	Total (A+B+C+D)	Total O&M Cost
2016-2017	1,505.75	1,333.45	1567.80	4,407.00	4,407
2025-2026	3,270.34	2,316.42	2565.50	8,152.25	8,152
2031-2032	5,484.68	3,271.87	3650.70	12,407.25	12,407

0.11 ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the "with" and "without" project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices. This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems.

The annual streams of project costs and benefit have been compared over the analysis period of 44 years to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR. The Economic Internal Rate of Return (EIRR) for the project has then been arrived using Discounted Cash Flow technique to the net benefit stream at economic prices.

The EIRR works out to **17.93 %**.

A sensitivity analysis of the EIRR with 10% cost overrun and 10% reduction in traffic materialization (separately) has been carried out. The EIRRs under these scenarios are given in **Table 0.19.**

Table 0.19: EIRRs - Sensitivity Analysis

Sensitivity Parameter	EIRR (%)
Basic EIRR	17.93
With increase in cost by 10%	17.06
With reduction in traffic materialization by 10%	17.59
With 10% reduction in traffic and increase in cost by 10%	16.73
With increase in cost by 20%	16.07

It can be seen that 10% increase in cost affects economic viability more than it does in case of reduction in traffic for the project. Accordingly, it is recommended that controls should be exercised to keep the construction cost under check.

0.12 FINANCIAL ANALYSIS

0.12.1 The basic Project cost of the metro corridor at September 2011 prices is estimated at Rs 150551 Million. The cost of land is estimated at Rs.15,865 Million. Of the total land cost, Rs 4,985 Million is cost of private land and the cost of government land has been estimated at Rs 10,880 Million. The total cost of project including land, is estimated at Rs 166,416 Million.

The Central and State taxes and duties (Customs, Excise and VAT) amount to Rs 25,467Million. Of the total taxes and duties, Rs 20,432 Million are central taxes (Customs and Excise duty) and Rs 5,035 Million are state taxes (Value Added Tax). The component towards Octroi and insurance works out to be Rs. 2121 Million and Rs. 831 Million respectively.

For the purpose of financial analysis, only cost of private land being a cash payout has been added to the project. The government land is expected to be available on transfer basis. Further, JICA is expected to part fund the project through soft loan. The completion cost including IDC works out to Rs 217,523 Million

The revenue streams have been worked out based on MMRDA fare as well as DMRC fares (**Table 0.20**).The fare sensitivity of DMRC fares on the expected Metro ridership has not been considered in this comparison.

Table 0.20: Total Revenue Collection (Rs in Millions)

Source of Revenue	2017-2018		2030-2031		2035-2035	
	MMRDA	**DMRC**	**MMRDA**	**DMRC**	**MMRDA**	**DMRC**
Fare Box Revenue	6001	7029	15964	18512	20975	25347
Revenue from other Sources	600	703	1596	1851	2097	2535
Total Revenue	**6601**	**7732**	**17560**	**20364**	**23072**	**27881**

The FIRR calculations with the projected ridership, fare box revenue and based on both MMRDA &DMRC fare structure under various scenarios is given in **Table 0.21**.

Table 0.21- Project FIRR under different scenarios

SCENARIO		SCENARIO	
REVENUE BASED ON MMRDA FARES	**FIRR**	**REVENUE BASED ON DMRC FARES**	**FIRR**
Cost Without Any Taxes	2.17%	Cost Without Any Taxes	4.33%
Cost With Central Taxes	1.7%	Cost With Central Taxes	3.8%
Cost With Central & State Taxes	1.6%	Cost With Central & State Taxes	3.7%

It is concluded that the project will be able to comfortably bear the O&M cost and thus, has operational sustainability.

Scenario with VGF

To calculate the Viability Gap Funding (VGF) required to get the project FIRR of 12 % has been calculated with following assumptions:

1. The cost of the project at 2011 prices inclusive of all taxes is Rs 1,49,701 Million.
2. Govt land will be given free of cost for the project.
3. Stake holder contribution of Rs 12,500 million will be available.
4. The Debt Equity Ratio of 3:2 has been assumed for calculation of IDC
5. The rate of interest for market loan is taken as 10%.

VGF required With MMRDA fare structure will be about 89 % while with DMRC fares, the VGF requirement will be about 82 %. As the VGF requirement for the project is very high, the PPP implementation mode is not considered.

0.12.2 Involvement of Government

Government contribution is essential to keep debt-servicing levels low with a view to maintain overall long term sustainability of the system. Government involvement also generates considerable amount of confidence in other players involved in the process of construction & operation. The capital investment of Line-III of Mumbai metro project is estimated to give an economic rate of return to the tune of 17% and the city/society can recover the investment within 6 to 7 years time. Thus, the involvement of Government is essential to provide integrated, efficient public transport system in the City.

0.12.3 Funding For the Project

Following assumptions are made for the finalizing the funding pattern for the project:

i. **Cost of Land:** Govt land required for the project shall be given as grant by the State Government. Cost of private land has been added to the project and included as government equity but efforts shall be made to meet this cost through TDR and higher FARs.

ii. **Exchange Rate Fluctuation Risk-** As adopted for Phase-I and Phase-II of Delhi Metro and recently approved Phase III of Delhi Metro, it is assumed that exchange rate fluctuation risk on the repayment of JICA loan shall be borne in equal proportion by the equity holders, viz, GOI & GOM.

iii. **Payment of Dividend-** As adopted for Phase-I & Phase-II of Delhi Metro, this metro corridor of Mumbai MRTS shall be exempted from the payment of dividend on equity till the senior debt has been fully repaid.

The total completion cost of the project including IDC and excluding govt land works out to Rs 217,523 Million. The funding for the same shall be as under:

a. Government Contribution – GOI & GOM will contribute a total equity of Rs 64,343 Million which is 30% of the total completion cost. This means that both GOI and GOM will share 15% of the total cost amounting to Rs 32,172 Million.

b. JICA Loan – JICA funding of 60 % of total completion cost excluding taxes, duties and land cost, works out to 48% of the total completion cost including land and taxes and amounts to Rs 104,647 million as loan.

c. Subordinate Debt: To pay back state and central taxes and duties amounting to Rs 33,109 Million which is 15% of the total completion cost of the project, interest free Subordinate Debt from GOI and GOM is considered. It includes Rs 2471 Million Octroi which can be waived off by the City agencies as the project is for the benefit of the City. The payment of this loan will be after the payment of JICA loan.

d. Stake holder Contribution: The cost of stations falling in the areas belonging to MIAL (Mumbai International Airport Authority & ASIDE (Assistance to States for Infrastructure Development for Export Promotion) will be borne by them. Total 5 stations fall in their area and cost of the stations amounting to Rs 14,563 Million (7% of the total project cost) is proposed to be contributed by these agencies as stake holder contribution.

Table 0.22 Financing of Project Completion Costs Including IDC

Year	JICA debt	Sub debt	Equity	Stake holder	Total
2012-13	-	248	483	109	840
2013-14	656	1,407	2,735	619	5,417
2014-15	1,360	3,311	6,434	1,456	12,561
2015-16	2,910	7,284	14,155	3,204	27,553
2016-17	3,166	7,946	15,442	3,495	30,050
2017-18	2,973	7,615	14,799	3,349	28,736
2018-19	1,406	3,642	7,078	1,602	13,727
2019-20	358	993	1,930	437	3,718
2020-21	25	662	1,287	291	2,265
TOTAL	**104,647**	**33,109**	**64,343**	**14,563**	**217,523**
% Share	**48%**	**15%**	**30%**	**7%**	**100%**

With above funding pattern, the project generates positive cash flows during the analysis period of 44 years. But once the payment of loan starts the project has negative cash flows for 11 years and the project is not able to meets its loan obligations. However, after these 11 years, the project has positive cash flows except two years when replacement of the equipments is required. During the negative cash flow period, the loan liability of the project can be met by soft loans from MMRDA/MMRC which will be adjusted from future surplus revenues. Thus, the project has potential to service its debt.

All over the world all metro systems do require support from government in initial years till the system gets established and its revenue generation potential is truly exploited. Mumbai Metro Line III may also be implemented on the basis of these international practices.

0.13 IMPLEMENTATION PLAN

Effective institutional arrangements need to be made in order to enable the Colaba - Bandra - SEEPZ Metro Corridor project to be implemented without any loss of time and cost over-run.

An SPV named MMRC (Mumbai Metro Rail Corporation Ltd.) was incorporated on 30.4.2008 with the mandate “To establish, Operate and Maintain Guided Urban Transit Systems in and around Mumbai City so as to meet the urban transport needs of Mumbai”.

It is suggested to have a two tier organization with well defined responsibilities for getting this project executed. At the apex will be the restructured **MMRC** (with representation of Govt. Of India) - a lean but effective organization with full mandate and total power – with accountability The second level will be a project management team called “General Consultants” who will be engaged by the **MMRC** on contract basis and who will be fully responsible for planning, design and project management. In fact they will be the “Engineers” for the **MMRC**, who is the “client”.

For expeditious resolution of various problems arising during the implementation of the project, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Maharashtra should be set up. Other members of this Committee may be the Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project.

This Committee should meet once a month and sort out all problems brought before it by **MMRC**. For Delhi Metro also such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro rail project.

At the Central Government level an Empowered Committee, under the chairmanship of Cabinet Secretary, is presently functioning for Delhi Metro project. Other members of this Committee are Secretaries of Planning Commission, Ministry of Home Affairs, Ministry of Urban Development, Ministry of Surface Transport, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi Government and a representative from the PMO. It is suggested that the role of this Empowered Committee should be extended to include Mumbai Metro project also and the Chief Secretary, Maharashtra is inducted as a member.

Union Cabinet had set up a Group of Ministers (GOM) to take decisions on behalf of the Cabinet on policy matters concerning Delhi Metro project. The Group of Ministers is chaired by the Home Minister. Other members of the GOM are Minister of Urban Development and Poverty Alleviation, Minister of Railways, Minister of Finance and Company Affairs and Deputy Chairman Planning Commission. The GOM meets whenever any problem requiring decision on behalf of the Union Cabinet is to be taken. It is suggested that the role of this GOM is enlarged to include Mumbai Metro. The Chief Minister, Maharashtra should be inducted as a member and attend the meetings whenever any issue concerning Mumbai Metro is to be deliberated upon.

It is recommended that the construction of Colaba – Bandra – SEEPZ metro line is taken under the Metro Railways Act 1978. As and when the comprehensive Metro Act is processed and enacted, it will give the required legal cover for the Operations and Maintenance of Colaba – Bandra – SEEPZ metro line.

Experience of Delhi Metro project has shown that the taxes and duties (including custom duty, Excise Duty, Sales Tax, Taxes on electricity, Municipal Taxes) constitute about 15 – 16% of a metro project cost. **MMRDA/ MMRC** may try to get exemption from these for the implementation of this important infrastructure project.

Further, the transfer of Govt. land required for the project could be considered free of cost or at the most at Govt. rates. The cost of private land could also be recovered through TDRs and higher FARs.

MMRDA/MMRC may consider roping in more stakeholders, who would directly/ indirectly benefit from the system, for sharing the cost of metro construction.

Additional Development Cess due to improved accessibility/ higher property rates (as a result of metro availability) may also be considered in the immediate influence area of metro corridor. MMRDA may also consider issue of Metro Bonds, exploring commercial development on Depot land and implementing TOD concept along the Corridor.

1. INTRODUCTION

1.1 BACKGROUND

Mumbai, the financial capital of India, has witnessed phenomenal growth in population and employment. The trend is expected to continue in the future. The job opportunities it offers have served as a major attraction for immigration from hinterland of Maharashtra as well as from all parts of the Country. Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. It comprises of 7 municipal corporations, 13 municipal councils and 996 villages and extends over an area of 4,355 sq.km. MMR is projected to have population and employment (both in terms of formal and informal) as 34.0 million and 15.3 million respectively in the year 2031.

The dominant feature of the passenger movements in Mumbai is overwhelming dependence of travel on transport modes and walk. In MMR, public transport systems are overcrowded and the road network is congested as there is a large gap between the demand and supply.

Four-fold growth of population since 1951 has been largely accommodated in the suburbs while the highest concentration of jobs has remained in the Island City. The physical characteristics of the City are such that the suburbs have been constrained to spread northwards only, and all transport facilities are concentrated within three narrow corridors. Today's major challenge is to provide connectivity and promote growth by providing adequate inputs to the infrastructure which would improve the quality of life of the residents.

1.1.1 Population

The total population of Greater Mumbai in 2001 was 119.14 lakh (double of the 1971 population of 59.7 lakh). The decadal growth in population during 1971-81 was around 38 percent and has remained around 20 percent during 1981-91 and 1991-2001 respectively. (**Table 1.1**)

Table 1.1: Trend of Population in Greater Mumbai (in Million)

Year	Island City		Western Suburbs		Eastern Suburbs		Total Greater Mumbai	
	Pop.	Decadal growth	Pop.	Decadal growth	Pop.	Decadal growth	Pop.	Decadal growth
1971	3.07 (51.42%)		1.71 (28.64%)		1.19 (19.93%)		5.97 (100%)	
1981	3.28 (39.81%)	6.84	2.86 (34.71%)	67.25	2.10 (25.49%)	76.473	8.24 (100%)	38.02
1991	3.17 (31.92%)	-3.35	3.95 (39.78%)	38.11	2.80 (28.20%)	33.33	9.93 (100%)	20.51
2001	3.35 (28.13%)	5.68	5.10 (42.82%)	29.11	3.46 (29.05%)	23.57	11.91 (100%)	19.94

Source: Master Plan of Mumbai Metro, December 2007

The population growth in the island area over the 30 year period between 1971 – 2001 is only 9 percent. However, the growth in suburbs (western and eastern) has been phenomenal. The suburban population has grown to almost 300 percent over the same period.

As evident, the share of island population has been declining continuously. The proportion of island area population in total Greater Mumbai has declined to 28 percent in 2001 from 51 percent in 1971. The share of suburbs has gone up to almost 72 percent of the total population of Greater Mumbai. Also, in 2001, the proportion of population in Western suburbs is almost 43 percent of the total population of Mumbai while that in eastern suburbs is only 29 percent.

1.1.2 Employment

The employment growth during 1971-1998 in different areas of Greater Mumbai is shown in **Table 1.2**. The share of employment in Island City has fallen to 56 percent in 1991 from 72 percent in 1971. However, it has increased to 61 percent in 1998. The share of employment in western suburbs was around 25 percent of total employment in Greater Mumbai in 1998 and that of eastern suburbs was about 15 percent.

Table 1.2: Employment in different areas of Greater Mumbai

Year	Island City	Western Suburbs	Eastern Suburbs	Greater Mumbai
1971	1.09 (71.90%)	0.24 (15.38%)	0.19 (12.71%)	1.53 (100%)
1981	1.39 (63.62%)	0.51 (23.03%)	0.29 (13.35%)	2.19 (100%)
1991	1.34 (55.62%)	0.64 (26.30%)	0.44 (18.08%)	2.42 (100%)
1998	1.59 (60.51%)	0.65 (24.91%)	0.38 (14.58%)	2.62 (100%)

Source: Master Plan of Mumbai Metro, December 2007

1.1.3 Transport Scenario

Comprehensive Transportation Study (CTS) for Mumbai Metropolitan Region estimated total daily demand of 34.3 million trips per day by all modes - of which 60% are by walk. Among the total trips by mechanized modes, 73% trips are by public transport and 9% by para-transit modes. The Study also indicates the low annual growth rates of public transport trips. During the decade 1991-2001, the average annual growth rate of trips by rail was 1.8 % whereas for buses, the scenario was negative (**Table 1.3**).

Table 1.3: Public Transport Ridership (Trips in Lakh)

Mode	Trips Per Day			% Growth Per Year	
	1981	1991	2001	1981-91	1991-01
Rail	**39.76**	**47.73**	**57.24**	**1.8**	**1.8**
Bus	**48.51**	**60.22**	**56.04**	**2.2**	**-0.7**
Total Pub. Transport	88.27	107.95	113.28	2.0	0.5

Source: CTS for MMR, by LASA

Mumbai aspires to be one of the globally competitive cities in the world but falls short on several grounds, with transportation inadequacies being a notable drawback. Due to the City's geographical constraint, the road and rail infrastructure development could not keep the pace with the growing demand for last 4 -5 decades. In order to improve the overall traffic and transportation scenario in Mumbai/MMR and to cater to the future travel needs, the Government of Maharashtra (GOM) through MMRDA has undertaken several studies and identified metro mode as efficient, economically viable and environment friendly mass transport system.

1.2 MUMBAI METRO MASTER PLAN

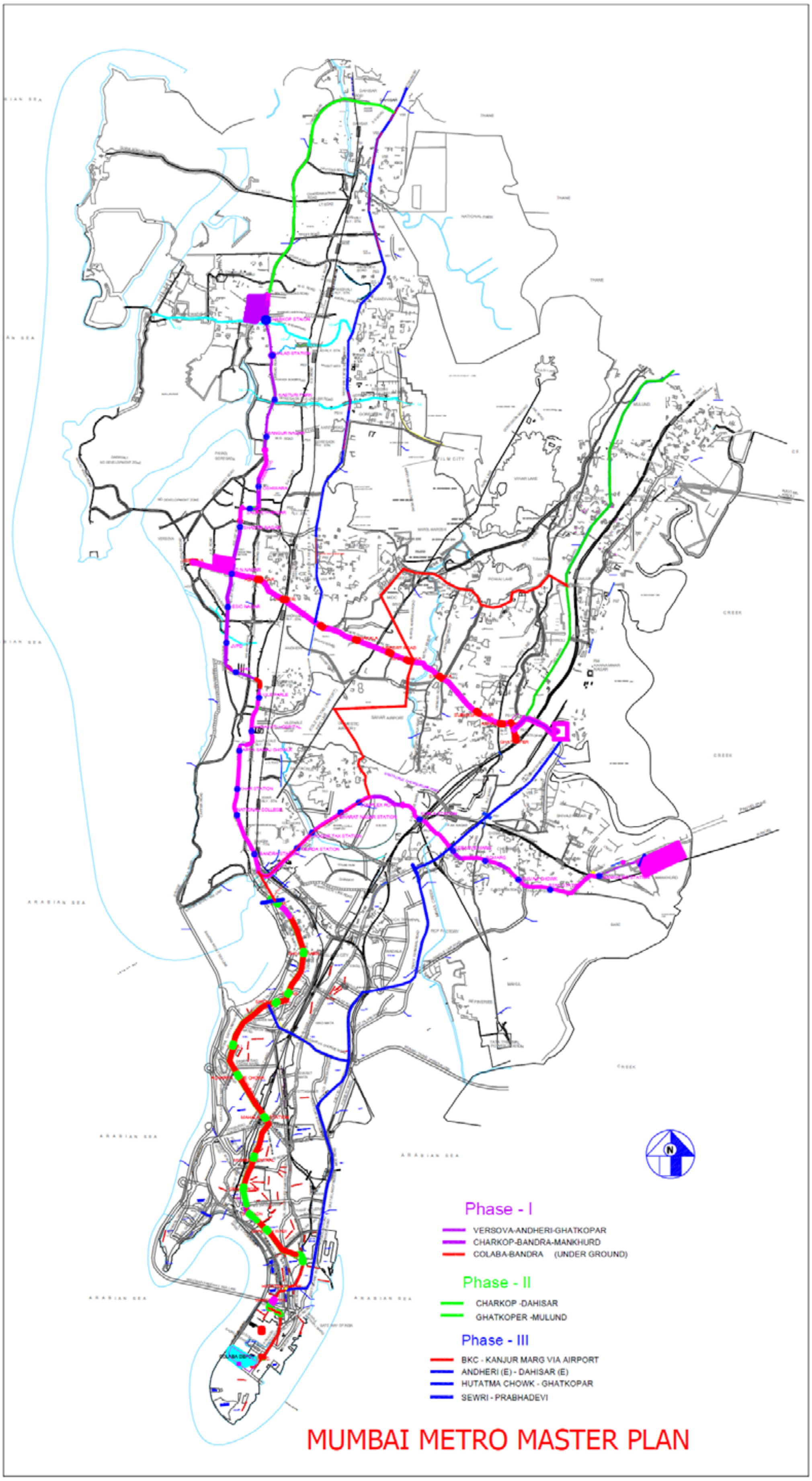
To decongest the existing public transport systems and increase mobility across the Region, DMRC in 2004 prepared a Metro Master Plan for Mumbai (**Table 1.4**, **Figure 1.1**). A total of 146.5 km of network had been planned for MMR, to be implemented in three phases, Phase 1: 2005-2011, Phase II: 2011- 2016 and Phase III: 2016-2021.

DPR studies for all the three Phase I metro corridors has been carried out during the period 2005-2009 (Line 1: Versova-Andheri-Ghatkopar, Line 2: Mankhurd-Bandra-Charkop and Line III: Colaba-Bandra). In 2010, MMRDA also carried out the DPRs of four lines of Phase II & III. Among these, RITES carried out the DPR for BKC - Kanjur Marg (via Air port) with extension from BKC to Mahim (Total Length - 23.5 km).

Table 1.4: Phasing of Mumbai Metro Master Plan

Sr. No.	Corridor	Length of the Corridor (km)	Capital Cost @ 2003 prices (Rs. In Crores)	Peak Hour Peak Direction Flow (PHPDT)	Phasing	Phase wise length (km)	Proposed Period of Implementation
1	Versova – Andheri – Ghatkopar	15.0	1500	31421	I	63.8	2005-2011
2	Colaba (Backbay) – Mahim – Charkop	36.0	5085	43356			
3	Mahim – Mankhurd	12.8	1595	28022			
4	Charkop – Dahisar (East)	7.5	750	19094	II	19.9	2011-2016
5	Ghatkopar – Mulund	12.4	1540	32698			
6	BKC to Kanjurmarg via Airport	19.5	3225	21441	III	62.8	2016-2021
7	Andheri (East) – Dahisar (East)	18.0	1800	25504			
8	Hutatma Chowk – Ghatkopar	21.8	3455	18354			
9	Sewri – Prabhadevi	3.5	875	4446			

Figure 1.1: Mumbai Metro Master Plan



To provide multimodal access to the airport passengers at CSIA, (being developed as a world class airport), it has long been considered necessary to provide metro connectivity to/ from major parts of the City. Initially this was contemplated via Line I (Versova – Andheri – Ghatkopar), but the spur line connection was not found feasible.

The National Facilitation Committee (NFC), in its meeting held on September 3, 2009, decided that the metro connectivity to the CSIA be expedited and put in the phase 1, rather than in the phase 3 as per Metro Master Plan. This was decided to be achieved by merging Line 6 of Phase 3, named BKC – Kanjur Marg via Airport with the Line 3 of Phase I, i.e. Colaba – Mahim – Bandra and run through services from Colaba till SEEPZ.

With this background, MMRDA through MMRC commissioned the services of RITES to update both the studies ; viz. the first conducted by DMRC for Colaba – Mahim – Bandra Metro Line (2007) and the second by RITES for Mahim – BKC – Kanjur Marg (2010); and prepare a combined DPR for the running of through services on the fully underground Colaba – Bandra – SEEPZ corridor (**Figure 1.2**).

1.3 STUDY OBJECTIVES

To review and update the existing details given in the DPRs of Colaba – Mahim – Bandra and Mahim – BKC – Kanjur Marg and formulate a DPR for the combined corridor of Colaba – Bandra – SEEPZ with necessary fresh surveys and studies which ensures

i. a fully underground metro alignment that is well integrated with the other mass transit systems;

ii. adequate infrastructural facilities (e.g. stabling lines, cross-overs, substations, control, etc.) for ensuring quality operation of the proposed Metro Corridor.

1.4 SCOPE OF WORK

i. Review the available information data, maps, reports including ridership figures, topographic survey details and geotechnical reports.

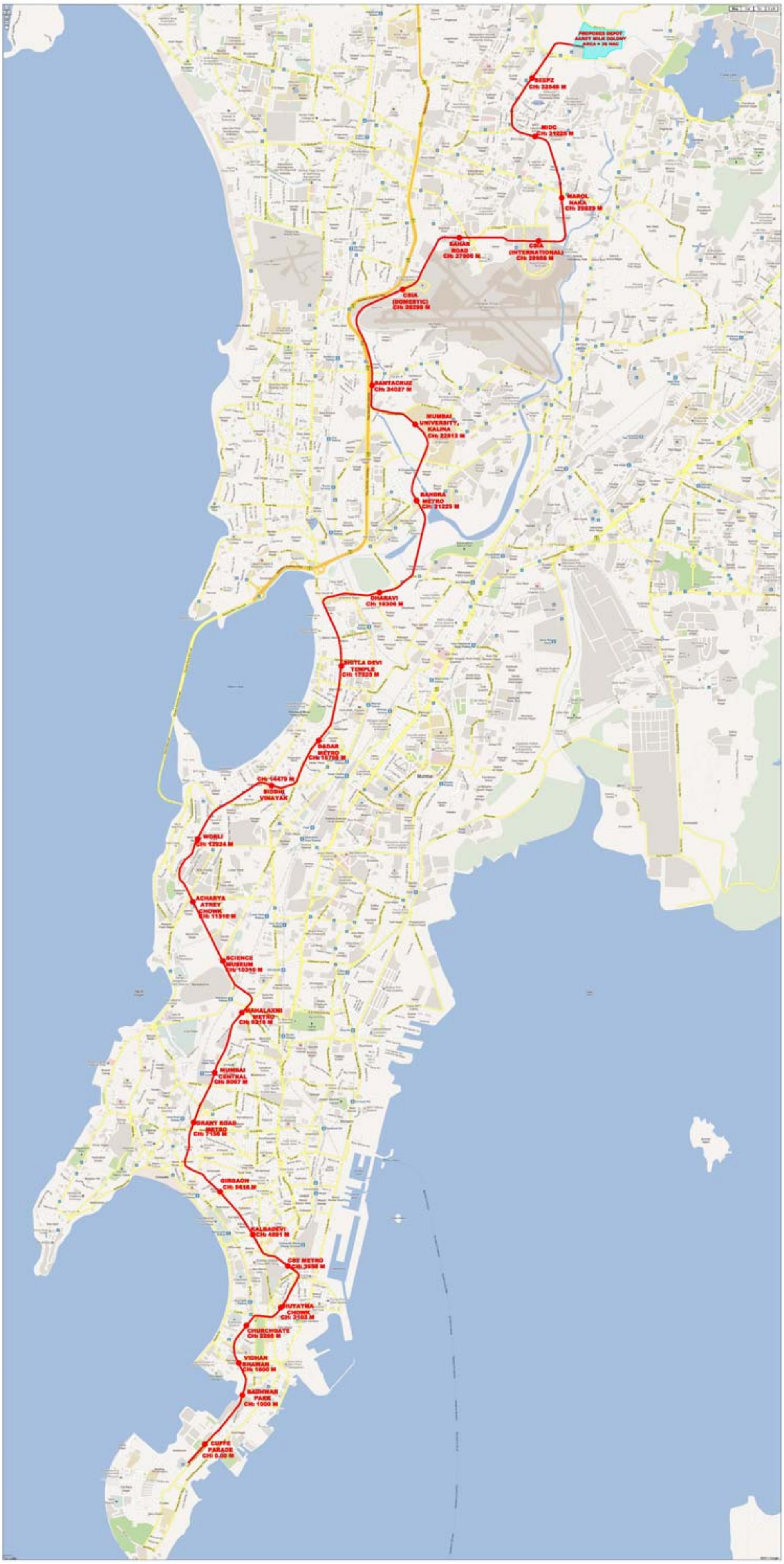
ii. Identify areas which require update and carry out missing data and that omitted from previous studies, surveys.

iii. Review and update the geometric design of the route alignment covering both horizontal and vertical profiles of the Metro. The alignment details would be discussed with MMRDA and finalised accordingly.

iv. In previous DPR, station locations have been finalised; however in case of relocation the same is to be decided upon in consultation with MMRDA.

v. Integrate proposed Colaba – Mahim – Bandra Metro (Line-III underground) and Charkop – Bandra – Mankhurd Mero (Line – II) at Bandra with suitable interchange (underground to elevated)

Figure 1.2: Proposed Colaba – Bandra – SEEPZ Metro Corridor



vi. Integrate Colaba – Bandra (Line – III) with Mahim – BKC – Kanjur Marg (Line – VI) to prepare a combined report of through corridor as Colaba – Mahim – BKC – Airport – SEEPZ (fully underground). Make the changes to the extent, as in Line VI DPR, Mahim is considered as elevated.

vii. A feasibility study for locating underground/ at grade depot at suitable location and prepare preliminary engineering design and layout with required maintenance facilities as per recommended schedules of rolling stock maintenance, good enough for reasonable cost estimates including outline of construction methodology. The depot will also have facilities for maintenance of Track, OHE, Signalling and Communication, AFC, Station Services, Ventilation and Air conditioning, Lighting, Fire fighting, Evacuation system etc. Operation Control Centre will be located in depot area.

viii. Prepare train operation plan for various horizon years separately for Colaba – Bandra and Colaba – Bandra – BKC – Airport – SEEPZ including rakes requirement.

ix. To update the construction, operation and maintenance costs for the alignment, stations and rake requirements at current price levels for Colaba – Bandra as well as for combined corridor.

x. Revise economic and financial analysis as per updated costs. For the financial analysis use the proposed JICA funding pattern (60% JICA, 21% State and 19% Central funding) and study loan repayment plans and implications.

xi. Study the interchange/ integration with other modes of public transport including BEST buses, suburban trains and IPT.

xii. Update Environmental Impact Assessment, including required CRZ clearances and environment management plan as required including number of trees that will have to be cut and lowering of water table during construction, etc.

xiii. Address security related issues in line with guidelines/ directions of the Ministry of Home Affairs, GoI.

xiv. MMRDA will provide copy of DPR prepared by DMRC in 2005 and 2007 including ridership projections and Link Loads. The consultants will however list out the information/data required by them for the specific purpose of this study.

xv. “Guidelines for Preparation of Detailed Project Reports” issued by MoUD will be used to the extent applicable.

xvi. Within the overall frame work as indicated above, Consultants are free to make recommendations for improving the project viability, acceptability, constructability and operational efficiency to provide better quality of service.

xvii. Consultants will also address the clarification sought by MoUD vide letter No. K-14011/36/2009-Metro dated 29 January 2011.

1.5 STUDY PROGRESS AND SUBMISSIONS

The work was award in August 2011. The first three deliverables i.e. Inception Report , Options Report and Draft Final Report were submitted well within schedule. After intense discussions and joint visits, Corridor Alignment, Station locations and other details for the Study have been finalized. The study progress stages are as follows:

Study progress	Date
Study Awarded	**02.08.2011**
Start-off Meeting and discussion with MMRDA	11.08.2011
Submission of Inception Report	**24.08.2011**
Joint Site visit with MMRDA & Discussion on Corridor Alignment and Station locations	25.08.2011
Review Meeting with MMRDA on Corridor Alignment, Station locations and study progress	29.08.2011 and 06.09.2011
Meeting & Discussions with MMRDA on Depot & Mid-Terminal locations	15.09.2011
Presentation to MC, MMRDA on Corridor Alignment, Stations, Mid-Terminal & Depot locations and study progress	22.09.2011
Joint Site visit with MMRDA & Discussion on Corridor Alignment and locations of Stations and Depot	23.09.2011
Submission of Options Report	**30.09.2011**
Meeting & Discussions with MMRDA on Options Report and decisions required for Draft Final Report	05.10.2011
Topographic Surveys	10.10.2011
Meeting with MMRDA to finalise Ridership, Corridor Alignment and Station locations	19.10.2011
Submission of Draft Final Report	08.11.2011
Presentation to MC, MMRDA on Draft Final Report	22.11.2011
Meeting & Discussions with MMRDA for finalising the Detailed Project Report	23.11.2011 and 29.11.2011

Out of four deliverables for the study, Final Report is the fourth and final deliverable. It covers the entire scope of work of the study and incorporates the observations/ suggestions received on the Draft Final Report

1.6 COMPOSITION OF REPORT

The report has 13 chapters with the following contents:

i. The first chapter discusses the study background, objectives and scope.

ii. Chapter two consists of travel characteristics in the study area, the traffic demand forecast carried out in CTS and ridership assessment on the Study Corridor.
iii. Chapter three is on system design and includes components like permanent way traction system, signalling, telecommunication, fare collection and rolling stock.
iv. Chapter four is of civil engineering design including horizontal and vertical alignment of the proposed corridor.
v. Chapter five is on station planning with particular focus on Intermodal Integration and Dispersal Facilities.
vi. Chapter six presents the train operation plan.
vii. Chapter seven discusses the maintenance facilities /depots.
viii. Chapter eight relates to power supply and traction system.
ix. Chapter nine presents the socio economic and environment impact assessment of the proposed metro rail corridor.
x. Cost estimates are presented in chapter ten.
xi. Chapter eleven presents the economic analysis for the project
xii. Financial analysis, fare structure, financial viability and financing options are discussed in chapter twelve.
xiii. Chapter thirteen presents the proposed implementation plan.

2. RIDERSHIP ESTIMATION

2.1 STUDY AREA CHARACTERISTICS

The proposed Colaba - Bandra - SEEPZ Metro Corridor will facilitate the commuters to travel from South Mumbai to Airport via Mahim-Bandra Kurla Complex (BKC). It will also provide direct access to the economic hubs such as BKC, MIDC Industrial Estate, SEEPZ and famous landmarks such as Kalina University, Mahalaxmi. The total length of the proposed metro corridor is **33.51 km**. It is broadly divided into six sections as indicated in **Table 2.1** and **Figure 2.1.** The entire Metro Corridor is proposed to be constructed underground. The indicated station names are tentative, based on the locational landmarks for ease of comprehension, and these may be subject to change at a later date.

Table 2.1: Colaba – Bandra – SEEPZ Metro Corridor : Major Sections

Section	Section Name	Length (Km)
1.	Colaba/WTC/ Cuffe Parade to CST	4.475
2.	CSTto Science Museum	7.000
3.	Science Museum to Mahim	7.000
4.	Mahim to Airport	7.000
5.	Airport Region	5.000
6.	Airport to SEEPZ	3.033
TOTAL		33.508

Section 1 is about 4.5 km long and starts from Colaba/ WTC/ Cuffe Parade station and ends at CST Metro station. Six stations (Cuffe Parade, Badhwar Park, Vidhan Bhavan, Churchgate, Hutatama Chowk and CST Metro) are proposed in this section with an average inter-station spacing of 0.8 km . The first station will be Cuffe Parade in Woods Park near President Hotel. Alignment further follows the Cuffe Parade Road, Vidhan Bhavan, JRD Tata Road, Veer Nariman Road, Hutatama Chowk and Dadabhai Nauroji Road up to CST. CST Metro station is proposed on Mahapalika Road along Azad Maidan. Passenger interchange will be with Western Railway at Churchgate and with Central Railway at CST.

Section 2 is about 7 km long and serves areas of Kalbadevi, Cheera Bazar, Girgaon, Grant Road, Mumbai Central, Jacob Circle, Mahalaxmi and Phoenix Mill. Six stations (Kalbadevi, Girgaon, Grant Road Metro, Mumbai Central Metro, Jacob Circle and Science Museum) are proposed with an average inter-station spacing of 1.05 km. From CST Metro station, the alignment follows the Mahapalika Road along Azad Maidan upto Metro Square. The alignment further follows JSS road, Lamington road, Dr. A Nair Road upto Jacob Circle. The alignment crosses the Western Railway tracks at Mahalaxmi and aligns along E. Moses Road with a station at Science Museum. The Corridor generally runs under the existing roads. The passenger interchange with Western Railway will be at Mumbai Central and Mahalaxmi, and with upcoming Monorail at Mahalaxmi.

Section 3 is about 7 km long and the areas of Worli, Prabhadevi, Dadar, Shivaji Park and Mahim will be served. Five stations (Acharya Atrey Chowk, Worli, Sidhi Vinayak, Dadar Metro and Sheetla Devi Temple) are proposed in this section with an average inter-station spacing of 1.35 km. From Science Museum station, the alignment follows the E. Moses Road, Dr. Annie Basant Road, Swatantrya Veer Savarkar Marg up to Sidhi Vinayak and takes right turn along Appasaheb Marathe Marg to further align along Gokhale Road, Lady Jamshedjee Road, A.S. Gaya Marg and SV Road. Passenger interchange will be with proposed Prabhadevi station of MTHL Metro corridor at Sidhi Vinayak.

Section 4 is about 7 km long and covers the areas of Dharavi, BKC, Mumbai University Kalina and Santacruz. Four stations (Dharavi, Bandra Metro, Mumbai University Kalina, Santacruz) are proposed with an average inter-station spacing of 1.65 km. Sheetla Devi Temple station is proposed on Lady Jamshedji Road. The alignment moves further North along SV Road, and after turning right along R. Hospital Marg, crosses the WR tracks and aligns along Mahim-Sion Link/ Station Road. After crossing the Mahim Creek (Mithi River) just east of the Sion-Bandra Link Road, the alignment passes through BKC, Valmiki Nagar (slum area), Kalina University and Western Expressway up to Airport. Passenger interchange with Metro line – 2 (Charkop – Bandra – Mankhurd) will be at Bandra Metro (ITO) station.

Section 5 is about 5 km long and passes through Airport region. The alignment serves the Domestic and International airport terminals as well as the Sahar Road Catchment areas. The alignment in this section was finalised in consultation with Mumbai International Airport Pvt. Ltd. (MIAL) and MMRDA by avoiding the runway. Three stations (CSIA Domestic, Sahar Road and CSIA International) are proposed with an average inter-station spacing of 1.65 km.

Section 6 is about 3 km long and covers the areas of Marol, MIDC Industrial Estate, Andheri (E) and SEEPZ. 3 stations (Marol Naka, MIDC and SEEPZ) are proposed in this section with an average inter-station spacing of 1.2 km. From airport, the alignment passes through Chimatpada slum area where Marol Naka station has been proposed. Further, the alignment passes below the built-up area of MIDC Industrial Estate, along Krantiveer Lakhuji Salve Marg and terminates short of junction of JVLR. The last station i.e. SEEPZ is proposed near SEEPZ bus depot. Passenger interchange with Metro line – 1 (Varsova – Andheri – Ghatkopar) will be at Marol Naka. The alignment terminates north of Jogeshwari – Vikhroli Link Road at Aarey Milk Colony (0.542 Km beyond SEEPZ station), where depot is located.

2.2 PLANNING PARAMETERS

MMRDA has carried out a Comprehensive Traffic Study (CTS) and the data of the Study have been used in assessing the ridership on the proposed Metro Corridor.

The CTS has examined a range of alternatives for distribution of population and employment in the MCGM and Rest of the Region (RoR) in order to determine the sensitivity of the road and transit system networks, in terms of both need and priorities, to significantly different land development options or strategies as summarized in **Table 2.2.**

Figure 2.1: Proposed Metro Corridor in MMR

Priority	Sl. No.	Corridor Description	Length (Kms.)
1	M7	Andheri (East) - Dahisar (East)	15.9
2	M5	Ghatkopar-Mulund	12.4
3	M17	Mankhurd-Vashi-Narthen Gaon-Kalyan	37.1
4	M11/M13	Thane-Bhiwandi	15
5	M12	Thane-Ghodbander-Dahisar	27.2
6	M4	Charkope-Dahisar	7.5
7	M8	Hutatma Chowk-Ghatkopar	22.4
8	M10	Dahisar-Mira Road-Manikpur-Virar	29.9
9	M6	BKC-Marol Naka via Airport	8.5
10	M9	Sewri-Prabhadevi	3.5
11	M24	Sewri-Kharkopar	19.7
12	M19	Targhar-Kharkopar-Nhava Sheva-Dronagiri	18.7
13	M18	Vashi-Belapur-New Airport-Panvel	18.8
14	M20	Kharkopar-Dhutum-Pirkone	14.5
1	SR7	Ranjanpada-Kharkopar-Targhar-Seawood (new link)	13.9
2	SR1	Diva-Vasai Road	40.1
3	SR5	Panvel-Uran	26.9
4	SR9	Diva-Panvel	26.7
5	SR6	Kharkopar-Jite (new link)	22.9
6	SR4	Panvel-Karjat	27.6
7	SR8	Thal-Alibag (new link)	5.4
8	SR2	Panvel-Jite-Thal	60.9
9	SR10	Thane-Bhiwandi	12.5

Table 2.2: Range of Population and Employment Levels

Clusters	Population (In lacs)					Employment (In lacs)				
	2005	2031 P1	2031 P2	2031 P3	2031 P4	2005	2031 E1	2031 E2	2031 E3	2031 E4
Island	33.9	54.4	47.8	40.8	37.4	22.6	40.3	36.2	28.4	20.5
Western	56.3	91.8	78.8	71.5	61.3	23.0	48.0	41.5	30.8	19.3
Eastern	38.4	61.2	53.6	47.6	40.8	11.4	21.5	19.3	14.4	11.1
Total MCGM	128.6	207.4	180.2	159.9	139.5	56.9	109.8	97.0	73.5	51.0
Thane	15.2	16.0	26.2	26.2	26.2	3.9	7.2	9.9	13.3	14.9
Navi Mumbai /CIDCO	15.0	22.8	33.0	33.0	39.8	5.9	10.0	12.1	17.5	22.3
Mira Bhayander	6.3	13.6	13.6	13.6	13.6	1.5	2.6	2.5	3.9	5.0
Bhiwandi	6.8	13.1	13.1	13.1	13.1	2.1	4.3	4.3	4.5	4.5
Vasai-Vihar	7.1	13.1	13.1	14.8	18.2	1.6	2.4	4.1	7.2	9.1
Pen-SEZ	1.2	18.8	13.7	27.2	37.4	0.2	8.5	12.8	18.6	31.2
Rural: Alibagh-Karjat khopoli	4.9	5.6	5.6	5.6	5.6	0.7	0.8	0.9	1.1	1.1
Total	**208.2**	**340.0**	**340.0**	**340.0**	**340.0**	**77.6**	**153.0**	**153.0**	**153.0**	**153.0**

Source: CTS for MMR, by MMRDA

The major changes expected in socio economic parameters which will affect the overall development as well as transportation for the horizon year 2031 are summarized in the **Table 2.3**.

Table 2.3: Expected Changes (2005-2031) in Socio Economics factors

2005	2031
• **Population 20 million** - 47% living in slums - 1,505,000 apartments - 4.42 persons/household • **Employment 7.5 million** - Employ. Partic. Rate 0.37 - 2.3 million working in offices - 1.5 million working in industries - 56% employed in formal sector - 40% walk to work	• **Population 34 million** - 14% living in slums - 6,400,000 apartments - 3.90 persons/household • **Employment 15.3 million** - Employ. Partic. Rate 0.45 - 6.4 million working in offices - 4.5 million working in industries - 70-80% employed in formal sector - 25-30% walk to work

Source: CTS for MMR, by MMRDA

The difference in work travel characteristics is shown in **Table 2.4** with the office workers travelling more than twice the distance than other employment. Over 70% of office workers use public transit as compared to 53% for the employees in industry and 37% for other types of employment.

Table 2.4: Travel Characteristics of Existing Employment

	Office	Industry	Other
Average Trip Distance(km)	17.2	11.9	8.3
Mode to work			
Walk	18.3%	42.6	51.5%
Train	58.5%	39.2%	27.2%
Bus	16.0%	13.7%	9.9%
Car	2.9%	1.2%	1.4%
2W	2.4%	1.8%	8.3%
Taxi	0.4%	0.0%	0.1%
A/Rickshaw	1.4%	1.4%	1.7%

Source: CTS for MMR, by MMRDA

In order to sustain a population level of 34 million and an employment of 15.3 million, the economy of Mumbai must be more broad-based and it was concluded that the Industrial proportion of 30% of the future total employment was appropriate and reasonable in terms of both landuse need and transportation planning. **Table 2.5** gives the changes in employment characteristics during 2005-2031.

Table 2.5: Assumed Change in Employment Characteristics 2005-2031

Employment	Survey (2005)	Projected (2031)
Office	31.0%	42.0%
Industry/Factory	18.0%	28.0%
Warehouse	1.4%	1.5%
Total Industry	19.4%	29.5%
Other Employment		
Residential	12.1%	5.0%
Film Industry	0.8%	0.5%
Shop	14.6%	8.0%
Restaurant/Eating Place	0.6%	0.5%
Hotel	1.2%	1.3%
Entertainment/Tourism	0.8%	0.8%
Place of Education	2.0%	2.0%
Health Facility	1.6%	1.5%
Agriculture	0.7%	0.2%
Construction Site	1.3%	1.5%
Varies day to day	8.4%	5.2%
Others	5.6%	2.0%
Total Other Employment	49.6	28.5%
Total Employment	**100.0%**	**100.0%**

Source: CTS for MMR, by MMRDA

The CTS screened 6 growth scenarios from the possible 16 combinations of population and employment to narrow down the selection to best characterize the range of possible futures for the MMR. The following set of criteria was adopted for evaluating the growth scenarios:

- Cost of transport network
- Pass- km, pass- hr and average speeds: bus and suburban rail and metro modes
- Vehicle- km, vehicle- hr and average speeds: private vehicles and IPT modes
- Average trip length of bus and suburban rail and metro modes

On comparative evaluation and short listing as given in **Annexure 2.1,** P2E2, P3E3, P4E4 were shortlisted by MMRDA as the appropriate options to be carried forward in completing TRANSFORM, on the planning principle that the long term transportation strategies should respond to several futures rather than reflect a single development future. The ranking of these scenarios is given in **Table 2.6.** The P3E3 population/ employment scenario has been subsequently adopted as the preferred strategy.

Table 2.6: Comparative Evaluation of Growth Scenarios

Scenario	Cost of Transport Network	Average Speed of Bus, Suburban and Metro	Average Speed of PV and IPT Modes	Trip Length of Bus, Suburban and Metro
P1E2	2	1	3	2
P2E1	3	3	2	3
P2E2	2	1	2	2
P3E3	3	1	1	1
P3E4	1	2	2	1
P4E3	2	3	3	2

2.3 COMMITTED TRANSPORT NETWORK: 2031

The starting point for developing the horizon year (2031) transport network is the base year (2010) transport network. Several studies have been carried out for identifying and prioritizing the transport corridors in MMR. The major projects that are under active implementation/under progress are as follows:

- Capacity enhancements to Mumbai sub-urban railway system under Mumbai Urban Transport Project: Rail Component (Phase-I & Phase-II)
- Mumbai Metro Line 1 and Line 2 , Mumbai Monorail Phase 1
- Mumbai Urban Transport Project: Road Component
- MUIP Improvements

All the committed transport network in Greater Mumbai have been considered while preparing the horizon year (2031) transport network.

2.3.1 Master Plan for Mumbai Metro

An integrated metro network with an aggregate length of 146.5 km has been identified. The total metro master plan network is proposed to be implemented in three different phases at an approximate capital cost of Rs.19,525 Crores at 2003 price level. (**Table 2.7**)

Table 2.7: Phasing of Mumbai Metro Master Plan

Line No.	Metro Line Name	Length (km)	Length Elevated (km)	Length Under Ground (km)	Total cost (Rs. Crore)	Proposed Period of Implementation
1	Versova-Andheri-Ghatkopar	15.00	15.00	0.00	2025	2005-2011
2	Colaba-Bandra	20.40	12.20	8.20	7529	2007-2013
3	Charkop - Bandra – Mankhurd	31.87	31.87	0.00	5616	2006-2011
4	Charkop - Dahisar	7.50	7.50	0.00	1012	2011-2016
5	Ghatkopar-Mulund	12.40	12.40	0.00	1674	2011-2016
6	BKC- Airport - Kanjur Marg	19.50	11.00	8.50	4686	2016-2021
7	Andheri(E) – Dahisar(E)	18.00	18.00	0.00	2430	2016-2021
8	Hutatma Chowk - Ghatkopar	21.80	13.30	8.50	4996	2016-2021
9	Sewri - Prabhadevi	3.50	0.00	3.50	1318	2016-2021

Source: CTS for MMR, by MMRDA

2.3.2 MUTP: Road Component

Under MUTP road Component, major East-West links have been proposed and total cost of road component of MUTP is approximately Rs.1016 Crores at 2001 prices. In the horizon year transport network, the following road based projects have been considered.

- Jogeshwari-Vikhroli Link Road (JVLR)
- Santacruz-Chembur Link road (SCLR)
- ROB at Jogeshwari (North)
- ROB at Jogeshwari (South)
- ROB at Vikhroli
- Station area Traffic Improvements Schemes
- Other Traffic Management and safety Schemes

2.3.3 MUIP Improvements

MMRDA developed a Master Plan (2001-2021) for integrated road development with the objective of strengthening and augmenting the capacity of the existing road network, mainly in suburbs where the intensity and demand for traffic has increased significantly. The proposed road network improvements under MUIP were mostly as per Sanctioned Development Plan (SDP) and provide connectivity to the North-South and East-West arterial roads in suburbs and Island City. In Eastern suburbs, there are 52 roads proposed for improvements including the missing links. In Western Suburbs, there are 60 roads proposed for improvements and in Island City, there are 22 roads proposed for improvements. The estimated cost of the proposed improvements is about Rs 2560 Crores at 2003 price. In the horizon year transport network of the CTS, the major proposed improvements under MUIP have been considered.

2.4 Model Development

The base year model (2010) was developed by first of all building a "best estimate" of the trip matrices (for both road-based personal vehicles and public transport). This was based on a combination of data from previous studies carried by MVA and recently collected traffic and trip making data. A process of matrix estimation was then used to further refine these matrices to match the observed vehicle and passenger flows as derived from the survey data and other sources.

The transport model includes the following different vehicle and user types:

- Car & 2-wheeler
- Goods Vehicle
- Auto rickshaw/taxi
- Buses
- Train

The base matrices for road-based vehicles were initially developed from the previous MVA Study and information available from recent studies such as the CTS. A matrix estimation process was then used to produce updated matrices for the base year (2010) using traffic survey data. Trip length distribution and journey times were monitored in this process.

A similar process of matrix estimation was used to build the public transport demand from existing information.

The derivation of travel demand in this manner then allowed detailed analysis to be carried out on the relationship between travel demand and the cost of travel by alternative modes. This was then applied to derive parameters to be used in the future year model.

2.4.1 Public Transport Assignment

For this aspect of the model, a detailed public transport sub-model has been developed. This is to ensure that the different existing and future public transport choices and costs of these choices are properly reflected in the modelling process. First of all it considers two main travel modes:

- Bus as main mode – road based PT only
- Rail as a main mode - commuter rail in the existing situation (with MRT included for the future)

The public transport network is defined as a set of individual routes each having their own service level characteristics – travel time, comfort, headway and fares. In the existing situation, the costs of travel by the two main modes are calculated based on the generalised cost (GC) of travel, comprising the following components:

- Public Transport GC = (In–Vehicle Time x In–vehicle time Factor)
  + (Walk Time x Walk Time Factor)

  + (Wait Time x Wait Time Factor)

  + (Number of Transfers x Interchange Penalty)

  + Fare / Value of Time (willingness to pay)

For the existing situation, the following parameters were adopted for the public transport assignment.

Walk factors, that is the perception of waiting time and transferring compared to in-vehicle time, were derived from the Stated Preference (SP) survey carried out by MVA for recent studies. Wait time factors were based on industry standards.

Table 2.8: Public Transport Model - Key Parameters (2010)

Item	**Parameter Values**				
	IVT Factor	**Wait Time Factor**	**Interchange Penalty (min)**	**Walk Time Factor**	**Value of Time (Rs/hour)**
Mode Specific Data					
Metro [FUTURE]	1.00	2.00	12		
Air-Con Bus	1.20	2.00	12		
Regular Bus	1.40	2.00	12		
Rail	Crowding	2.00	12		
Link Specific Data				1.5	
Person Value of Time by Income Group					
Low					10
Medium					31
High					92

In-vehicle time factors for public transport modes are based on assumed differences in perceptions of comfort and journey time unreliability. All in-vehicle time factors are based on an MRT reference case (future model) which will be providing optimal journey time reliability and comfort. The basic journey time unreliability penalty has been assumed as 20% of in-vehicle time for road based public transport, while additional discomfort has also been assumed as 20% of IVT for non-air conditioned modes.

The Interchange penalty represents the psychological disutility of transferring between services (as opposed to using a direct route) which is added to the actual cost involved during an interchange – walk, wait and possibly additional fare. Once the costs of each mode are calculated then the estimated passenger trips derived from the demand model are then assigned onto the public transport network whereby for a given origin – destination pair, the route taken will be based on the lowest generalised cost.

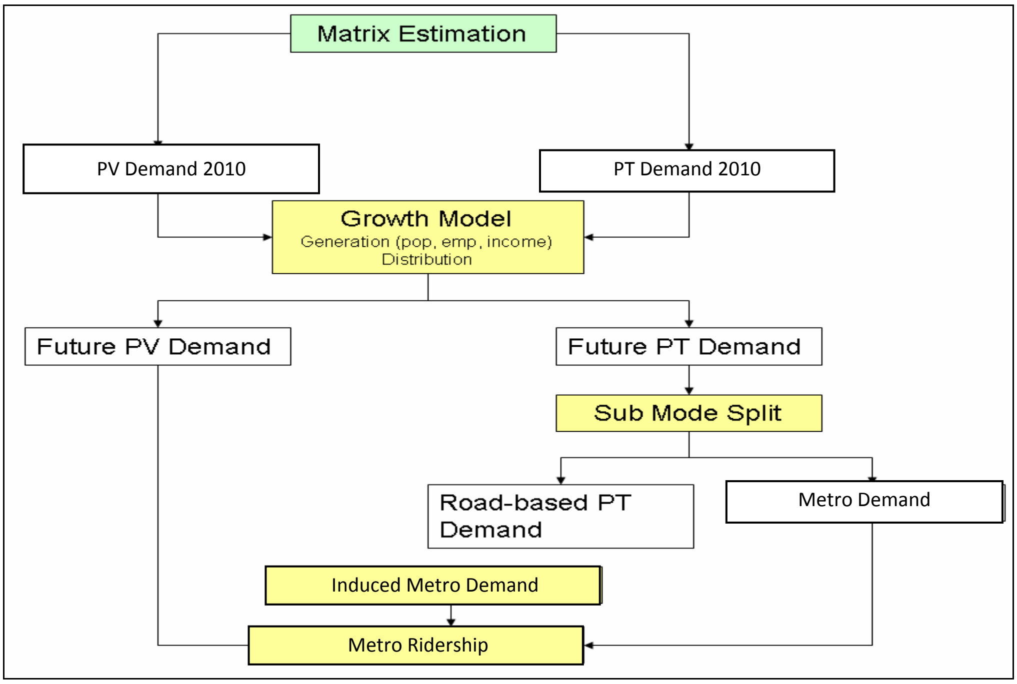
2.4.2 Future Model Development

The model is developed for future benchmark years which for this study have been selected as 2016, 2021 and 2031 in addition to the base year of 2010. This section describes the model structure for the future years and then the forecasting assumptions prepared for the benchmark years.

Forecast Year Model Structure

Figure 2.2 shows the progression of the model structure from the 2010 structure in which separate demand matrices for private and public transport were developed from observed data.

Figure 2.2: Outline of Forecast Year Model structure



The basis for the future year travel demands is the growth model shown in the above figure between the 2010 and future model application. The model is calibrated in 2010 to develop a relationship between land use data (population and employment), income/vehicle ownership and trip making. This relationship is then used in the future to forecast total trip making and modal share between private and public transport in the future. Within public transport, the share between road and rail-based travel is then calculated. The costs for this split are derived from the detailed public transport sub-model.

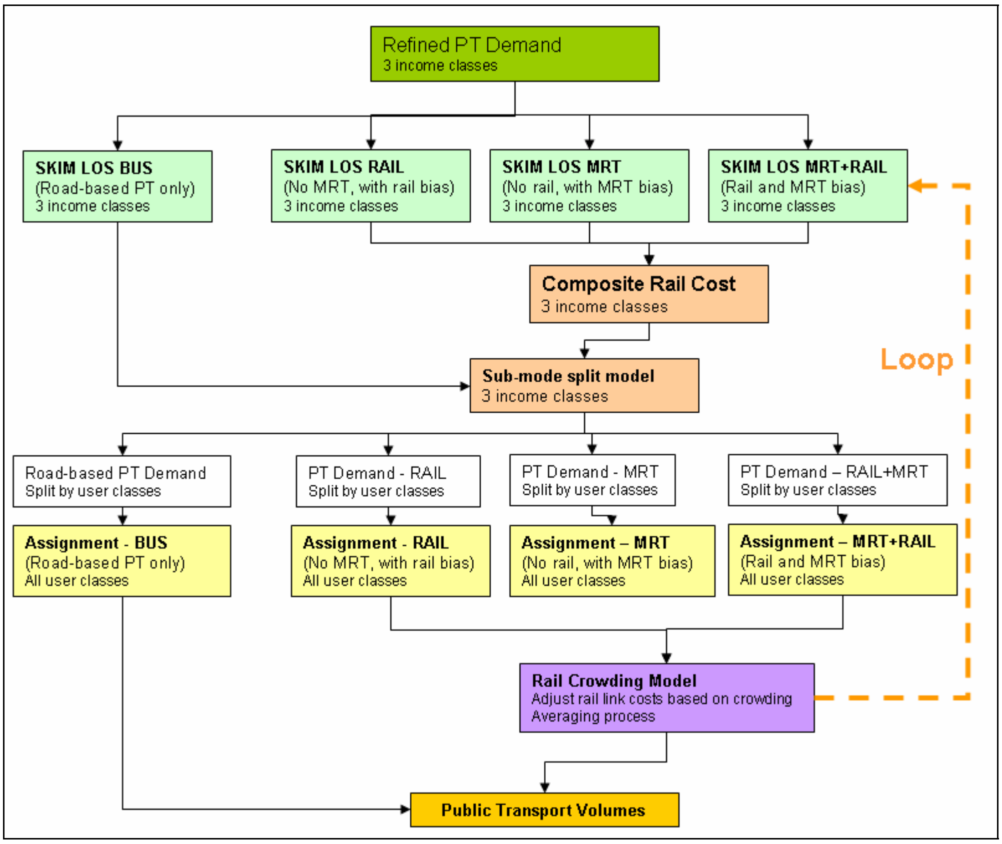
The sub-model for rail needs to consider the following alternatives for the future situation:

- Rail commuter as main mode – existing rail commuter services with bus as a feeder
- MRT as main mode – future MRT system, no rail service but bus as a feeder

- Mixed rail as main mode – future MRT system and rail commuter used together with bus as feeder.

The public transport sub-model structure then becomes quite complex as shown in **Figure 2.3** as the different costs of alternatives (which combine to form Level of Service – LOS – or generalized cost), by different income groups needs to be considered.

Figure 2.3: Future Year Application of Public Transport Sub-Model



Note: LOS (level of service) refers to a set of variables such as in-vehicle time, waiting time, fares etc…

The parameters feeding into the generalized cost (or LOS) calculation are largely the same as those shown in Table 2.8. The exceptions to this are the future year value-of-time some adjustments to the in-vehicle-time factors for buses to reflect the improvements in bus service provision (eg. better information, bus priority measures etc). Furthermore, it can be expected that in the future more of the bus fleet will be air conditioned compared to today.

ROAD NETWORK ASSUMPTIONS

Future road network assumptions have been developed based on official sources such as road network Master Plan prepared by MMRDA (Mumbai Urban Infrastructure Project).

The following major road projects have been included in the horizon year road transport network in line with the recommendations of CTS.

- Eastern Freeway
- Elevated Link – Sewri – Worli
- Western Freeway Sea Link (WFSL)
- WFSL north extension – Bandra – Dahisar

In addition to these committed road projects, there is also a programme of road network improvements including flyovers and junction improvements at a more local level. These should have the impact of generally providing some additional capacity/speed improvement on the road network. To reflect these local changes, road capacity on the existing road network has been assumed to grow at 1% per annum.

Public Transport Network Assumptions

<u>Rail Network</u>

As discussed in Section 1, there are plans for development of 147 km of metro network, a monorail network and upgrading of the commuter railway. **Table 2.9** below sets out the network assumptions adopted by year in the model:

Table 2.9: Railway Network Assumptions

Year	Assumed Rail Network Development
2012	Metro Line 1: Versova – Andheri – Ghotkopar
	Monorail Phase 1: Jacob Circle – Wadala – Chembur
2015	MUTP Rail Improvements
2016	Metro Line 2: Charkop – Bandra – Mankurd including extension to Dahisar
2016	Metro Line 3: Colaba – Bandra-SEEPZ

2.5 RIDERSHIP ON PROPOSED COLABA - BANDRA - SEEPZ METRO CORRIDOR

While estimating the ridership figures for the Colaba - Bandra - SEEPZ Metro corridor, following important considerations have been made :

- P3E3 landuse scenario is considered. This scenario allocates growth to MCGM and RoR in equal proportion.
- Future road and rail/ metro network as detailed in the previous section.
- Future employment potential in MIDC and SEEPZ considered
- Shift in Domestic Passengers from Domestic to International Terminal
- Traffic from domestic and international airport is considered as Special Generator. Design year (2026) passengers : 40.7 million per annum. Considering the

reliability provided by Metro & the good connectivity (with Line 1 and Line 2 metro in operation) and the envisaged severe traffic congestion in the CSIA area, high proportion of airport users (particularly domestic passengers) would prefer Metro. Also, the employees and the Meters/ Greeters (about 0.7 per passenger) would also prefer Metro in comparison to other modes.

- Proposed landside development in the CSIA Area, including the Convention Centre and the envisaged huge employment is considered.
  - Interchanges with other mass transit corridors have been considered; Churchgate Metro - with W. Railway, CST Metro - with C. Railway, Mumbai Central Metro - with W. Railway, Mahalaxmi Metro - with W. Railway & Monorail, Bandra Metro (ITO) - with Charkop – Bandra -Mankhurd Line 2, Marol Naka - with Versova – Andheri – Ghatkopar Metro Line 1.
- Metro Fare is considered as 1.5 times the ordinary bus fare.
- Speed of the metro is taken as 35 Kmph.
- Frequency of metro service is considered as 4 minutes for 2016, 3 minutes for 2025 and 2.5 minutes for 2031 horizon years.

The daily ridership, peak hour station loads, peak hour section loads and trip length distribution for the Line 3 Metro Corridor are given in the subsequent paragraphs.

2.5.1 Daily Ridership

The proposed Metro Corridor is expected to have a daily ridership of 16.99 Lakh and maximum PHPDT of 42,000 by 2031. The daily ridership and PHPDT on the corridor are shown in **Table 2.10**.

Table 2.10 : PHPDT and Daily Ridership for Colaba - Bandra - SEEPZ Corridor

Corridor	2016		2025		2031	
	Max. PHPDT	Daily Ridership (in Lakh)	Max. PHPDT	Daily Ridership (in Lakh)	Max. PHPDT	Daily Ridership (in Lakh)
Colaba-Bandra - SEEPZ	25700	10.06	39000	13.87	42000	16.99

2.5.2 Station Loads

Daily and Peak hour station loads for 2016, 2025 and 2031 are shown in **Tables 2.11 to 2.14**.

Table 2.11 : Projected Daily Station Loads along Proposed Colaba - Bandra - SEEPZ Metro Corridor

	Year	2016			2025			2031		
	Station	Boarding	Alighting	B + A	Boarding	Alighting	B + A	Boarding	Alighting	B + A
1	Colaba/ Cuffe Parade	36660	42513	79173	50519	58585	109104	61916	71801	133717
2	Badhwar Park	28639	32469	61108	39465	44743	84209	48369	54837	103206
3	Vidhan Bhavan	19258	36605	55862	26538	50443	76981	32525	61823	94347
4	Churchgate Metro	30148	41770	71918	38547	57561	96108	50242	70546	120788
5	Hutatma Chowk	36674	49866	86541	53534	68718	122253	65611	84221	149832
6	CSTM Metro	41924	79880	121804	53772	110078	163850	65890	134911	200801
7	Kalbadevi	36631	43990	80621	46483	60620	107103	53969	74296	128265
8	Girgaon	40450	31955	72405	50715	44035	94750	62160	53969	116129
9	Grant Road Metro	36419	22710	59129	46191	31295	77486	58610	38355	96965
10	Mumbai Central Metro	38279	28401	66680	52750	39137	91887	72654	47967	120620
11	Mahalaxmi Metro	40764	25910	66674	57180	35705	92885	78076	43760	121836
12	Science Museum	21643	19122	40765	27828	26351	54179	38023	32296	70319
13	Acharya Atrey Chowk	40835	39944	80779	51275	55044	106319	67840	67462	135302
14	Worli	27554	44092	71646	37970	60761	98731	53540	74468	128008
15	Siddhi Vinayak	39346	39002	78348	52222	53747	105969	67010	65872	132882
16	Dadar Metro	77284	53997	131281	111497	74410	185907	136650	91197	227847
17	SheetlaDevi Temple	41810	35948	77758	67610	49538	117148	82862	60714	143576
18	Dharavi	44260	26900	71160	70000	37069	107069	86790	45432	132222
19	Bandra Metro	69310	61934	131243	108510	85347	193857	128990	104601	233591
20	Mumbai University (Kalina)	13209	31907	45116	20208	43969	64177	28800	53888	82688
21	Santacruz Metro	36597	21195	57792	47937	29207	77144	51793	35796	87590
22	CSIA(Domestic)	26921	39606	66526	31090	54578	85668	36106	66891	102997
23	Sahar Road	27430	23835	51265	37301	32846	70147	41717	40256	81973
24	CSIA (International)	17116	40857	57973	23587	56303	79890	27910	69004	96914
25	Marol Naka	46540	31058	77598	64134	42800	106933	70606	52455	123061
26	MIDC	37886	28268	66154	47212	38954	86166	50867	47742	98609
27	SEEPZ	52910	32760	85670	72912	45145	118057	80360	55329	135689
	Total	1006497	1006493	2012990	1386988	1386991	2773979	1699887	1699889	3399776

Table 2.12: Projected Peak hour Station Loads along Proposed Colaba - Bandra - SEEPZ Metro Corridor (Peak Direction : SEEPZ to Colaba)

	Year	2016			2025			2031		
	Station	Boarding	Alighting	B + A	Boarding	Alighting	B + A	Boarding	Alighting	B + A
1	Colaba/ Cuffe Parade	0	4251	4251	0	5858	5858	0	7180	7180
2	Badhwar Park	65	3182	3247	89	4385	4474	110	5374	5484
3	Vidhan Bhavan	130	3531	3660	179	4865	5044	219	5963	6182
4	Churchgate Metro	1135	2618	3753	1264	3608	4872	1849	4422	6271
5	Hutatma Chowk	389	4727	5116	536	6514	7051	657	7984	8641
6	CSTM Metro	1898	5538	7437	2216	7632	9848	3015	9353	12368
7	Kalbadevi	1570	3735	5305	1764	5147	6911	2162	6308	8470
8	Girgaon	1737	2560	4297	1891	3528	5419	2718	4324	7042
9	Grant Road Metro	1473	1538	3011	1630	2119	3749	2498	2598	5096
10	Mumbai Central Metro	1910	1631	3541	2432	2248	4680	3781	2755	6536
11	Mahalaxmi Metro	1970	997	2967	2515	1374	3889	3882	1684	5566
12	Science Museum	1043	872	1915	1238	1202	2440	1909	1473	3382
13	Acharya Atrey Chowk	1821	2879	4700	2009	3968	5977	3262	4863	8125
14	Worli	1366	3244	4610	1683	4470	6153	2863	5479	8342
15	Siddhi Vinayak	1547	2460	4007	1932	3390	5322	2968	4155	7123
16	Dadar Metro	4827	2920	7747	7152	4023	11175	8765	4931	13696
17	SheetlaDevi Temple	3117	1931	5048	5595	2661	8256	6857	3261	10118
18	Dharavi	3796	1077	4873	6231	1484	7715	7137	1819	8956
19	Bandra Metro	5335	2294	7629	8852	3162	12014	9849	3875	13724
20	Mumbai University (Kalina)	1038	1403	2441	1631	1933	3564	1702	2369	4071
21	Santacruz Metro	2783	442	3225	3835	610	4444	4004	747	4751
22	CSIA(Domestic)	2273	1320	3593	2632	1818	4450	3026	2229	5255
23	Sahar Road	2119	649	2768	2920	894	3814	3179	1096	4275
24	CSIA (International)	1517	1436	2953	2090	1978	4069	2362	2425	4787
25	Marol Naka	4148	527	4675	5716	726	6442	6206	890	7096
26	MIDC	3594	130	3724	4453	179	4632	4758	219	4977
27	SEEPZ	5291	0	5291	7291	0	7291	8036	0	8036
	Total	57892	57892	115784	79777	79778	159555	97775	97775	195550

Table 2.13 : Projected Peak hour Station Loads along Proposed Colaba - Bandra - SEEPZ Metro Corridor (Non Peak Direction : Colaba to SEEPZ)

		2016			2025			2031		
	Station	Boarding	Alighting	B + A	Boarding	Alighting	B + A	Boarding	Alighting	B + A
1	Colaba/ Cuffe Parade	3666	0	3666	5052	0	5052	6192	0	6192
2	Badhwar Park	2799	65	2864	3857	89	3947	4727	110	4837
3	Vidhan Bhavan	1796	130	1926	2475	179	2654	3033	219	3252
4	Churchgate Metro	1880	1559	3439	2591	2148	4739	3175	2633	5808
5	Hutatma Chowk	3278	260	3538	4817	358	5175	5904	438	6342
6	CSTM Metro	2294	2450	4744	3161	3376	6537	3574	4138	7712
7	Kalbadevi	2093	664	2757	2884	915	3799	3235	1121	4356
8	Girgaon	2308	635	2943	3181	875	4056	3498	1072	4570
9	Grant Road Metro	2169	733	2902	2989	1010	3999	3363	1238	4601
10	Mumbai Central Metro	1918	1209	3127	2843	1666	4509	3484	2042	5526
11	Mahalaxmi Metro	2106	1594	3700	3203	2197	5400	3926	2692	6618
12	Science Museum	1121	1040	2161	1545	1433	2978	1893	1757	3650
13	Acharya Atrey Chowk	2263	1115	3378	3119	1537	4655	3522	1883	5405
14	Worli	1389	1165	2554	2114	1606	3720	2491	1968	4459
15	Siddhi Vinayak	2388	1440	3828	3290	1984	5275	3733	2432	6165
16	Dadar Metro	2901	2480	5381	3998	3418	7415	4900	4189	9088
17	SheetlaDevi Temple	1064	1664	2728	1166	2293	3459	1429	2810	4239
18	Dharavi	630	1613	2243	769	2223	2992	1542	2724	4266
19	Bandra Metro	1596	3899	5495	1999	5373	7372	3050	6585	9635
20	Mumbai University (Kalina)	283	1788	2071	390	2464	2854	1178	3020	4198
21	Santacruz Metro	877	1677	2554	959	2311	3270	1175	2832	4008
22	CSIA(Domestic)	419	2641	3060	477	3639	4116	585	4460	5045
23	Sahar Road	624	1735	2359	810	2391	3201	993	2930	3923
24	CSIA (International)	195	2650	2845	268	3652	3920	429	4476	4905
25	Marol Naka	506	2579	3085	697	3554	4251	855	4356	5210
26	MIDC	195	2697	2892	268	3717	3985	329	4555	4884
27	SEEPZ	0	3276	3276	0	4514	4514	0	5533	5533
	Total	42757	42757	85515	58922	58921	117843	72214	72214	144428

Table 2.14 : Projected Peak hour Station Loads along Proposed Colaba - Bandra - SEEPZ Metro Corridor (Both Directions)

		2016			2025			2031		
	Station	Boarding	Alighting	B + A	Boarding	Alighting	B + A	Boarding	Alighting	B + A
1	Colaba/ Cuffe Parade	3666	4251	7917	5052	5858	10910	6192	7180	13372
2	Badhwar Park	2864	3247	6111	3947	4474	8421	4837	5484	10321
3	Vidhan Bhavan	1926	3660	5586	2654	5044	7698	3252	6182	9435
4	Churchgate Metro	3015	4177	7192	3855	5756	9611	5024	7055	12079
5	Hutatma Chowk	3667	4987	8654	5353	6872	12225	6561	8422	14983
6	CSTM Metro	4192	7988	12180	5377	11008	16385	6589	13491	20080
7	Kalbadevi	3663	4399	8062	4648	6062	10710	5397	7430	12827
8	Girgaon	4045	3195	7240	5072	4404	9475	6216	5397	11613
9	Grant Road Metro	3642	2271	5913	4619	3130	7749	5861	3836	9697
10	Mumbai Central Metro	3828	2840	6668	5275	3914	9189	7265	4797	12062
11	Mahalaxmi Metro	4076	2591	6667	5718	3571	9289	7808	4376	12184
12	Science Museum	2164	1912	4076	2783	2635	5418	3802	3230	7032
13	Acharya Atrey Chowk	4084	3994	8078	5128	5504	10632	6784	6746	13530
14	Worli	2755	4409	7165	3797	6076	9873	5354	7447	12801
15	Siddhi Vinayak	3935	3900	7835	5222	5375	10597	6701	6587	13288
16	Dadar Metro	7728	5400	13128	11150	7441	18591	13665	9120	22785
17	SheetlaDevi Temple	4181	3595	7776	6761	4954	11715	8286	6071	14358
18	Dharavi	4426	2690	7116	7000	3707	10707	8679	4543	13222
19	Bandra Metro	6931	6193	13124	10851	8535	19386	12899	10460	23359
20	Mumbai University (Kalina)	1321	3191	4512	2021	4397	6418	2880	5389	8269
21	Santacruz Metro	3660	2119	5779	4794	2921	7714	5179	3580	8759
22	CSIA(Domestic)	2692	3961	6653	3109	5458	8567	3611	6689	10300
23	Sahar Road	2743	2384	5127	3730	3285	7015	4172	4026	8197
24	CSIA (International)	1712	4086	5797	2359	5630	7989	2791	6900	9691
25	Marol Naka	4654	3106	7760	6413	4280	10693	7061	5245	12306
26	MIDC	3789	2827	6615	4721	3895	8617	5087	4774	9861
27	SEEPZ	5291	3276	8567	7291	4514	11806	8036	5533	13569
	Total	100650	100649	201299	138699	138699	277398	169989	169989	339978

2.5.3 Peak Hour Section Loads

The Peak hour section loads for 2016, 2025 and 2031 horizon years are shown in **Table 2.15**.

Table 2.15: Peak Hour Section Load for Colaba - Bandra - SEEPZ Metro Corridor

Sr. No.	Station	Length (Km)	2016		2025		2031	
			Colaba - SEEPZ	SEEPZ - Colaba	Colaba - SEEPZ	SEEPZ - Colaba	Colaba - SEEPZ	SEEPZ - Colaba
1	Colaba/ Cuffe Parade	-	3666	0	5052	0	6192	0
2	Badhwar Park	1.00	6400	4252	8820	5858	10809	7180
3	Vidhan Bhavan	0.60	8066	7369	11116	10154	13623	12444
4	Churchgate Metro	0.69	8387	10770	11558	14840	14166	18188
5	Hutatma Chowk	0.82	11406	12253	16018	17184	19631	20761
6	CSTM Metro	0.85	11250	16591	15803	23162	19067	28087
7	Kalbadevi	0.94	12679	20230	17772	28578	21181	34426
8	Girgaon	0.73	14352	22395	20077	31960	23606	38572
9	Grant Road Metro	1.54	15788	23219	22056	33598	25731	40178
10	Mumbai Central Metro	0.91	16497	23284	23233	34087	27174	40278
11	Mahalaxmi Metro	1.15	17010	23005	24240	33903	28407	39252
12	Science Museum	1.10	17090	22032	24351	32762	28544	37054
13	Acharya Atrey Chowk	1.20	18238	21861	25933	32726	30183	36617
14	Worli	1.41	18462	22920	26441	34684	30706	38218
15	Siddhi Vinayak	1.56	19410	24797	27747	37472	32007	40834
16	Dadar Metro	1.28	19830	25711	28327	38930	32717	42021
17	SheetlaDevi Temple	1.77	19230	23803	27200	35801	31336	38187
18	Dharavi	1.78	18247	22617	25746	32867	30154	34591
19	Bandra Metro	1.92	15944	19898	22372	28120	26619	29273
20	Mumbai University (Kalina)	1.59	14439	16857	20298	22430	24777	23299
21	Santacruz Metro	1.22	13639	17222	18946	22732	23120	23966
22	CSIA(Domestic)	2.27	11417	14881	15784	19507	19244	20709
23	Sahar Road	1.61	10307	13928	14203	18694	17307	19912
24	CSIA (International)	1.05	7851	12458	10820	16668	13260	17828
25	Marol Naka	0.87	5778	12376	7963	16556	9759	17891
26	MIDC	1.40	3276	8755	4515	11565	5533	12575
27	SEEPZ	1.32	0	5291	0	7291	0	8036

2.5.4 Trip Length Distribution

Trip Length Distribution of passengers using Colaba – Bandra - SEEPZ Metro corridor is presented in **Table 2.16.**

Table 2.16: Trip Length Distribution for Colaba - Bandra - SEEPZ Metro Corridor

Trip Length in Km	% of Passengers
0 to 3	12
3 to 5	29
5 to 8	16
8 to 12	8
12 to 15	16
15 to 20	10
20 to 25	9
25 to 30	1
>30	100

2.5.5 Ridership For Train Operation

Based on the section-wise PHPDT figures, it is seen that the corridor has two distinct sections in terms of passenger loading – Colaba - Bandra with higher peak section loads, and Bandra – SEEPZ with comparatively lower section loads.

It is therefore suggested to have a mid-terminal facility at Bandra Metro station – which will enable differential train frequencies in these two sections.

The broad PHPDT values for the two sections considered for working on the train operation plan, rake requirement, etc. for different horizon years are presented in **Table 2.17**.

Table 2.17 : PHPDT For The Two Sections of Colaba - Bandra - SEEPZ Metro Corridor

Year	**2016**	**2025**	**2031**
	Peak Direction of Travel		
Section	**SEEPZ - Colaba**	**SEEPZ - Colaba**	**SEEPZ - Colaba**
Colaba Bandra Metro (ITO)	25000	36000	40000
Bandra Metro (ITO) - SEEPZ	16000	18000	21000

The hourly variation of the peak section load on the two sections for working on the train operation plan for different horizon is presented in Table 2.18.

2.5.6 Design Traffic

The proposed Metro corridor would however, continue to serve the City beyond 2031. Accordingly, the System and all civil structures are proposed to be designed for a design traffic load of 45000 PHPDT - with 8 car rakes having passenger capacity of 3000 (sitting – 372, standing – 2628 @ 8 passengers/ m^2).

Table 2.18 : Hourly Variation Of Peak Section Load For The Two Sections of Colaba - Bandra - SEEPZ Metro Corridor

Colaba - Bandra Section						
	2016		2025		2031	
Timings	Section Load		Section Load		Section Load	
	Colaba-Bandra	Bandra-Colaba	Colaba-Bandra	Bandra-Colaba	Colaba-Bandra	Bandra-Colaba
05:00 - 06:00	3000	4000	5000	6000	6000	8000
06:00 - 07:00	7000	9000	12000	15000	14000	17000
07:00 - 08:00	12000	17000	19000	29000	22000	32000
08:00 - 09:00	19000	25000	27000	36000	30000	42000
09:00 - 10:00	19000	25000	27000	36000	30000	42000
10:00 - 11:00	16000	22000	23000	32000	25000	37000
11:00 - 12:00	15000	19000	21000	26000	23000	28000
12:00 - 13:00	15000	16000	21000	20500	23000	22000
13:00 - 14:00	15000	16000	21000	20500	23000	22000
14:00 - 15:00	15000	16000	21000	20500	23000	22000
15:00 - 16:00	18000	16000	27000	20500	30000	22000
16:00 - 17:00	21000	17000	31000	23000	36000	25000
17:00 - 18:00	25000	19000	36000	25000	42000	30000
18:00 - 19:00	25000	19000	36000	25000	42000	30000
19:00 - 20:00	21000	16000	32000	20000	37000	25000
20:00 - 21:00	18000	13000	26000	16000	30000	20000
21:00 - 22:00	15000	9000	20000	13000	24000	15000
22:00 - 23:00	9000	6000	14000	9000	17000	11000
23:00 - 24:00	4000	4000	8000	6000	10000	8000
24:00 - 01:00	3000	3000	5000	5000	7000	6000
01:00 - 02:00	3000	3000	5000	5000	6000	6000

Bandra – SEEPZ Section

	2016		2021		2031	
Timings	Section Load		Section Load		Section Load	
	Bandra-SEEPZ	SEEPZ-Bandra	Bandra-SEEPZ	SEEPZ-Bandra	Bandra-SEEPZ	SEEPZ-Bandra
05:00 - 06:00	2500	2500	3000	3000	4000	4000
06:00 - 07:00	6000	6000	7000	7000	9000	9000
07:00 - 08:00	11000	11000	13000	13000	15000	15000
08:00 - 09:00	16000	16000	18000	18000	21000	21000
09:00 - 10:00	16000	16000	18000	18000	21000	21000
10:00 - 11:00	12000	12000	14000	14000	17000	17000
11:00 - 12:00	10000	10000	11500	11500	13500	13500
12:00 - 13:00	8500	8500	10000	10000	10000	10000
13:00 - 14:00	8500	8500	10000	10000	10000	10000
14:00 - 15:00	8500	8500	10000	10000	10000	10000
15:00 - 16:00	10000	10000	11500	11500	12500	12500
16:00 - 17:00	12000	12000	13500	13500	15000	15000
17:00 - 18:00	16000	16000	18000	18000	21000	21000
18:00 - 19:00	16000	16000	18000	18000	21000	21000
19:00 - 20:00	13000	13000	15000	15000	17000	17000
20:00 - 21:00	11500	11500	13500	13500	15000	15000
21:00 - 22:00	9000	9000	11500	11500	12500	12500
22:00 - 23:00	6000	6000	7500	7500	9000	9000
23:00 - 24:00	4500	4500	5500	5500	6500	6500
24:00 - 01:00	3000	3000	3500	3500	4000	4000
01:00 - 02:00	2000	2000	2500	2500	3000	3000

Annexure 2.1

Ta... cenario Wise Comparison: Cost of Transport Network

Scenario	Reduction in Cost by deleting some road and transit links (Rs. 1000 Crore)					Adjusted Cost of Transport Network (Rs. 1000 Crore)					Ratio to Max. Cost	Cost based Ranking of Scenario
	Road	Transit	Total	% Road	% Transit	Road	Transit	Total	% Road	% Transit		
P1E2	8.14	12.04	20.18	40.33	59.67	14.73	123.68	138.41	10.64	89.36	0.98	2
P2E1	8.34	9.05	17.39	47.97	52.03	14.53	126.67	141.20	10.29	89.71	0.99	3
P2E2	8.34	11.91	20.25	41.19	58.81	14.53	123.81	138.34	10.50	89.50	0.98	2
P3E3	6.04	11.19	17.23	35.04	64.96	16.84	124.53	141.37	11.91	88.09	1.00	3
P3E4	6.39	16.75	23.14	27.61	72.39	16.40	118.06	135.44	12.17	87.83	0.96	1
P4E3	6.38	12.97	19.35	32.95	67.05	16.50	122.74	139.24	11.85	88.15	0.98	2

Table 6-7: Scenario Wise Comparison Pass-km, Pass-hr and Average Speed: Bus and Suburban & Metro m...

Scenario	Bus			Suburban + Metro			Total (PT)			Ranking
	Pass-km (million)	Pass-Hr. (million)	Speed (kmph)	Pass-km (million)	Pass-Hr. (million)	Speed (kmph)	Pass-km (million)	Pass- Hr. (million)	Speed (kmph)	
P1E2	8.3	0.46	18.05	155.6	4.5	34.32	163.9	5.0	32.83	1
P2E1	8.3	0.46	18.05	178.2	5.5	32.23	186.4	6.0	31.15	3
P2E2	7.9	0.44	18.04	169.2	4.9	34.46	177.0	5.3	33.12	1
P3E3	7.0	0.39	17.97	166.7	4.8	34.67	173.7	5.2	33.42	1
P3E4	6.0	0.34	17.91	161.3	4.9	32.73	167.3	5.3	31.79	2
P4E3	6.7	0.37	17.95	172.0	5.3	32.58	178.7	5.7	31.62	3
Base Year	12.52	1.05	11.95	47.32	1.36	34.86	59.84	2.41	24.82	

Tab... nario Wise Comparison, Average Trip Length: Bus and Suburban Rail & Metro modes

Scenario	Pass. Trips (Million)		Trip Length (kms)		Ranking		Weighted*
	Bus	Rail	Bus	Rail	Bus	Rail	Ranking
Base Year	1.38	2.33	9.06	20.32			
P1E2	1.08	7.08	7.65	21.99	6	1	2
P2E1	1.47	7.53	5.62	23.68	5	6	3
P2E2	1.54	7.43	5.1	22.77	4	4	2
P3E3	1.56	7.38	4.46	22.6	3	3	1
P3E4	1.56	7.3	3.84	22.08	1	2	1
P4E3	1.54	7.42	4.34	23.18	2	5	2

Table 6-9: Scenario Wise Comparison Veh.-km, Veh.-hr and Average Speed: Private vehicles and IPT Modes

Scenario	Veh-Km (Million)	Veh-hrs (Million)	Avg. Speed (kmph)	% of Max Avg. Speed	Ranking
Base Year	6.25	0.20	31.35		
P1E2	13.43	0.34	39.90	82.99	3
P2E1	13.17	0.28	47.00	97.75	2
P2E2	13.23	0.28	46.94	97.63	2
P3E3	13.26	0.28	48.08	100.00	1
P3E4	13.31	0.28	46.93	97.62	2
P4E3	13.33	0.33	40.14	83.50	3

3. SYSTEM DESIGN

3.1. PERMANENT WAY

3.1.1. Choice of Gauge

Mumbai Metro Corridors I and II are being implemented with Standard Gauge (SG). With the objective of uniformity, this corridor is also proposed to be on Standard Gauge (1435mm).

3.1.2. Track Structure

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus, it is imperative that the track structure selected for Metro systems should be long lasting and requires minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The track structure has been proposed keeping the above philosophy in view.

i. General

Two types of track structures are proposed for any Metro. The normal ballasted track is suitable for At-Grade (surface) portion of Main Lines and in Depot (except inside the Workshops, inspection lines and washing plant lines). The ballastless track is recommended on Viaducts and inside tunnels as the regular cleaning and replacement of ballast at such location will not be possible.

From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose even the turnouts will have to be incorporated in LWR/CWR. The track will be laid with 1 in 20 canted rails and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

ii. Rail Section

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg. /m) rail section. Since on main lines, sharp curves and steep gradients would be present, the grade of rail on main lines should be 1080 Head Hardened as per IRS-T- 12-96. As these rails are not manufactured in India at present, these are to be imported. For the Depot lines, the grade of rails should be 880, which can be easily manufactured indigenously.

iii. Ballastless Track on Mainlines

- **Tunnels**

  In the tunnels, plinth type ballastless track can be adopted. Alternatively, Prestressed Concrete Sleepers can be fixed in second pour concrete. This type of ballastless track is preferred inside the tunnels as it absorbs the noise generated below the coaches.

iv. Ballastless Track in Depot

The ballastless track in Depot may be of the following types:

- Discretely supported on concrete/steel pedestal for inspection lines.
- Embedded rail type inside the Workshop.
- Plinth type for Washing Plant line.
- Normal Ballastless (as on viaduct) for Washing lines, Stabling and other running lines.

v. Turnouts

- From considerations of maintainability and riding comfort, it is proposed to lay the turnouts also with 1 in 20 cant. Further, it is proposed to adopt the following two types of turnouts:

  - On main lines, 1 in 9 type turnout with a lead radius of 300 metres and permissible speed on divergent track as 40 km/h (**Figure 3.1**).

  - On Depot lines, 1 in 7 type turnout with a lead radius of 140 metres and permissible speed on divergent track as 25 km/h (**Figure 3.2**).

- The Scissors cross-overs on Main Lines (1 in 9 type) will be with a minimum track centre of 4.50 m (**Figure 3.3**).

- The proposed specifications for turnouts are given below: -

  - The turnouts should have fan-shaped layout throughout the turnout so as to have same sleepers/base-plates and slide chairs for both LH and RH turnouts.

  - The switches and crossings should be interchangeable between ballasted and ballastless turnouts (if required).

- The switch rail should be with thick web sections, having forged end near heel of switch for easy connection with lead rails, behind the heel of switch. The switches should have anti creep device at heel of switch for minimising the additional LWR forces transmitted from tongue rail to stock rail.

Figure 3.1: Turnout tg. 1/9 R = 300m

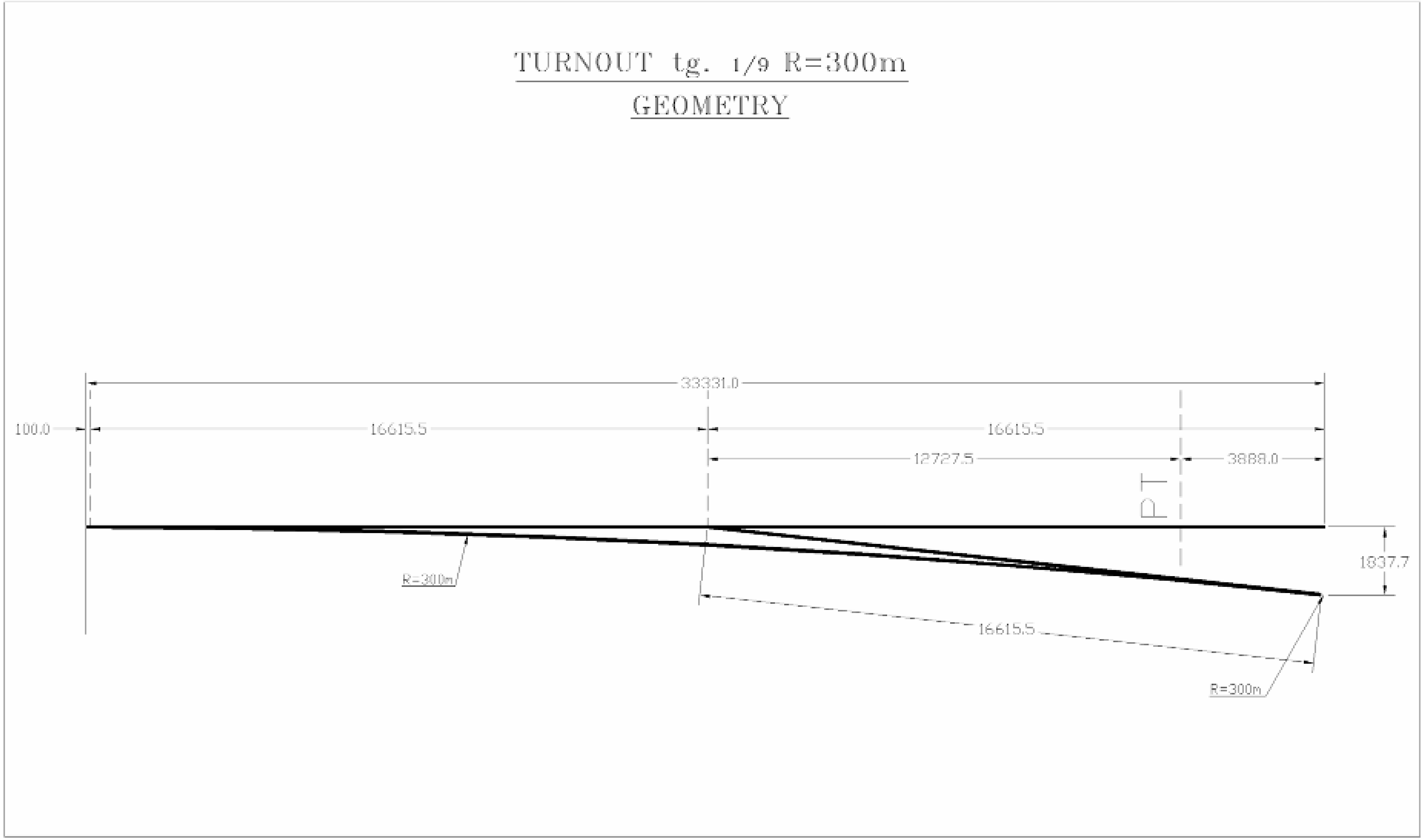


Figure 3.2: Turnout tg. 1/7 R = 140m

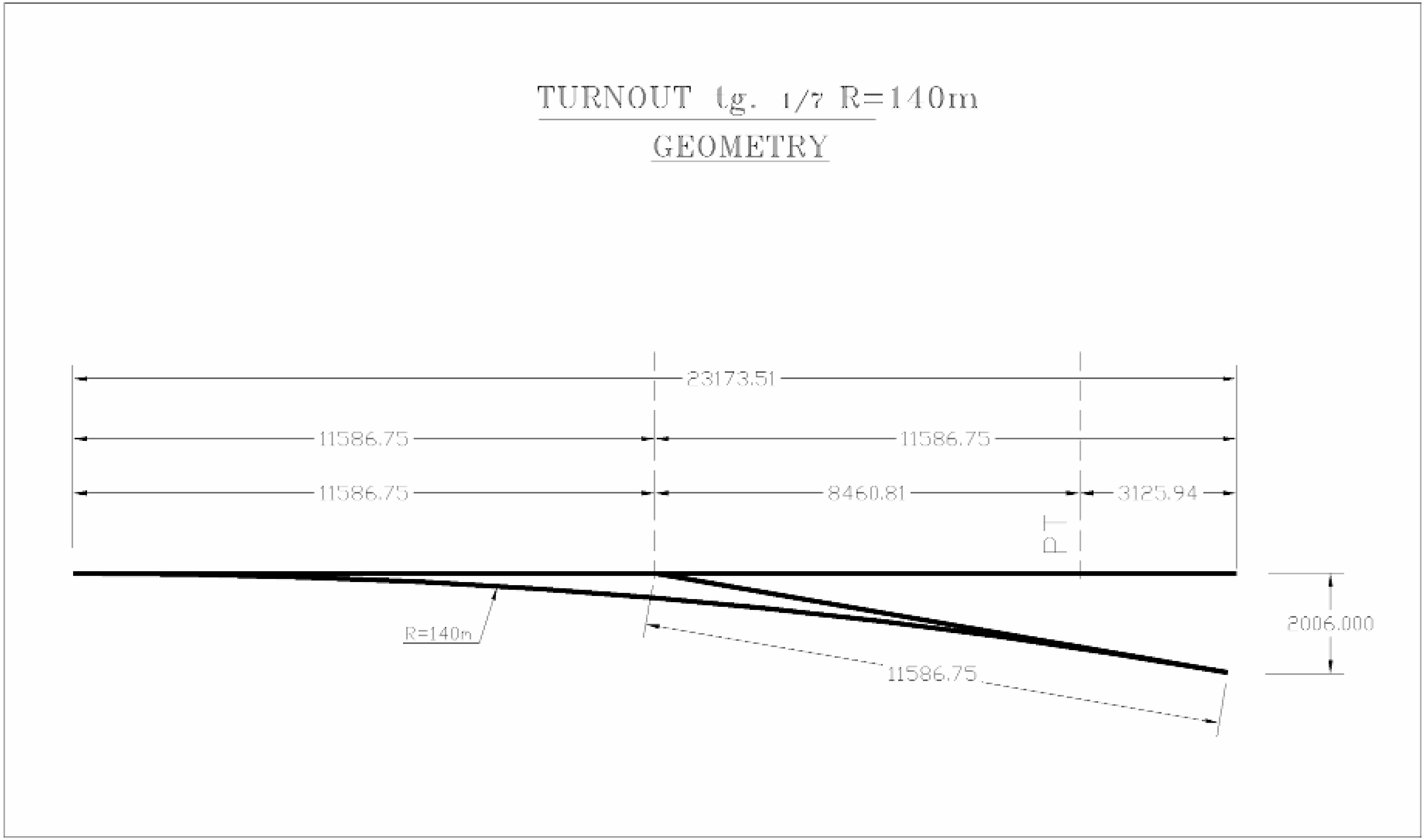
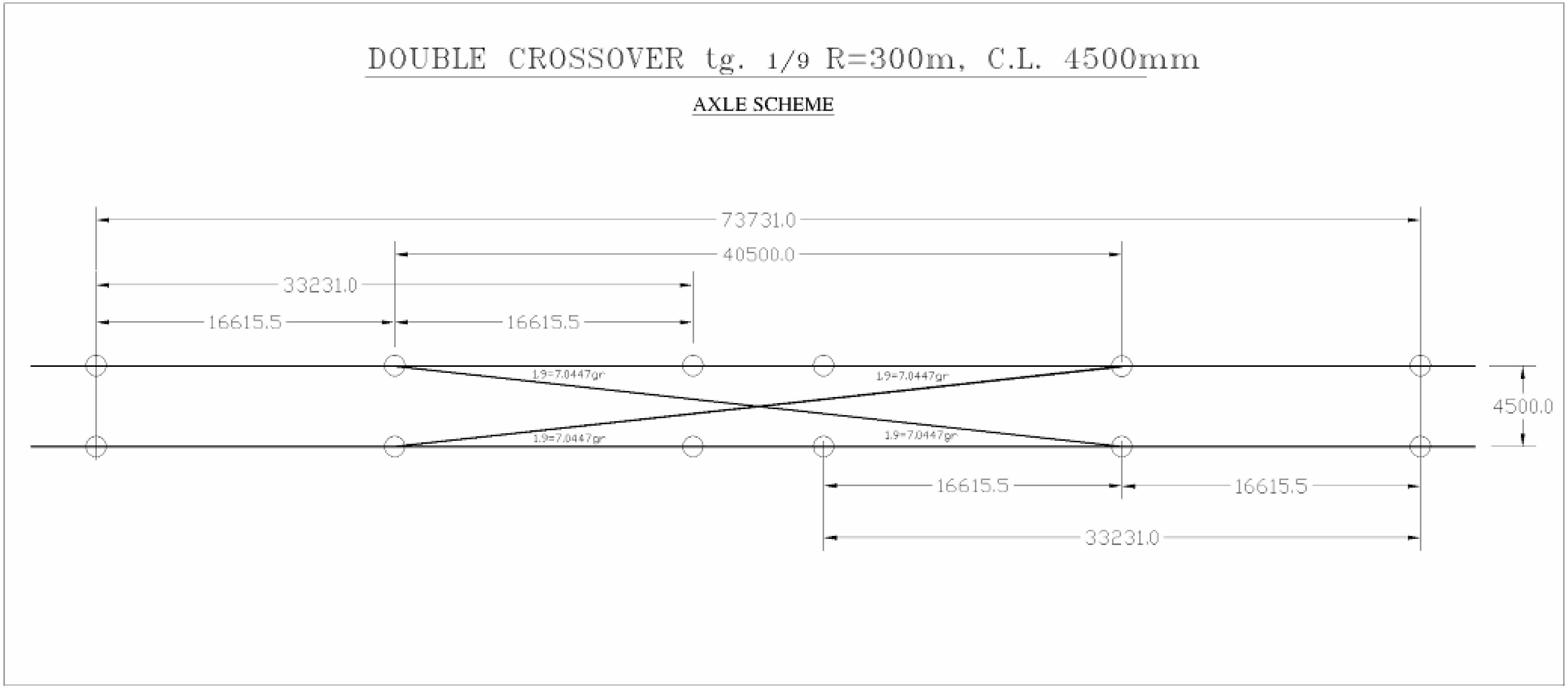


Figure 3.3: Double Crossover tg. 1/9 R = 300m, C.L. 4500 mm



- The crossings should be made of cast manganese steel and with welded leg extensions. These crossings should be explosive hardened type for main lines and without surface hardening for Depot lines.

- The check rails should be with UIC-33 rail section without being directly connected to the running rails.

vi. Buffer Stops

On main lines and Depot lines, friction buffer stops with mechanical impact absorption (non-hydraulic type) need to be provided. On elevated section the spans on which friction buffer stops are to be installed are to be designed for an additional longitudinal force of 85 T, which is likely to be transmitted in case of Rolling Stock impacting the friction Buffer Stops.

3.1.3. Rail Structure Interaction

For continuing the LWR/CWR on Viaducts, the elevated structures are to be adequately designed for the additional longitudinal forces likely to be transmitted as a result of Rail-Structure interaction. Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) also. REJ in ballasted track will be for a maximum gap of 120 mm, whereas on ballastless track, it will be of 180 mm.

3.1.4. Welding

Flash Butt Welding Technique is to be used for welding of rails. Alumino-Thermit Welding is to be done only for those joints which cannot be welded by Flash Butt Welding Technique, such as joints at destressing locations and approach welds of switches & crossings. For minimising the population of Thermit welds, mobile (rail-cum-road or portable) Flash Butt Welding Plant will have to be deployed.

3.2. TRACTION SYSTEM

Traditionally, electric traction is used in Metro systems as a prerequisite for requirement of high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz., 750V dc third rail, 1500V dc overhead catenary and 25kV ac overhead catenary system. Presently, all these three systems are in use in India (750 V dc third rail in Kolkata Metro, 1500V dc catenary in Mumbai suburban of Central & Western Railways and 25kV ac catenary in Delhi Metro & Indian Railways). 1500 V dc system of Central and Western Railways in Mumbai suburban is currently being converted to 25kV ac.

The alignment of proposed corridor is mostly underground. Keeping in view the ultimate traffic requirements, uniformity, standardization and other techno-economic considerations, ***25kV ac traction system*** is considered to be the best solution and hence, proposed for adoption. Suitable measures will be required for the mitigation of EMI & EMC caused by 25 kV single-phase traction currents.

The details of the traction system are given in Chapter 8.

3.3. SIGNALLING

3.3.1. Introduction

The signalling system shall provide the means for an efficient train control and ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network.

3.3.2. Signalling And Train Control

i. Overview

Metro carries la arge number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting ‘Distance to go’ ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems. This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in adverse weather.
- Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
- Improve maintenance of Signalling and telecommunication equipment by monitoring system status of trackside and train borne equipment and enabling preventive maintenance.

Signalling & Train Control system on the line is planned for a design headway of 2.5 minutes so as to meet sustained train operation at 3 minutes interval during peak periods.

ii. System Description and Specifications

The Signalling and Train Control system shall be as below. Sub-system/ components will conform to international standards like CENELEC, IEC, BS, IS, ITU-T etc:

a. Continuous Automatic Train Control

Continuous Automatic Train Control will consist of - ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems:

• **Automatic Train Protection (ATP)**

Automatic Train Protection is the primary function of the train control systems. This sub-system will be inherently capable of achieving the following objectives in a fail-safe manner. Line side signals will be provided at diverging routes (i.e at points & crossings), which shall serve as backup signalling in case of failure of ATP system. However, in such cases, train speed will be automatically restricted to 15-25 kmph.

- Cab Signalling
- Track Related Speed Profile generation based on line data and train data continuously along the track
- Continuous monitoring of braking curve with respect to a defined target point
- Monitoring of maximum permitted speed on the line and speed restrictions in force
- Detection of over-speed with audio-visual warning and application of brakes, if necessary
- Maintaining safety distance between trains
- Monitoring of stopping point
- Monitoring of Direction of Travel and Rollback
- Fouling protection

The ATP system shall preferably be based on well proven coded audio frequency track circuits successfully operating many metro system.

The cab borne equipment will be of modular sub-assemblies for each function for easy maintenance and replacement. The ATP assemblies will be fitted in the vehicle integrated with other equipment of the rolling stock.

• **Automatic Train Operation (ATO)**

This system will operate the trains automatically from station to station while remaining within the safety envelope of ATP and open the train doors. Driver will close the train doors and press a button when ready to depart. In conjunction with ATP/ ATS, ATO can control dwell time at stations and train running in accordance with headway/ timetable.

• **Automatic Train Supervision (ATS)**

A centralised train supervision system will be installed to facilitate the monitoring of train operation and also remote control of the station. The train supervision will log each train movement and display it on the workstations with each Traffic Controller at the OCC and on one workstation placed in the Station Control room (SCR) with each Station Controller.

The centralized system will be installed in the Operation Control Centre. The OCC will have a projection display panel showing a panoramic view showing the status of tracks, points, signals and the vehicles operating in the relevant section/ whole system. ATS will provide following main functionalities:

- Automatic Route setting
- Automatic Train Regulation
- Continuous Tracking of train position
- Display Panel & Workstation interface
- Adjustment of station dwell time
- Link to Passenger Information Display System for online information
- Computation of train schedules & Time table Local ATS (LATS) will be installed in interlocked stations.

b. Interlocking System:

- **Computer Based Interlocking (CBI)**

At all stations with points and crossings, Computer Based Interlocking (CBI) will be provided for operation of points and crossings and setting of routes.

The setting of the route and clearing of the signals will be done by workstation, which can be either locally (at station) operated or remotely from the OCC.

This sub-system is used for controlling vehicle movements into or out of stations automatically from a workstation. All stations having points and crossings will be provided with workstations for local control. Track occupancy, point position, etc. will be clearly indicated on the workstation. It will be possible to operate the workstation locally, if the central control hands over the operation to the local station. The interlocking system design will be on the basis of fail-safe principle.

The equipment will withstand tough environmental conditions encountered in a Mass Transit System. Control functions in external circuits will be proved both in the positive and negative wires. Suitable IS, IRS, BS standards or equivalent international standards will be followed in case wiring, installation, earthing, cabling, power supply and for material used in track circuits, relays, point operating machines, power supply etc.

- **Track Circuits**

Coded Audio Frequency Track Circuit will be used for vehicle detection and for transmission of data from track to train for mainline operation and audio frequency track circuit for depot operation.

- **Point Machines**

Non-Trailable Electrical Point Machine capable of operating with either 110V DC or 3-phase 380V AC will be used on main line. The depot point machine will preferably be trailable type.

iii. Standards

The following standards will be adopted with regard to the Signalling system.**Table 3.1**

Table 3.1: Standards adopted for Signalling System

Description	Standards
Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for shunting, workshop/inspection shed areas.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Track Circuit	Audio frequency Track circuits on running section, test track and in depot.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
UPS (uninterrupted power at stations as well as for OCC)	For Signalling, Telecommunications and automatic fare collection – preferably redundant.
Train protection system	Automatic Train Protection system.
Automatic train supervisory systme	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC.
Redundancy for ATP/ ATS.	Redundant Train borne equipment and ATS equipment at OCC.
Cables	Outdoor cables will be steel armoured as far as possible. Underground cables shall be low smoke zero halogen type.
Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for signal application.
Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables. CENELEC/IEEE standards to be implemented for EMC/EMI.
Train Working under emergency (ATP failure)	Running on sight with line side signal with speed automatically restricted between 15-25 kmph.
Environmental Conditions	Air-conditioners for all equipment rooms.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.

3.3.3. Space Requirement For Signalling Installations

Adequate space for proper installations of all Signalling equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment shall be generally 60 sq.m for UPS Room (common for signaling and telecom), 60 sq.m for Signalling equipment room at interlocked station with points & 30 sq.m at non-interlock stations for Signalling. These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC and the Depot, the areas required shall be as per the final configuration of the equipments and network configuration keeping space for further expansion. For laying the cable along with track a viaduct size 500x250 mm to be provided at opposite side of power cable and 200x250 mm each side along the track for optic fibre cable and connectivity from viaduct to equipment room to be provided.

3.3.4. Maintenance Philosophy For Signalling Systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments will be followed. Card / module / sub-system level replacement shall be done in the field. Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.

The defective card/ module / sub-system taken out from the section will be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the faults and undertake minor repairs. Cards / modules / equipments requiring major repairs as specified in suppliers documents will be sent to manufacturer's workshop.

3.4. TELECOMMUNICATION

3.4.1. Introduction

The telecommunication system acts as the communication backbone for Signalling systems and other systems such as Power SCADA, AFC etc and provides telecommunication services to meet operational and administrative requirements of metro network.

The telecommunication facilities proposed are helpful in meeting the requirements for

i. Supplementing the Signalling system for efficient train operation.
ii. Exchange of managerial information
iii. Crisis management during emergencies
iv. Passenger information system
v. Providing communication path for other systems
vi. CCTV image capturing at station for safety and security requirement of Metro area.

The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchange
- Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.

- Centralised Clock System
- Instant on line Radio Communication between Central Control and Moving Cars and maintenance personnel.
- Data Channels for Signalling, Power SCADA, Automatic Fare Collection etc.
- Surveillance system for security of Metro Area
- Access control for equipment/operator rooms

3.4.2. Telecommunication System And Transmission Media

i. Optical Fibre Cable - Main Telecommunication Bearer

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system. Considering the channel requirement and keeping in view the future expansion requirements a 96 Fibre optical fiber cable is proposed to be laid in ring configuration with path diversity.

SDH STM-4 based system shall be adopted with SDH nodes at every station and OCC. Access at 2MB level will be adopted for the each node. . Further core routers and switches shall be provided for GE network at stations and at OCC to cater for very high bandwidth consuming system like CCTV etc.The same Giga Ethernet (GE) backbone shall be used to carry the traffic of power SCADA, BMS and AFC. GE will support VLAN, QOS, LACP, SNMP as minimum.

ii. Telephone Exchange

For an optimized cost effective solution Small exchanges of 128 port each shall be planned at each station and a 256 Port Exchange at the Terminal Station and the OCC. The Exchanges will serve the subscribers at all the stations and OCC. The exchanges will be interconnected at multiple 2 MB level through optical fibre cable. The Exchanges shall be software partitioned for EPABX and Direct Line Communication from which the phones shall be extended to the stations. Centralized recording system for console and Tetra channel is to be provided.

iii. Mobile Radio Communication

Mobile Radio communication system having 8 channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. This system now is widely adopted for mobile radio communication in metro / rapid transit services abroad. All the stations and the OCC will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets. These persons will be able to communicate with each other as well as with central control. To provide adequate coverage, based on the RF site survey to be carried out, base stations for the system will be located at sites conveniently selected after detailed survey.

The frequency band for operation of the system will be that for TETRA in 400/800 MHz band as per the availability and preferably same as being used in other Corridors.

The system shall provide Instant mobile radio communication between the motorman of the moving cars from any place and the Central Control .The motorman can also contact any station in the network through the central control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance.

iv. Passenger Announcement System

The system shall be capable of announcements from the local station as well as from OCC. Announcements from OCC will have over-riding priority in all announcements.

v. Centralised Clock System

This will ensure an accurate display of time through a synchronization system of slave clocks driven from a Master Clock at the operation control center. The Master Clock signal shall also be required for synchronization of SDH and Exchanges. The System will ensure identical display of time at all locations. Clocks are to be provided at platforms, concourse, Station Master's Room and other service establishments and passenger supervisory booth have the top most priority over OCC and station.

vi. Passenger Information Display System

These shall be located at convenient locations at all stations to provide bilingual visual indication of the status of the running trains and will typically indicate information such as destination, arrival/departure time, and also special messages in emergencies. The boards shall be provided at all platforms and concourses of all stations.

vii. **CCTV System**

The CCTV system shall ensure real time surveillance of a public and selected areas as well as video recording for post event analysis. Those CCTV shall be treated in all station and depot areas to cover train movement and operational areas and also areas required for public safety and security.

viii. Network Monitoring and Management

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a network management system (NMS), which will help in diagnosing faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance. The proposed NMS system will be covering radio communication, Optical Fiber Transmission system and Telephone Exchange.

3.4.3. Standards

The standards proposed to be adopted for telecommunication systems are shown in **Table 3.2:**

Table 3.2 Standards Proposed for Telecommunication Systems

System	Standards
Transmission System	SDH and GE based for the entire telecom network.
Transmission Media	Optical Fibre system as the main bearer for bulk of the telecommunication network,
Telephone Exchange	EPABX of minimum 128 ports is to be provided at all Stations and an Exchange of 256 Ports to be provided at Terminal Station & OCC.
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel and central control.
Train Destination Indicator System	LED/LCD based boards with adequate visibility to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and also special messages in emergencies.
Centralized clock system	Accurate display of time through a synchronisation system of slave clocks driven from a master clock at the OCC and sub – master clock in station. This shall also be used for synchronisation other systems.
Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement.
Redundancy (Major System)	Redundancy on Radio base station equipment. Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.
Environmental Conditions	All equipment rooms to be air-conditioned.
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

3.4.4. Space Requirement For Telecom Installations

Adequate space for proper installations of all Telecommunication equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for S & T equipment shall be generally 60 sq.m each for Telecom Room and 60 sq.m. for UPS Room (common for signal and telecom). These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC, the areas required shall be as per the final configuration of the equipments and network configuration keeping space for further expansion.

3.4.5. Maintenance Philosophy For Telecom Systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments shall be followed. Card / module / sub-system level replacement shall be done in the field. Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.
The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the

faults and undertake minor repairs. Cards / modules / equipments requiring major repairs as specified in suppliers documents shall be sent to manufacturer's workshop.

3.4.6. Training

Training facilities for S&T/OCC/SCR staff & motor man specially on new technology systems like CATC etc. are to be developed for general appreciation, to develop job specific skills and for refresher courses. A training area of minimum 220 sq. mtr. Shall

3.5. AUTOMATIC FARE COLLECTION

3.5.1. Introduction

Mass Rapid Transit Systems handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. In view of above, computer based automatic fare collection system is proposed.

AFC system proves to be cheaper than semi-automatic (manual system) in long run due to reduced manpower cost for ticketing staff, reduced maintenance in comparison to paper ticket machines, overall less cost of recyclable tickets (Smart Card/Token) in comparison to paper tickets and prevention of leakage of revenue. Relative advantages of automatic fare collection system over manual system are as follows:

i. **Manual fare collection systems have the following inherent disadvantages:**

- Large number of staff is required for issue and checking of tickets.
- Change of fare structure is time consuming as has to be done at each station.
- Manipulation possible by jamming of mechanical parts.
- Staff and passenger interaction leading to more chances of confrontation.
- 100% ticket checking at entry / exit impossible.

ii. **Automatic fare collection systems have the following advantages:**

- Less number of staff required.
- Fully closed and gated system.
- Less possibility of leakage of revenue due to 100% ticket check by control gates.
- Recycling of ticket fraudulently by staff avoided.
- Efficient and easy to operate, faster evacuation both in normal and emergency.
- System is amenable for quick fare changes. It can handle multi fare tables.
- Management information reports generation easy.
- System has multioperator capabilities. Same Smart Card can be used for other applications also, such as Buses, Tram, other Metro Operator, and Banks etc.
- Revenue between different operators shared easily by using CCHS.
- More security in H/W and S/W level, so less no. of chance of fraud by Hackers.
- Park & ride equipment facilities also linked with AFC system for automatic parking facility for smart card holders.

- AFC systems are the worldwide-accepted systems for Metro environment.

The proposed ticketing system shall be of Contact less Smart Token/ Card type. The equipments for the same shall be provided at each station Counter/Booking office and at convenient locations and will be connected to a local area network with a computer in the Station Master's room. Equipment and installation cost of Contact less Smart Card /Token based AFC system is similar to magnetic ticket based AFC system, but Contactless system proves cheaper due to reduced maintenance, less wear and tear and less prove to dusty environment.

iii. Choice of Control Gates

Retractable flap type or Control Gates are proposed.

iv. Passenger Operated Machine / ticket Vending Machine (TVM)

Space for provision of Passenger Operated Machines (Automatic Ticket Dispensing Machines) for future, shall be provided at stations.

3.5.2. Standards

The standard proposed for AFC systems are shown in **Table 3.3:**

Table 3.3 Standards Proposed for AFC Systems

Standards	Description
Fare media	Contactless smart token – For single journey. Tokens are captured at the exit gate. Contactless smart card – For multiple journeys. Contactless readers shall be as per ISO 14443 standard.
Gates	Computer controlled retractable flap/turnstile type automatic gates at entry and exit. There will be following types of gates: Entry Exit Reversible Disabled – Wide reversible gate for disabled people.
Station computer, Central computer and AFC Net work	All the fare collection equipments shall be connected in a local area network with a station server controlling the activities of all the machines. These station servers will be linked to the AFC central computer situated in the operational control centre through the optic fibre communication channels. The centralized control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
Ticket office machine (TOM/EFO)	Computerized Ticket office machine shall be installed in the stations for selling cards/ tokens to the passengers.
TVM	It can sale single ride tickets. Additional loading facility can also provide.
Ticket Readers	Ticket reader shall be installed near EFO for passengers to check information stored in the token / cards.
Portable card decoder (PTD)	It can be provided to check information of cards & tokens in the running train.
UPS	Common UPS of S&T system will be utilized.
Maintenance philosophy	Being fully Contactless systems, manpower requirement for maintenance is much less compared to system with magnetic tickets. However, adequate facilities to be provided similar to that of S&T systems.

3.5.3. Integration of AFC with other lines and modes of transport

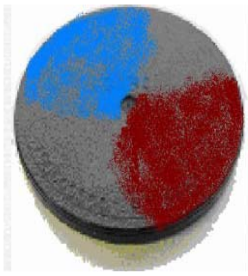
In Mumbai, different metro lines may be constructed and operated by different operators. In view of passenger convenience and operational efficiency, it is proposed that AFC system for different metro lines should be integrated and smart card based fare products should be inter-operable. AFC system shall take into account revenue sharing mechanism among different operators based on journeys performed at each system. The single ride tickets (tokens) may not be inter-operable and limited to each operators system.

The proposed AFC system shall provide interfaces to other operators such as suburban rail, bus, parking, toll etc. so that these systems may also be integrated with common smart card based fare products. Hence, passengers need not carry different cards for different applications.

Entry/ Exit Gates

Ticket Collecting System

Contact Less Smart Card



Contact Less Smart Token

TVM

Ticket Card Reader

3.6. ROLLING STOCK

Rolling Stock proposed for Colaba – Bandra – SEEPZ Metro will be similar to Rolling Stock of Line - I of Mumbai Metro and Delhi Metro. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed for the present corridor are presented in **Table 3.4**; the basis of which is given in the following paragraphs.

Table 3.4: Broad Features of Rolling Stock

S. No.	Parameter	Colaba – Bandra – SEEPZ Corridor
1	Vehicle dimensions	
	Length (including coupler)	DT-M-T-M-T-M-M-DT : 178360 mm
	Width	3200mm
	Height	4118mm
2	Coach construction	Lightweight stainless steel body
3	Tare Weight	DT (42.0T), T (42.0T), M (42.0T)
4	Axle load	17 T
5	Propulsion system	3 phase drive system with VVVFcontrol
6	Type of traction supply	25kV ac Overhead collection

3.6.1. Optimization of Coach Size

The Corridor Colaba – Bandra – SEEPZ Metro Line is completely underground. Considering the clearances and also the space required for service and cables etc., the coach with following principal dimensions has been prescribed.

Table 3.5: Size of the Coach

Car	Length	Width at Door	Height over AC portion of Roof
Driver Trailer car	21.84 m	3.2 m	3.9 m
Trailer/Motor car	21.74 m	3.2 m	3.9 m

Principal dimensions are shown in **Figure 3.7** and **3.8.**

3.6.2. Passenger Carrying Capacity

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibule to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 3 persons per square meter of standing floor area in normal state, 6 persons in crush state and 8 persons in dense crush state of peak hour.

Therefore, Driving Trailer with 21.84 m car body length, with 3.2 m car body width and longitudinal seat arrangement conceptually have the capacity of 43 seated, 239 standing thus a total of 282 passengers for a car, and a Motor car with 21.74 m car body length, with 3.2 m car body width and longitudinal seat arrangement conceptually have the capacity of 50 seated, 257 standing thus a total of 307 for a car is envisaged considering a standee area of 6 person/sq. meter. **Table 3.6** shows these figures.

Table 3.6: Carrying Capacity of Mass Rail Vehicles

	Driving Trailer car		Non-driving Trailer car / motor car		4 car Train	6 car Train	8 car Train
	Normal	**Crush**	**Normal**	**Crush**	**Crush**	**Crush**	**Crush**
Seated	43	43	50	50	186	286	386
Standing	**120**	239	**129**	257	992	1506	2020
Total	**163**	282	**179**	307	1178	1792	2406

NORMAL-3 Per/sqm of standee area, CRUSH-6 Per/Sqm of standee area

3.6.3. Weight

The weights of motor cars and trailers are estimated in **Table 3.7**, considering the average passenger weight as 60 kg.

Table 3.7: Weight of Mass Rail Vehicles (TONS)

Description	DTC	TC	MC
TARE	42	42	42
Passenger			
(Normal)	9.8	10.7	10.7
(Crush)	16.9	18.4	18.4
Gross			
(Normal)	51.8	52.7	52.7
(Crush)	58.9	60.4	60.4

Heavy rush of passenger, having 10 standees per sq. meter can be experienced occasionally. As done in DMRC, it will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should therefore be designed for 17 T axle load.

3.6.4. Coach design and basic parameters

The important criteria for selection of rolling stock are as under:

i. Proven equipment with high reliability
ii. Passenger safety feature
iii. Energy efficiency
iv. Light weight equipment and coach body
v. Optimised scheduled speed
vi. Aesthetically pleasing Interior and Exterior
vii. Low Life cycle cost
viii. Flexibility to meet increase in traffic demand

The controlling criteria are reliability, low energy consumption, light weight and high efficiency leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

3.6.5. Required Power

For a typical average intersection distance of 1 Km, the running time will be 82.5 sec to 72.85 sec to achieve schedule speed of 30 KMPH with dwell station time of 30 sec. To achieve this running time between stations, the following values of acceleration and deceleration were assumed in consideration of riding comfort, adhesion and requirement of makeup time.

- Max. Acceleration: **0.78 m/s2**
- Max. Deceleration **1.0 m/s2 (Normal brake)**
- More than **1.3 m/s2 (Emergency brake)**

Figure 3.4: Simplified Velocity – time operation curve

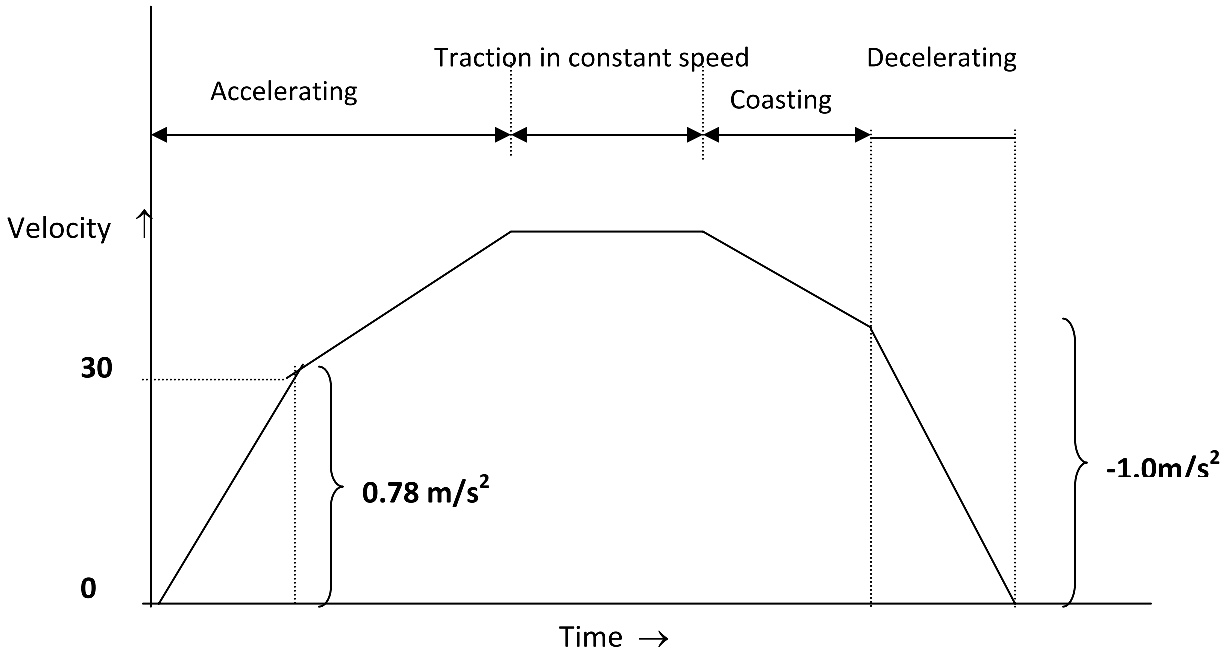
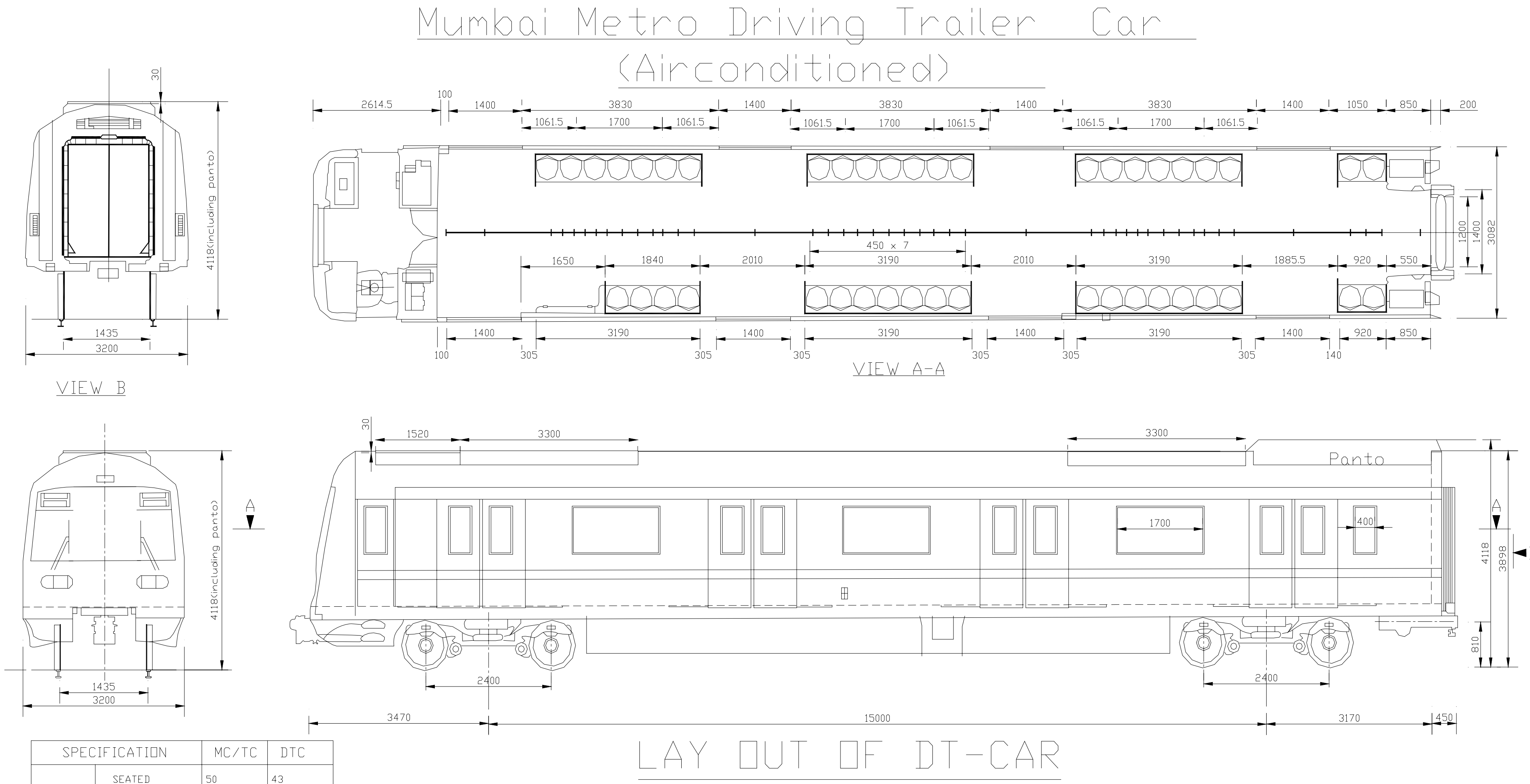
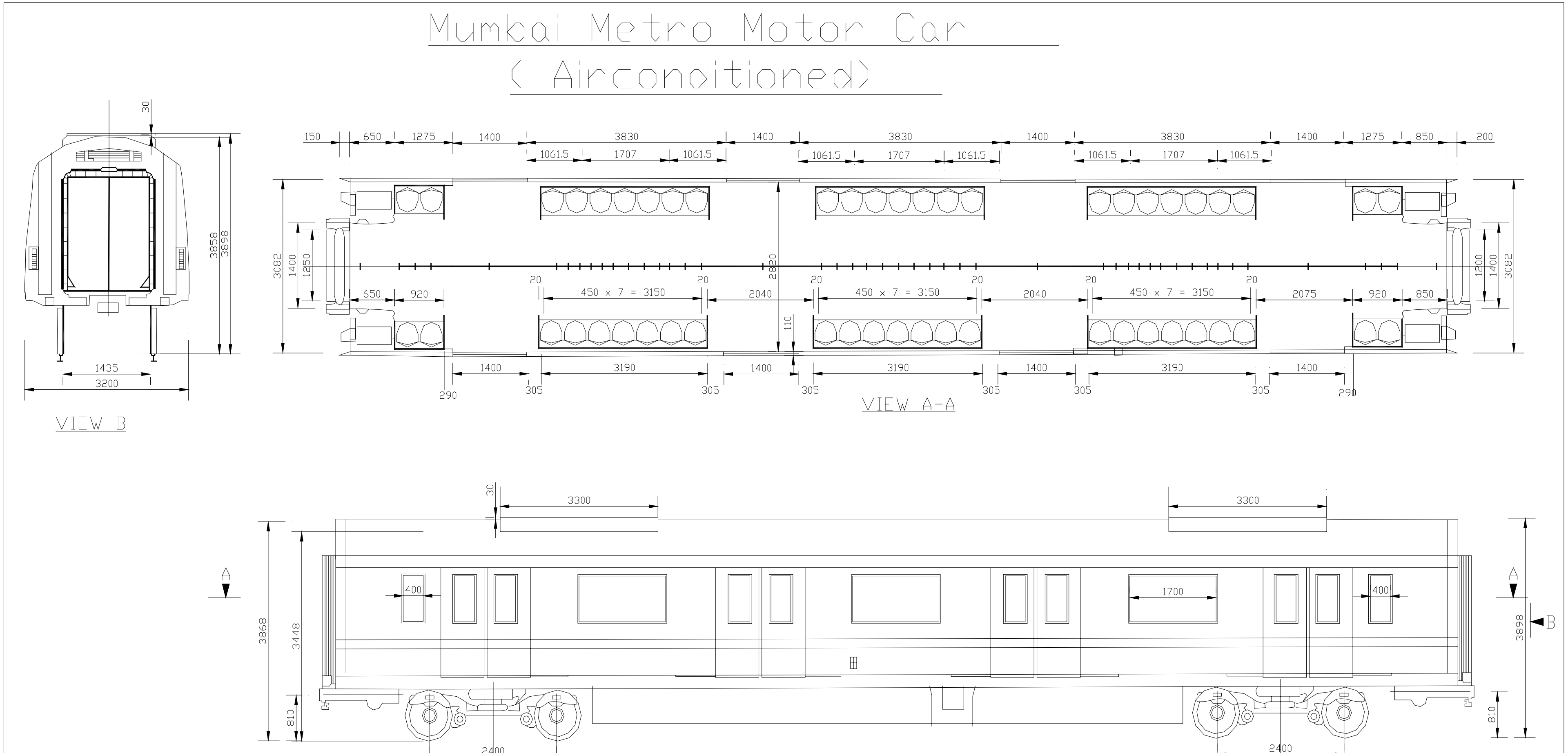


Figure 3.5: Layout of DT-Car



SPECIFICATION		MC/TC	DTC
PASSENGER CAPACITY	SEATED	50	43
	STANDEES (6 PERSONS/M^2)	257	239
	TOTAL	307	282
MAXIMUM DESIGN SPEED		90KM/HOUR	
MAXIMUM OPERATIONAL SPEED		80KM/HOUR	
NOMINAL VOLTAGE		25 KV AC	

Figure 3.6: Layout of M-Car



SPECIFICATION		MC/TC	DTC
PASSENGER CAPACITY	SEATED	50	43
	STANDEES (6 PERSONS/M^2)	257	239
	TOTAL	307	282
MAXIMUM DESIGN SPEED		90KM/HOUR	
MAXIMUM OPERATIONAL SPEED		80KM/HOUR	
NOMINAL VOLTAGE		25KV AC	

3.6.6. Selection of Technology

i. Low life cycle cost

The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems. It is possible to achieve these objectives by adopting suitable proven technologies. The selection of following Technologies has been adopted to ensure low life cycle cost.

ii. Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs which may have to be carried out up to 4-5 times during the service life of these coaches. It is now standard practice to adopt stainless steel or aluminium .The car bodies with aluminium requires long and complex extruded sections which are still not manufactured in India. Therefore aluminium car body has not been considered for use. Stainless steel sections are available in India and therefore Stainless steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during the service life of the cars.

The stainless steel car body leads to energy saving due to light weight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti corrosive properties as well as an improvement of riding comfort and safety in case of crash or fire. A design life of 30 years for coach has been recommended.

iii. Bogies

Bolster less light weight bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000km. The use of air spring at secondary stage is considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. The perturbation from the track are also dampened inside the car body on account of the secondary air spring along with suitable Vertical Hydraulic Damper. The primary suspension system improve the curve running performance by reducing lateral forces through application of conical rubber spring . A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

iv. Braking System

The brake system shall consist of –

i. An electro-pneumatic (EP) service friction brake

ii. A fail safe, pneumatic friction emergency brake

iii. A spring applied air-release parking brake

iv. An electric regenerative service brake

v. Provision of smooth and continuous blending of EP and regenerative braking

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology. The regenerative braking should have air supplement control to bear the load of trailer car. In addition, speed sensors mounted on each axle control the braking force of the axles with anti skid valves, prompting re-adhesion in case of a skid .The brake actuator shall operate either a tread brake or a wheel disc brake.

v. Propulsion System Technology

In the field of Electric Rolling Stock, DC series traction motors have been widely used due to its ideal characteristics and good controllability for traction applications. But these required intensive maintenance because of commutators and electro-mechanical contactors, resistors etc.

The brush less 3 phase induction motors has now replaced the d.c. series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase a.c. drive and VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

For Mumbai Mass Rapid Transit System, three phase AC traction drive that are self ventilated, highly reliable, robust construction and back up by slip/slid control have been recommended for adoption. Converter and Inverter should be IGBT based. The advanced IGBT contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. The inverter unit uses optical fiber cable to connect the control unit to the gate interface. The optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in Trains of Mumbai MRTS.

vi. Interior and gang ways

The passenger capacity of a car is maximized in a Metro System by providing longitudinal seats for seating and utilizing the remaining space for standing passenger. Therefore all the equipments are mounted on the under frame for maximum space utilization. The gangways are designed to give a wider comfortable standing space during peak hours along with easy and faster passenger movement especially in case of emergency.

vii. Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach have been considered. These doors shall be of such dimensions and location that all the passenger inside the train are able to evacuate within least possible time without conflicting movement .As the alignment passes through elevated section at 10 to 12 meters above ground, automatic door closing mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically by a switch in Driver cab. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors. The door shall be of Plug in Type as this has the advantage of being flush with coach body when closed giving it a stream line look apart from increasing the available space along width inside the coach.

viii. Air –conditioning

With passenger loading of 6 persons /m^2 for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, the air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of automatically controlling interior temperature throughout the passenger area at all times under varying ambient condition up to full load. For emergency situations such as power failure or both AC failures etc ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

ix. Cab Layout

The modern stylish driver panel shall be FRP moulded which give maximum comfort and easy accessibility of different monitoring equipments to the driver along with clear visibility .The driver seat has been provided at the left side of the cabin.

3.6.7. Communication

The driving cab of the cars are provided with continuous communication with base Operational Control Center and station control for easy monitoring of the individual train in all sections at all the time. Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars which permit conversation between passengers and the drivers in case of any emergency.

3.6.8. Noise and Vibration

The train passes through heavily populated urban area .The noise and vibration for a metro railway become important criteria from public acceptance view point. The sources of noise are:

i. Rail-wheel interaction
ii. Noise generated from equipment like Blower, Compressor, air conditioner, door, Inverter etc.

iii. Traction motor in running train. For elimination and reduction of noise following feature are incorporated:-

- Provision of anti drumming floor and noise absorption material
- Low speed compressor , blower and air conditioner
- Mounting of under frame equipments on anti-vibration pad
- Smooth and gradual control of door
- Provision of GRP baffle on the via-duct for elimination of noise transmission
- Provision of sound absorbing material in the supply duct and return grill of air conditioner
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes

The lower vibration level can be achieved by provision of bolster less type bogies having secondary air spring.

3.6.9. Passenger Safety Features

i. ATP/ATO

The rolling stock is provided with Continues Automatic Train Protection and Automatic Train Operation to ensure absolute safety in the train operation. It is an accepted fact that the 60-70% of accidents take-place on account of human error. Adoption of this system ensures freedom from human error. The on board computerized ATC system compare and verify the continuous data like speed etc. for safest train control

ii. Fire

The rolling stock is provided with fire retarding materials having low fire load, low heat release rate, low smoke and toxicity inside the cars. The electric cables used are also normally low smoking zero halogen type which ensures passenger safety in case of fire.

iii. Crash worthiness features

The rolling stock is provided with inter car couplers having crashworthiness feature which reduces the severity of injury to the passengers in case of accidents.

iv. Gangways

Broad gangways are provided in between the cars to ensure free passenger movement between cars in case of any emergency.

Figure 3.7: Interior View of Metro Rail

Figure 3.8: Gangways in Metro Rail

Figure 3.9: Passenger Doors

Figure 3.10: Driving Cab

3.7. VENTILATION AND AIR-CONDITIONING SYSTEM

The details of the Ventilation and Air-conditioning (VAC) system requirements for the underground sections of the proposed corridor includes the following:

- Station Air-conditioning System
- Ventilation System for station plant rooms (ancillary spaces)
- Station Smoke Management System
- Tunnel Ventilation System

3.7.1. Need For Ventilation And Air Conditioning

The underground stations of the Corridor are built in a confined space. A large number of passengers occupy concourse halls and the platforms, especially at the peak hours. The platform and concourse areas have a limited access from outside and do not have natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the authority's staff;
- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing;
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way;
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates, etc. working in the stations;
- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

This large quantity of heat generated in underground stations cannot be extracted by simple ventilation, especially when the outdoor air temperature and humidity is high. It is, therefore, essential to provide mechanical cooling in order to remove the heat to the maximum possible extent. As the passengers stay in the stations only for short periods, a fair degree of comfort conditions, just short of discomfort are considered appropriate.

3.7.2. Sub Soil Temperature

The temperature conditions of sub-soil play a vital role in the system design of the underground stations. It is also expected that water table surrounding the underground alignment is not very much below the surface level, thereby facilitating adequate heat exchange between the tunnel structures and soil.

3.7.3. Internal Design Conditions In Underground Stations

With hot and humid ambient conditions of Mumbai during the summer and monsoon months, it is essential to maintain appropriate conditions in the underground stations in order to provide a 'comfort-like' and pollution-free environment. The plant capacity and design of VAC system needs to be optimized for the designed inside conditions.

The Indian Standards & Codes, which pertain to office-buildings, commercial centres and other public utility buildings, have no guidelines on temperature standards to be maintained for the underground mass rapid transit systems as yet. The standards used for buildings cannot be applied straightaway for the underground spaces, because the patrons will stay for much shorter durations in these underground stations.

The comfort of a person depends on rapidity of dissipation of his body heat, which in turn depends on temperature, humidity and motion of air in contact with the body. Body heat gets dissipated by the process of evaporation, convection and conduction. Evaporation prevails at high temperature. Greater proportion of heat is dissipated by evaporation from the skin, which gets promoted by low humidity of air. The movement of air determines the rate of dissipation of body heat in the form of sensible and latent heat.

There are different comfort indices recognized for this purpose. The 'Effective Temperature' criterion was used in selecting the comfort conditions in earlier metro systems, including the north-south section of Kolkata Metro. In this criterion, comfort is defined as the function of temperature and the air velocity experienced by a person. More recently a new index named RWI (Relative Warmth Index) has been adopted for metro designs worldwide. This index depends upon the transient conditions of the metabolic rate and is evaluated based on the changes to the surrounding ambience of a person in a short period of about 6 to 8 minutes. It is assumed that during this period human body adjusts its metabolic activities. Therefore in a subway system where the train headway is expected to be six minutes or less, RWI is the preferred criterion.

3.7.4. Design Parameters For VAC System

Based on the reasons stated in the previous sections. The following VAC system design parameters are assumed in the present report.

(1) <u>Outside ambient conditions:</u>

This is based upon ASHRAE recommended design conditions for 2% and 1% criteria, as under

	2% Criterion	1% Criterion
Summer:	33.2 DB, 24.0 WB; (72.4 kJ/Kg)	34.0 DB, 23.3 WB; (69.0 kJ/kg)
Monsoon:	30.9 DB, 27.1 WB; (85.2 kJ/Kg)	31.3 DB, 27.4 WB; (87.5 kJ/kg)

For the proposed underground corridor in Mumbai, it is suggested to use 2% criteria, which is defined as the conditions, when the DB or WB temperatures are likely to exceed for only 2% of the total time.

(2) Inside design conditions:

Platform areas	–	27 deg. C at 55 % RH
Concourse	–	28 deg. C at 60% RH

(3) Tunnel design conditions

Normal conditions	–	Max. DB 40 deg. C
Congested conditions	--	Max. DB 45 deg. C

(4) Minimum fresh air – 10 % or 18 CMH (m^3/h) (in station public areas).

3.7.5. Design Concepts For VAC System

There are various VAC design concepts technically feasible in a subway system that can provide and maintain acceptable subway environment conditions under different requirement and constraints. These are: Open type; Closed type; Mid - Tunnel Cooling; Semi Transverse Ventilation; Use of jet fans; use of mid-shafts; platform screen doors etc. An overview of VAC systems in other metros like Jubilee line extension, Bangkok, etc. that have similar climatic behaviour and ambient conditions have provided valuable information in deciding VAC concept for Mumbai Underground Corridor. The experience available from the design of VAC system for Delhi Metro also provides key guidelines.

From the experience of DMRC, for such conditions it can be concluded that with open shaft system the piston effects can be sufficient to maintain acceptable conditions inside the tunnel, as long as the ambient DB temperature is below 33^0C. When the outside temperature is higher than 33^0C, the tunnel shafts should be closed to prevent any further exchange of air with atmosphere. The station premises (public areas) can be equipped with separate air-conditioning system during the summer and monsoon months to provide acceptable environment for patrons. There shall be provision of Trackway Exhaust System (TES) by which platform air can be re-circulated. The train cars reject substantial heat inside subway. When the trains dwell at the stations, TES would capture a large portion of heat released by the train air-conditioners mounted on the roof tops and under gear heat because of braking, before it is mixed with the platform environment.

The train heat generated inside the tunnel sections would be removed by the train piston action. It is envisaged that for the design outside conditions, it may not be necessary to provide forced ventilation using Tunnel Ventilations Fans for normal operating conditions. The number of shafts required would be two or three depending on the inter-station distances. The two shafts would be at the end of the stations and the third shaft, if required, can be built at the mid-tunnel section. These end-shafts at the stations also serve as Blast Relief Shafts, i.e. the piston pressure is relieved to the atmosphere before the air-blast reaches the station. All these shafts are connected to the tunnels through dampers. The dampers are kept open when the exchange of air with the atmosphere is permitted (Open system). For the closed system, the shaft dampers can be in closed mode and the displaced air is dumped in the adjacent tunnel.

Generally each tunnel ventilation shaft has a fan room in which there are two fully reversible tunnel ventilation fans (TVF) are installed with isolation dampers. These dampers are closed when the fan is not in operation. There is a bypass duct around the fan room, which acts as a pressure relief shaft when open during normal conditions, and enables the flow of air to bypass the TV fans, allowing air exchange between tunnels with flows generated by train movements.

Dampers are also used to close the connections to tunnels and nozzles when under different operating conditions. The details for the shaft sizes, airflow exchange with the atmosphere, fan capacities can be estimated in more accurate manner with the help of Computer Simulations during the detailed design stage.

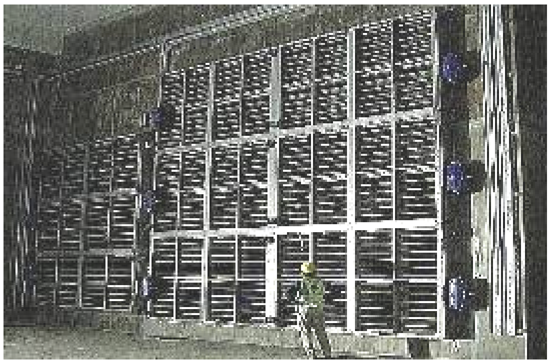


Fig 3.11: Tunnel Ventilation Dampers

3.7.6. Track Way Exhaust System (TES)

The TES is to be installed in the trainways of each station to directly capture heat rejected by the vehicle propulsion, braking, auxiliary and air conditioning systems as the train dwells in the station.The TES includes both an under platform exhaust (UPE) duct and an Over-trackway (OTE) exhaust duct. The TES uses ducts formed in the under platform void and over the trackway. Exhaust intakes are to be located to coincide with the train-borne heat sources.

Fig 3.12: Trackway Exhaust Fan

3.7.7. Tunnel Ventilation System (TVS)

The TVS is provided in a Subway system essentially to carry out the following functions:

a) Train Pressure relief during normal operation

b) Ventilation during maintenance periods, if required

c) Removal of smoke during emergency conditions

d) Maintenance of smoke free evacuation route and provision

Fig 3.13: Tunnel Ventilation Fan

of adequate fresh air during fire related emergencies.

There are various operating modes (scenarios) for the Tunnel Ventilation system. These are described as under:

NORMAL CONDITIONS

Normal condition is when the trains are operating to timetable throughout the system, at prescribed headways and dwell times, within given tolerances. The primary source of ventilation during normal conditions is generated by the movement of trains operating within the system and, in some cases, the trackway exhaust system.

During summer and the monsoon seasons, the system will be functioning essentially with the station air conditioning operating. The vent shafts to the surface will enable the tunnel heat to be removed due to train movements. The platform air captured by the trackway exhaust system shall be cooled and recirculated in the station. For less severe (i.e. cool) environmental conditions (or in the event of an AC system failure), station air conditioning will not be used and ventilation shafts will be open to atmosphere (open system) with the trackway exhaust system operating. For cold conditions, the closed system or open system mode may be used, but without any station air conditioning. System heating is achieved by the train heat released into the premises.

CONGESTED CONDITIONS

Congested conditions occur when delays cause disruption to the movement of trains. It is possible that the delays may result in the idling of a train in a tunnel section. Without forced ventilation, excessive tunnel temperatures may result reduced performance of coach air conditioners that may lead to passenger discomfort.

During congested operations, the tunnel ventilation system is operated to maintain a specific temperature in the vicinity of the car air conditioner condenser coils (i.e. allowing for thermal stratification). The open system congested ventilation shall be via a ‘push-pull’ effect where tunnel vent fans behind the train are operated in supply and tunnel vent fans ahead of the trains are operated in exhaust mode. Nozzles or booster (jet) fans will be used to direct air into the desired tunnel, if required.

EMERGENCY CONDITIONS

Emergency conditions are when smoke is generated in the tunnel or station trackway. In emergency conditions, the tunnel ventilation system would be set to operate to control the movement of smoke and provide a smoke-free path for evacuation of the passengers and for the fire fighting purposes. The ventilation system is operated in a ‘push-pull’ supply and exhaust mode with jet fans or nozzles driving tunnel flows such that the smoke is forced to move in one direction, enabling evacuation to take place in the opposite direction depending upon the location of Fire on the train.

3.7.8. Pressure Transients

The movement of trains within the underground system induces unsteady air motion in the tunnels and stations. Together with changes in cross section, this motion of air results in changes in air pressure within trains and for wayside locations. These changes in pressure or 'pressure transients' can be a source of passenger discomfort and can also be harmful to the wayside equipment and structures. Two types of transient phenomenon are generally to be examined:

a) Portal Entry and Exit Pressure Transients – As a train enters a portal, passengers will experience a rise in pressure from when the nose enters until the tail enters. After the tail enters the pressure drops. Similarly, as the nose exits a portal, pressure changes are experienced in the train.
b) Wayside Pressure Transients – As trains travel through the system they will pass structures, equipment and patrons on platforms. Equipment would include cross passage doors, lights, dampers, walkways etc. Pressures are positive for the approaching train and negative for retreating trains.

Most rapid changes occur with the passage of the train nose and tail. The repetitive nature of these pressures may need to be considered when considering fatigue in the design of equipment.

The detailed analysis to assess the effect of pressure transients will be done during the design stage. For the portal entry/exits the effect of higher train speed may pose discomfort to the passengers. The estimation of Way-side transients during design stage would be necessary to select design mechanical strength of the trackside fixtures, e.g. false ceilings, light fittings etc at the platform levels.

3.7.9. Ventilation And Air Conditioning Of Ancillary Spaces

Ancillary spaces such as staff room, equipment plant room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/humidity.

All ancillary areas that require 24-hour air conditioning will be provided with fan-coil units (FCU) and standby AC units. During the revenue hours when the main chilled water system is running the FCU will be used for air-conditioning and in non-revenue hours standby AC units will be operated. Return air grilles will be fitted with washable air filters for the re-circulation of the air.

Where fresh air is required it will be supplied to the indoor unit via a fresh air supply system, complete with filter, common to a group of ancillary areas. The fresh air unit will be located in the VAC plant room and will be time switch controlled with local override. Temperature control will include an alarm setting, which is activated on attaining high temperature.

3.7.10. System Components For VAC

The various components and equipment used in the VAC system are described in the following sections:

Station Air Conditioning

The platform and concourse areas will be air-conditioned using supply 'air handling units' located in air-handling plant rooms throughout the station. Each platform will be served by at least two separate air handling units (AHU's) with the distribution systems combined along each platform to ensure coverage of all areas in the event of single equipment failure. Based on the initial estimation about 6 units (2 for the concourse each with 18 cum/s and 4 for the platform each having 24 cum/s air-flow) would be needed for the full system capacity.

Fig 3.14: Concourse Air Handling Unit

These air conditioning systems mix return air with a desired quantity of outside air. The outside air requirement is based on occupancy, with a minimum of 5 litres per second per person or 10% of circulated air volume, whichever is the greater. The provision of free cooling by a simple two-position economizer control system will be included, with the use of enthalpy sensors to determine the benefits of using return air or outside air. This will signal the control system to operate dampers between minimum and full fresh air, so as to minimize the enthalpy reduction needed to be achieved by the cooling coil. This mixture of outside and return air is then filtered by means of suitable filters and then cooled by a cooling coil before being distributed as supply air via high level insulated ductwork to diffusers, discharging the air into the serviced space in a controlled way to minimize draughts. Return air to the platform areas is extracted via the trackway exhaust system and either returned to the AHU'S or exhausted as required.

Water-cooled chiller units with screw compressors are recommended to be provided at each station, which are energy efficient. These units can be installed in a chiller plant room at surface level or in the underground premises. Based on the initial concept design, the estimated capacity for a typical station would be around 660 TR, hence three units of 330TR (including one stand-bye) may be required for full system capacity (i.e. design phpdt traffic requirement). During the detail design stage this estimated capacity might get marginally changed for individual station depending on the heat loads. It is recommended that initially two units of 330 TR may be installed with the provision in terms of space be kept for the future addition.

Fig 3.15: Platform Air Handling Unit

In view of the temperate outdoor conditions, alternatively, it is possible to utilize air-cooled chiller units, which can save large amount of water requirement. The air-cooled chillers should be equipped with screw compressors so that they can be operated at a very less load with high efficiency. These units also eliminate requirement of condenser water circuits including pumps, cooling towers and make up water plants, but are less efficient as compared to the water-cooled- units.

Tunnel Ventilation Fans

As described earlier tunnel ventilation fans will be installed in each of the fan rooms near vent shafts. There shall be two fans in a fan room at each end of the station. The fan capacity depends on the inter-station distances and may vary from 60 cum/s to 100 cum/s. The exact capacity will be obtained through the simulation during detailed design stage. If necessary, nozzle type structures made up of concrete or steel may also be constructed to achieve desired airflow and air velocity in the tunnel sections. Alternatively booster fans (jet fans) may be installed to direct the flow in the desired direction. These fans may also be used for emergency ventilation at crossover locations.

The trackway exhaust system will have two fans of each 30 cum/sec. for each platform. The connections to tunnels and shafts will be through damper units that may be either electrically or pneumatic actuated.

3.7.11. Space Requirement For Tunnel Ventilation System

The tunnel ventilation equipment plant rooms are normally located at each end of the concourse for the two level stations. The approximate area for tunnel ventilation fan room would be 600 sq. m. respectively at each end of the station. The tunnel vent shafts of approximately 20 sq. m. area will be constructed at each end of the stations. There shall be supply shaft and exhaust shafts of similar dimensions at the stations. For large inter station distances on the underground corridor, there may be necessity of constructing mid tunnel ventilation shaft for effective ventilation requirements.

3.7.12. Control And Monitoring Facilities

For the underground stations the control and monitoring of station services and systems such as station air-conditioning, ventilation to plant rooms, lighting, pumping systems, lifts & Escalators, etc shall be performed at Station Control Room (SCR). However, the operation and control of Tunnel Ventilation as well as Smoke Management system will normally be done through OCC. All these systems shall be equipped with automatic, manual, local and remote operation modes. The alarms and signals from the equipment at stations shall be transmitted to the OCC via communication network.

3.7.13. Codes And Standards

The concept VAC design is guided by the following codes and standards:

a) SEDH – Subway Environment Design Handbook

b) ASHRAE – Handbook, current series.

c) CIBSE – relevant document.

d) NFPA – 130, 2003 edition.

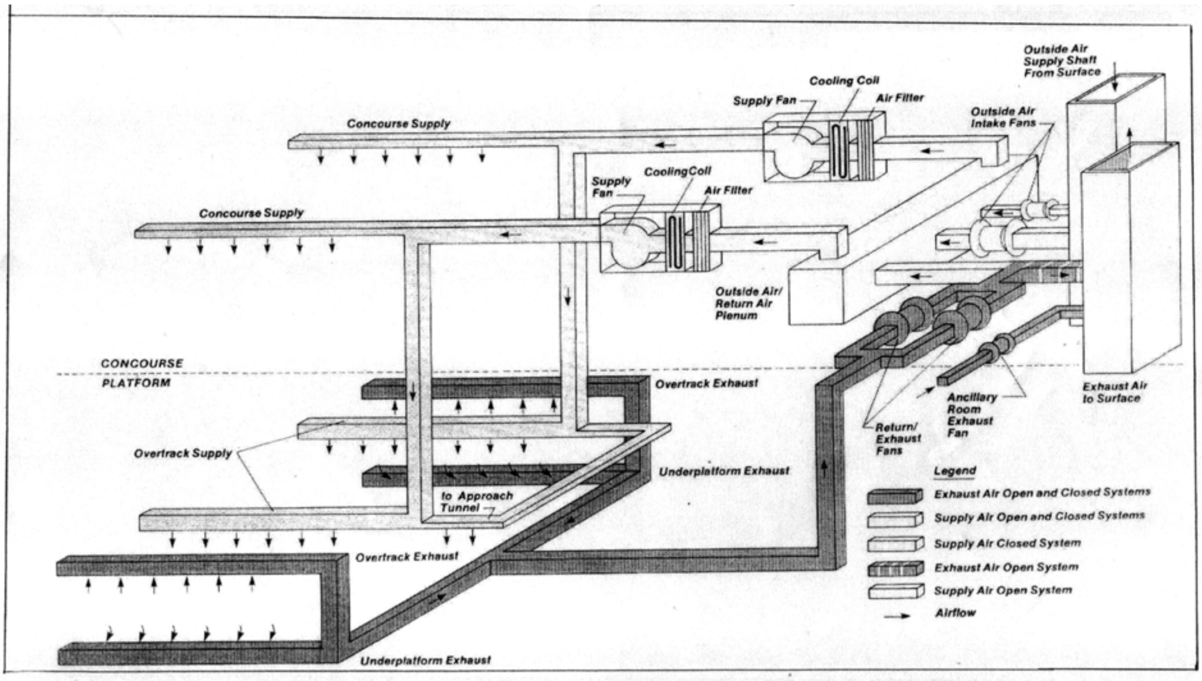


Figure 3.16 – Station Air Conditioning Closed System Scheme

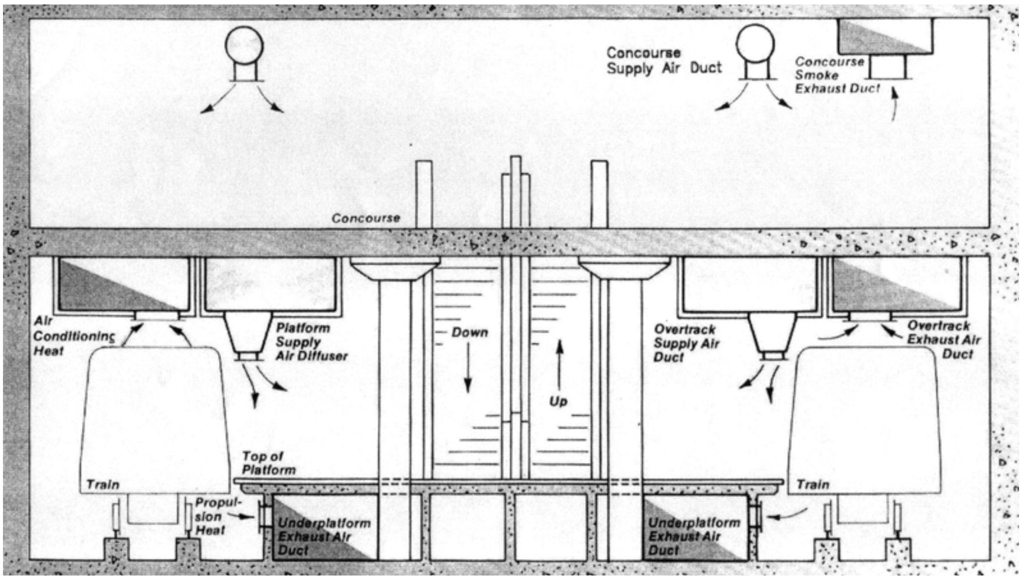


Figure 3.17 – Station Air Conditioning Section View

4. CIVIL ENGINEERING

4.1 ALIGNMENT PLANNING

4.1.1 Background

- The Detailed Project Report for Line 3 (Colaba – Bandra) of Mumbai Metro Phase – I was prepared in Oct'2007 and for Line 6 (Mahim – BKC – SEEPZ – Kanjur Marg) of Phase – II in April'2011.

- MMRC intends to implement Line 3 and Line 6 as one corridor i.e. as Colaba – Bandra - SEEPZ. The through Metro corridor i.e. Colaba – Bandra - SEEPZ is proposed to be fully underground.

- The consultant have developed various alignment options between Colaba - Mahim and presented to MMRC during the course of various discussions/meetings as well as in "Options Report" submitted in Aug'11.

- The corridor is proposed to have double line track, with a capacity to run 8 coach trains.

- The corridor is planned fully underground either on the edge of the existing road or along the median of the road and care has to be taken to cause least disruption to existing servicesand structures.

4.2 ENGINEERING SURVEY

4.2.1 Introduction

The collection of the existing topographic features to the required degree of accuracy was an important activity for the successful design of the proposed Mass Transit Corridor. During finalization of DPR's for line – 3 & 6, the topographical survey was carried out along the proposed alignment not less than 80 m wide or built up lines whichever is more as well as 100 m on station areas. To update the survey data, the detailed Topographical Survey between Colaba to Mahim has been carried out a fresh along the proposed alignment whereas survey data between Mahim to SEEPZ has been verified again and updated accordingly.

4.2.2 Survey Methodology

- For maintaining high precision in picking up maximum details in available time, the coordinates for the traverse points were fixed by using the GPS (Global Position System) between Colaba to Dharavi and closed traversing was carried out between GPS point by using Total station with one second accuracy and SOKKIA Auto levels with 1 mm accuracy for leveling works. The GPS station fixed with the help of DGPS are tabulated in **Table 4.1**:

Table 4.1: List of GPS coordinates

S.No.	Point No.	Northing	Easting	Elevation	Remarks
1	GPS1	2093120.263	270000.042	4.049	Pillar Fixed Near Median: 14m from North East Corner of Back Bay Bus stop compound wall and 30.42m from Colaba Defence Station Gate.
2	GPS1A	2093269.650	270144.837	3.958	Pillar Fixed Near Median: 14.15m from South West Corner of Winner Building compound wall and 16.43m from Colaba Defence Station Gate.
3	GPS2	2093838.093	272047.197	4.163	Nail Point Marked on Mahathma Gandhi Park Junction Median, Near Vidhan Bhawan: 23.00m from Vidhan Bhawan Compound wall and 22.30m from Bus Stop.
4	GPS2A	2094056.968	271906.043	4.269	Nail Point Marked on Madam Kama Road Median, Near Mantralaya: 18.99 m from Mantralaya West Gate and 11.71m from New Administrative Building West Gate.
5	GPS3	2094480.673	273639.725	6.365	Pillar fixed on Mahapalika Marg, Opposite to Directorate of Technical Education Building: 0.46m from Azad Maidan Compound wall and 34.26m from Mumbai Schools Sports Association Gate.
6	GPS3A	2094379.966	273730.579	7.261	Pillar fixed on Mahapalika Marg, at Balvant Phadke Chowk: 17.28m from North East Lift and 6.23m from Signal pole.
7	GPS4	2092972.475	275106.599	5.453	Nail Point Marked on Dr. Dadasaheb Bhadkamakar Road Footpath, Near Dena Bank:20.56m from North Side corner of Dena Bank Building and 14.37m from South Side corner of Dena Bank Building
8	GPS4A	2093035.575	275258.208	5.838	Nail Point Marked on Dr. Dadasaheb Bhadkamakar Road Median, at K.Gajanan Vertak Chowk: 11.71m from Shingne Building and 13.41m from Kothari Investment.
9	GPS5	2094023.518	277913.875	3.431	Pillar fixed on Bapu Rao Jagtap Marg Footpath, at Sunt Gadgey Maharaj Chowk: 12.80m from West corner of New Shirin Cinema and 21.20m from East corner of New Shirin Cinema.
10	GPS5A	2094135.977	277930.246	2.714	Pillar fixed on Sane Guruji Marg Median, at Sant Gadge Maharaj Chowk: 14.58m from Shiv Prasad Hotel and 13.41m from Café National Store.
11	GPS6	2092932.655	280148.523	6.922	Nail Point Marked on Dr.Anne Besant Road Median, at Podar Hospital Junction: 24.53m from south Side Podar Hospital Gate and 28.16m from Petrol Pump.
12	GPS6A	2093108.721	279847.631	3.846	Nail Point Marked on Dr. Anne Besant Road Median, at Aacharya Attray Chowk: 20.31m from Madhuben Nursery Gate and 19.24m from south corner of Temple.
13	GPS7	2094947.223	281784.667	5.044	Pillar fixed on Namdar Gopal Krusna Gokhlay Road Median, Near BMC School: 14.77m from BMC School Compound wall

S.No.	Point No.	Northing	Easting	Elevation	Remarks
					and 13.31m from Kanthariya Trust Building.
14	GPS7A	2094850.476	281515.061	5.243	Pillar fixed on Namdar Gopal Krusna Gokhlay Road Median,
15	GPS8	2095744.012	283914.401	6.166	Nail Point Marked on Lady Jamshedji Marg Median, Near Dadasaheb Abayankar Chowk:
16	GPS9	2096717.214	285179.465	4.408	Pillar fixed on Dharavi - Bandra Road T Junction.
17	GPS9A	2096619.758	285309.714	3.893	Pillar fixed on Dharavi - Bandra Road. 200m from T Junction.
18	GPS10	2096776.597	288154.362	4.591	Pillar fixed on Kalina - Santa Kruj road near Mumbai university gate No.2
19	GPS10A	2096600.285	288148.763	4.440	Pillar fixed on Kalina - Santa Kruj road opposite to Diamond awa hostel Mumbai University

- The two additional GPS points were also established in Mumbai University, Kalina to convert the survey details between Dharavi and SEEPZ on same GPS Coordinates. The Survey work was carried out through the existing roads/proposed alignment between Colaba to Mahim.

- The engineering topographic survey carried out along the alignment (not less than 80 m wide or upto built up lines whichever is more and up to 100 m wide on station areas) covering road/rail track and all natural and manmade features.

- The activities of topographical survey work were divided in following parts.

  a) Fixing the control points by GPS.
  b) Traversing between control points and calculation of closing error.
  c) Leveling including fixing of bench marks.
  d) Detailing of ground features and plotting the same in Auto Cad.
  e) Site verification by the agency.
  f) Complete verification of all above data/drawings by RITES Engineers.

- Monitoring of day to day topographical survey by expert engineer's team headed by a Manager level officer has been dedicatedly deputed to ensure the quality and progress of the work.

4.2.3 Methodology of Error Distribution

In Traversing:
Linear correction of any side = Closing error X length of that side/perimeter of traverse

Check for Angular Work:
The sum of interior angles= (2n-4) 90°
The sum of exterior angles= (2n+4) 90°
Where n=no. of sides of the traverse

In Leveling:
Proportionate distribution of error to the stations.

Arithmetical check:

$\sum$ BS - $\sum$ FS = $\sum$ RISE - $\sum$ Fall = Last R.L – First R.L. The Permissible error in leveling is 6mm / Km.

4.2.4 Survey Accuracy

- Linear measurement accuracy was 4 cm per Km.

- The Northing and Easting obtained by GPS coordinates used for survey detailing. The closed traverse was run in between these GPS stations by using Total Stations to established secondary traverse station, and the same were downloaded into the computer to convert the same data in autocad 2010 format. Detailed topographical survey was carried out with the help of these traverse station and finally prepared the survey map of the area. Survey plotting was carried out in the office simultaneously with the field work.

- The plotted sheets were taken to the site for verification to ensure that no details or structure was left out. Necessary modifications to the drawings were made and then final prints were taken from the plotter to the 1:1000 scale. The entire proposal, the mode of alignment and location of proposed stations is being designed with help of MX Rail Software. Temporary bench marks were established as directed by the engineer-in-charge.

4.2.5 Topographical Survey Procedure

4.2.5.1 Reconnaissance

Before starting the topographic survey, tentative route alignment was marked on eicher/google map. The survey teams along with RITES's engineers have done reconnaissance survey to familiarize the route alignment and identification the location for fixing the control traverse points and TBM location. The constraints to be encountered during survey work were also identified.

4.2.5.2 Traversing

19 Nos control traversing stations were established with the help of GPS on between Colaba to Mumbai University, Kalina. The secondary traverse points between these GPS traversing stations were established by running closed traverse with the help of Total station.

4.2.5.3 Precise Leveling

Levels of control traversing stations were established by using auto level. TBMs for the entire route alignment was established every 0.50 km (average) by Double territory method and fixed on available permanent structures along the route alignment. The Levelling was carried out by using precision auto level with accuracy of ±6√K. Reduced levels of all traverse stations and permanent control points were also taken w.r.t. TBMs.

4.2.5.4 Detailed Survey

- Based on the 'Easting' & 'Northing' values arrived by the Traversing and Elevation by Precise Leveling, detailed survey was carried out along the alignment.

- The survey covered road/rail track showing important structures all the bye lanes, footpaths, dividers/central verges, roads, railway tracks, trees, manholes and other structures, Nallahs, Storm water drains, H.T., L.T., Transmission lines, bridges, ROBs/RUBs/FOBs with type and spans, ponds, HFL and bed level of streams/Nallahs, level crossing with their type, traction masts, signal posts, etc. Spot/ Ground levels were taken at 25 m intervals in longitudinal as well as traverse direction and at sudden change of levels and other features etc., as decided by the Engineer-in-charge.

- Details of built-up areas including setbacks from building line / boundary wall, utility services such as electric lines, telephone lines, HT lines and over head crossings, manholes details, vertical clearance of overhead utilities etc. were taken and marked on the drawings.

- Location of approach roads, main roads, lanes showing road/lane name, carriageway, footpaths, central verge, drains and the widths of all the main and approach roads and at locations where there is a sudden change in widths of roads were measured physically and marked on the drawings.

- Details of Religious structures such as temples, Gurudwaras, Mosques, Churchs, Monuments, tombs etc. along the alignment were taken and marked on the drawings.

4.3 GEOMETRIC DESIGN NORMS

The design parameters related to the Metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters and the best-suited ones have been adopted for the System. For the underground and elevated stretch of the Corridor, the design parameters adopted in the various DPRs prepared by DMRC for standard Gauge.

4.3.1 Horizontal Alignment

As far as possible, the alignment follows the existing roads. On consideration of maximum allowable cant of 125 mm and cant deficiency of 100 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. However, in the underground section, desirable minimum radius of curve is taken as 300 m for ease of working of Tunnel Boring Machine.

The track centre in the underground section where stations are proposed to be done by cut & cover method has been proposed 15.05 m uniform throughout the section to accommodate island platform. The track centre having stations with NATM has been proposed 22m.

Track centre for entry to depot & at grade section has been kept 4.20 m uniformly throughout the section. For maximum permissible speed on curve with various radii **Table 4.2** may be referred.

Horizontal curves

Underground Section

Desirable Minimum Radius	:	300 m
Absolute minimum Radius	:	230 m
Minimum curve radius at stations	:	1000 m
Maximum permissible cant (Ca)	:	125 mm
Maximum cant deficiency (Cd)	:	100 mm

For entry to depot & at grade Section

Desirable Minimum Radius	:	200 m
Absolute minimum Radius	:	120 m
Maximum permissible cant (Ca)	:	125 mm
Maximum cant deficiency (Cd)	:	100 mm

Transition curves

For smooth ride on curves, suitable transition length has been provided at both ends of horizontal curves. Similarly, vertical curves have been introduced at the location of change of grades along the alignment. In case of ballast less track, it is desirable that the vertical curves and transition curves of horizontal curves do not overlap. These constraints may lead to reduced lengths of transition curves. However, for safety and comfort of passengers, the transition curves have to be designed with certain minimum parameters.

– **Length of Transitions of Horizontal curves (m)**

Minimum: 0.44 times actual cant or cant deficiency (in mm), whichever is higher.

Desirable: 0.72 times actual cant or cant deficiency, (in mm) whichever is higher

– Overlap between transition curves and vertical curves not allowed.

– Minimum straight between two Transition curves: either 25 m or NIL.

– Minimum curve length between two transition curves: 25 m

4.3.2 Vertical Alignment

- **Underground sections**

  Rail level at stations and in tunneling portion has been kept at least 15 m below the ground level. Since rock has been encountered at shallow depths from the existing ground level, in the range of 2.10 m to 10.0 m, and underground tunneling is proposed for construction. The rail level is kept such that, the entire tunnel is encased in the rock and a minimum of 6 m brock cushion is available over the tunnel. This will also avoid the underground utilities (except station areas) and building foundations. This requirement has been kept in view while designing the vertical profile.

- **Gradients**

  The stations are proposed to be on level stretch. Between stations, generally the grades may not be steeper than 3.0%. However, where existing road gradients are steeper than 3%, gradients up to 4% (compensated) can be provided in short stretches on the main line.

- **Vertical Curves**

  Vertical curves are provided when algebraic difference in gradient exceeds 0.4%. However, it is recommended to provide vertical curves at every change of gradient.

Radius of vertical curves:

– On main line (desirable) : 2500 m
(Minimum) : 1500 m
– Other Locations : 1500 m
– Minimum length of vertical curve : 20 m

4.3.3 Design Speed

The maximum sectional speed will be 80 km/h. However, the applied cant and length of transitions will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations. Computerized train simulation studies need to be conducted with proposed gradients at the time of detailed design stage. This is with the objective of keeping down the wear on rails on curves to the minimum.

Table 4.2: Cant, Permitted Speed and Minimum Transition length for various curves

Radius (m)	Actual Cant (mm)	Cant Deficiency (mm)	Permitted Speed (km/h)	Minimum Transition (m)
3000	20	8.72	80	10
2000	30	13.09	80	15
1000	50	36.17	80	25
800	60	47.72	80	30
500	90	82.35	80	40
400	125	90.43	80	55
300	125	100	70	55
200	125	100	55	55
150	125	100	50	55
120	125	100	45	55
100	125	100	40	55

4.3.4 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However, efforts have also been made to propose station locations: such that inter station distances are as uniform as possible. The average spacing of stations is kept 1.25 km.

List of stations along with their chainage and interstation distances (ISD) is given in **Table 4.3.**

Table 4.3: List of Stations

Sr No.	Station Name	Chainage (M)	INTER STATION DISTANCE (M)	GL/RL (M)	Proposed RL (M)	Level Difference (M)
1	Cuffe Parade	0	-	3.43	-12.30	-15.73
2	Badhwar Park	1000	1000	3.44	-12.00	-15.44
3	Vidhan Bhavan	1600	600	5.14	-16.50	-21.64
4	Churchgate Metro	2285	685	4.00	-19.50	-23.50
5	Hutatma Chowk	3102	817	6.65	-14.35	-21.00
6	CST Metro	3956	854	6.68	-10.00	-16.68
7	Kalbadevi	4891	935	5.15	-15.00	-20.15
8	Girgaon	5616	725	5.50	-15.10	-20.60
9	Grant Road Metro	7156	1540	2.41	-17.90	-20.31
10	Mumbai Central Metro	8067	911	1.95	-13.20	-15.15
11	Mahalakshmi Metro	9216	1149	2.35	-13.00	-15.35
12	Science Museum	10316	1100	2.16	-13.10	-15.26
13	Acharya Atrey Chowk	11516	1200	5.89	-11.00	-16.89
14	Worli	12924	1408	4.52	-11.40	-15.92
15	Siddhi Vinayak	14479	1555	4.70	-10.70	-15.40
16	Dadar Metro	15756	1277	4.85	-10.50	-15.35
17	Shitla Devi Temple	17525	1769	5.71	-9.60	-15.31
18	Dharavi	19306	1781	4.46	-10.60	-15.06
19	Bandra Metro	21271	1965	3.56	-11.60	-15.16
20	Mumbai University, Kalina	22812	1541	3.31	-9.00	-12.31
21	Santacruz	24027	1215	2.74	-12.30	-15.04
22	CSIA (Domestic)	26299	2272	5.35	-9.70	-15.05
23	Sahar Road	27906	1607	13.15	-2.15	-15.30
24	CSIA (International)	28958	1052	10.37	-5.00	-15.37
25	Marol Naka	29829	871	11.35	-5.00	-16.35
26	MIDC	31225	1396	25.72	8.50	-17.22
27	SEEPZ	32546	1321	29.81	14.00	-15.81

Note: Station names are tentative and subject to change

- Due to social/legal issues at any location, the station proposed by cut & cover may have to be done by NATM.
- Detailed Engineering for construction of station by NATM will be worked out before execution of work.
- The exact methodology of execution would, therefore, be finalized at Detailed Design stage.

4.4 DESCRIPTION OF ALIGNMENT

4.4.1 Introduction

The alignment starts from the southern tip of Mumbai City at Colaba/ Cuffe Parade near the WTC junction on Captain Prashant Pethe Marg and moves northwards. After crossing Badhwar Park, it turns left along Jagannath Bhosle Road, moves off the road and runs under the police baracks at Nariman point to connect Vidhan Bhawan and Mantralaya. Further, it aligns along Jamshedji Tata Road to connect with Churchgate Station.

After crossing Oval Maidan along Veer Nariman Road, the alignment further runs along Dr. D.N. Road upto west of CST Rly Station along Mahapalika Marg. Further, the alignment runs along JSS Road, Lamington Road and Dr. Anandrao Nair Marg. After crossing the WR tracks at Mahalaxmi, the alignment runs along Dr. E Moses Marg, Dr. Annie Basant Road, N. Gokhale Road and Lady Jamshedji Road. At Mahim, the alignment turns right along R. Hospital Road, moves along Mahim-Sion Link/ Station Road, crosses Mahim creek (Mithi River) just east of the Sion-Bandra Link Road and further crosses metro line II (Charkop – Bandra – Mankhurd corridor) at Bandra Metro Station (ITO). The alignment passes through Bandra-Kurla Complex, Bharat Nagar and Valmiki Nagar slums and Kalina University.

Further North, the alignment passes parallel to Santacruz – Chembur Link Road and eastern service road of Western Express Highway. The alignment enters into Mumbai Airport's premises and covers Domestic terminal, Sahar Road and International terminal. The alignment crosses metro line I (Versova – Andheri – Ghatkopar corridor) at Marol Naka. Further, the alignment passes through MIDC and SEEPZ area along Krantiveer Lakhuji Salve Marg. The terminal station is SEEPZ station opposite the SEEPZ Bus Depot. After north of Jogeshwari – Vikhroli Link Road a ramp has been proposed to provide the entry to depot at Aarey Milk Colony. Complete metro corridor is proposed to be underground.

4.4.2 Reference Point

For the planning convenience, the zero point of the Corridor is considered at the centre line of the proposed Cuffe Parade station. The chainage along the alignment increases in Northern direction. All elevations are from Mean Sea Level (MSL).

4.4.3 Terminals

i. Cuffe Parade Station (South terminal station)

The Southernmost station on the Metro corridor is Cuffe Parade station. The rail level for Cuffe Parade station has been kept 15.00 m (minimum) below the ground level. A passage has also been proposed to provide passenger dispersal facilities to World trade Centre. Reversal facilities have also been planned at Cuffe Parade station on southern end with stabling facilities.

ii. ITO Station (Mid Terminal)

ITO station will serve as the Mid Terminal station for the proposed corridor. This station will have one island and one side platform with provision of reversal facilities. Passenger interchange with Metro Line 2 (Charkop – Bandra – Mankhurd) has also been planned at this station.

iii. SEEPZ Station (North terminal station)

Eastern Terminal of the corridor will be SEEPZ. Reversal/stabling facility has also been planned at this station. The entry to depot at Aarey Milk Colony has also been planned after the station by providing the ramp north of Jogeshwari – Vikhroli Link Road.

iv. Interchange Stations

Efforts have been made to select station locations in such a fashion so as to provide convenient and efficient passenger interchange with other modes of transport such as other Metro rail lines, Monorail system, Bus system and Suburban Railway system. Following interchange stations are provided along the Corridor.

Table 4.4: Interchange Stations

Sr. No.	Name of station	Mode	Interchange with
1	Cuffe Parade	Bus System	Backbay Bus depot
2	Churchgate Metro	Western Railways and proposed Elevated Suburban Rail corridor	Churchgate Railway Station and Oval Maidan Station Of proposed Elevated Corridor Of Western Railways
3	CST Metro	Central railways	CSTM Railway Station
4	Mumbai Central Metro	Western Railways	Mumbai Central Railway Station and bus stand
5	Mahalaxmi Metro	Western Railways and Monorail	Mahalaxmi Railway Station and Jacob Circle Monorail Station
6	Siddhivinayak	Metro Rail	Proposed Siddhivinayak – Sewri MTHL Metro corridor
7	Shitla Devi Temple	Western Railways	At Mahim station with Western and Harbor lines.
8	Income Tax Office	Metro Rail line - 2	Charkop – Bandra – Mankhurd Metro Corridor
9	Marol Naka	Metro Rail line -1	Versova – Andheri – Ghatkopar Metro Corridor
10	SEEPZ	Bus System	SEEPZ Bus Stand

4.5 ALIGNMENT DESIGN

4.5.1 Design Considerations

Following considerations have been kept in view, while designing the alignment.

a) The alignment has been proposed generally either on the edge of the road or along the road for the entire corridor except at some locations where alignment is passing underneath the buildings, in order to minimize the acquisition of private land / properties.

b) Track centre have been proposed 15.05 m, in the section where stations are proposed by cut & cover method and 22.0 m where stations are proposed by NATM method.

c) Rail level of the corridor has been kept at minimum of 15.0 m below the ground/road level at station location and 18 – 20 m for mid sections. Wherever, the station proposed by NATM, the rail level has been proposed minimum 20 m below the ground/road.

d) Minimum radius of 230 m has been taken for the alignment except at in Kalina University where radius of 175 m has been proposed to provide the connectivity to future stabling lines. As TBM will not work for radius less than 230m, thus this section is proposed to be done in cut & cover for a length of 412m.

e) The normal grade of 3% i.e. 1 in 33.3 and exceptional of 4% i.e. 1 in 25 is compensated is proposed for the corridor.

f) For underground section, tunneling will be done by TBM. However, at stations are proposed to be constructed by cut & cover/NATM method at per site constraint, social/legal issues.

g) For station services like Chiller plant, DG set room, water/diesel tank, ventilation shaft, entry/exit etc. minimum 1000 sqm land will be required at each station.

h) Traffic diversion will be required where station are proposed by cut & cover method and are on the road.

i) Building condition survey to be conducted before starting the work and close monitoring will be required during execution of work.

j) The details of land requirement at station locations, running section, maintenance depot, sub-station and construction depot has been worked out and details are given in para 4.9.

Efforts have been made to accommodate the station entry/exit and escalator on the footpath of the road and open area of stations, wherein it is not possible, acquisition of Govt./private land has been proposed. For locating the permanent structures on footpath the permission from concerned owning agencies will be required.

To describe the alignment, the corridor has been divided into mainly two parts as detailed below.

i) Colaba to Mahim (Ch: (-) 475.0 m to Ch: 18000 m)
ii) Mahim to SEEPZ (Ch: 18000 m to Ch: 33525 m)

4.5.2 Colaba to Mahim (Ch: (-) 475.0 m to Ch: 18000 m)

To describe Colaba - Mahim section the alignment has been divided into three parts ;

a) Colaba to CST Metro Section (Ch: (-) 475.0 m to Ch: 4000 m)
b) CST Metro to Science Museum Section (Ch: 4000 m to Ch: 11000 m)
c) Science Museum to Mahim Section (Ch: 11000 m to Ch: 18000 m)

4.5.2.1 Colaba to CST Metro Section (Ch: (-) 475.0 m to Ch: 4000 m)

Ch: (-) 475.0 m to Ch: 1000 m

- The alignment starts from the southern tip of Mumbai City at Colaba/Cuffe Parade near the WTC junction along Captain Prashant Pethe Marg from Ch: (-) 475 m and off the road on west side. The alignment is straight for a length of 90 m, thereafter, it follows a left hand curve of 1150 m radius from Ch: (-) 385 m to Ch: (-) 276 m. After a straight of 423 m, the alignment follows a right hand curve of 600 m radius from Ch: 147 m to Ch: 260 m. Further, after a straight of 27 m, the alignment follows a left hand curve of 600 m radius from Ch: 287 m to Ch: 414 m and aligns along the centre of Cuffe Parade Road. Further, the alignment runs straight for a length of 344 m i.e. upto Ch: 758 m, thereafter, it follows a left hand curve of 250 m radius from Ch: 758 m to Ch: 906 m and runs straight afterwards along Jagannath Bhosle Road.

- Cuffe Parade station at Ch: 0.00 m has been proposed in this section. Cuffe Parade station has been proposed in the BMC garden (Woods garden). Reversal/stabling facilities have also been proposed at this station.

- Cuffe Parade station has been provided at a minimum depth of 15.0 m below the ground/road level. Level grade has been provided for Cuffe Parade station from Ch: (-) 475 m to Ch: 200 m. Further, a falling grade of 1.08% from Ch: 200 m to Ch: 450 m has been provided to go deep in mid section i.e. 18 – 20 m below ground/road level. Level grade from Ch: 450 m to Ch: 650 m has been provided to maintain minimum level in mid section. A rising grade of 1.65% from Ch: 650 m to Ch: 832 m has been provided to raise the level to a minimum of 15 m below ground for Badhwar Park station.

- BMC garden will need to be acquired temporarily from Ch: (-) 275 m to Ch: 150 m during construction, as this section is proposed to be done by cut & cover. Land will be required permanently for station facilities in this section.

- An additional entry/exit has also been planned near WTC through underground passage.

Ch: 1000 m to Ch: 2000 m

- The alignment continues to be on straight upto Ch: 1092 m, thereafter, it follows a left hand curve of 250 m radius from Ch: 1092 m to Ch: 1341 m and goes off the road and passes below the few buildings like PWD building (G+17) and tile shed building for police barrack. Further, after a straight of 109 m, the alignment follows a right hand curve of 1200 m radius from Ch: 1450 m to Ch: 1678 m and passes through the road between Vidhan Bhawan and SBI building. Further, the alignment runs straight for a length of 48 m, thereafter, it follows a right hand curve of 300 m radius from Ch: 1726 m to Ch: 2075 m and passes below the Vidhan Bhawan MLA quarter No. B2 & B3.

- Badhwar Park station at Ch: 1000 m has been proposed on Jagannath Bhosle Road at a depth of 15.0 m below the ground/road level.

- Vidhan Bhawan station at Ch: 1600 m has been proposed by NATM method due to space constraints and has been kept at a depth of 20.0 m below the ground level. Connectivity with the Administrative block of Mantralaya has also been proposed with this station.

- Level grade has been provided from Ch: 832 m to Ch: 1175 m for Badhwar park station. A falling grade of 1.80 m from Ch: 1175 m to Ch: 1425 m has been provided to go further deep in ground in mid section i.e. 18 - 20 m below ground level. Level grade from Ch: 1425 m to Ch: 1800 m has been provided for Vidhan Bhawan station.

- The alignment passes below the buildings, so care has to be taken while tunneling. Land will be required permanently for station facilities.

Ch: 2000 m to Ch: 3000 m

- The alignment continues to be on right hand curve of 300 m radius upto Ch: 2075 m and runs along the Jamshedji Tata Marg. After, a straight of 310 m, the alignment follows a right hand curve of 230 m radius from Ch: 2385 m to Ch: 2679 m and left hand curve of 242 m radius from Ch: 2680 m to Ch: 3007 m and aligns itself along Dr. Dadabhai Naoroji Marg.

- Western Railways is planning Elevated corridor from Oval Maidan to Virar. The proposed Metro alignment crosses the proposed EC alignment, which is also underground at Oval Maidan, at Ch: 2520. EC alignment is 14.50 m below the ground at Ch: 2520 m, accordingly depth of proposed Metro alignment has been kept 23.50 m below ground. Coordination with Western Railways will be required if any changes in the level of EC alignment occurs at that location.

- Churchgate Metro station at Ch: 2285 m has been provided in this section at a depth of 23.50 m below ground level. Both possibilities i.e. NATM/cut & cover will be there for construction of this station. This station will be integrated with Churchgate Railway station and proposed Oval Maidan station of Elevated corridor.

- A falling grade of 1.0% from Ch: 1800 m to Ch: 2100 m has been provided to further go deep in ground. Level grade from Ch: 2100 m to Ch: 2575 m has been provided for Churchgate Metro station. Further, a rising grade of 2.79% from Ch: 2575 m to Ch: 2772 m and falling grade of 0.22% from Ch: 2772 m to Ch: 2931 m has been provided to maintain minimum depth of 18 – 20 m below the ground/road level.

- The alignment passes below the Central Telegraph Office from Ch: 2780 m to Ch: 2840 m.

- No major constraints in this section except that permanent land for station services will be required.

Ch: 3000 m to Ch: 4000 m

- The alignment continues to run along Dr. Dadabhai Naoroji Marg. The alignment runs straight upto Ch: 3189 m, thereafter, it follows a left hand curve of 1200 m radius from Ch: 3189 m to Ch: 3305 m and goes off the road. After a straight of 160 m, the alignment follows a left hand curve of 230 m radius from Ch: 3465 m to Ch: 3856 m and aligns along Mahapalika Marg.

- Hutatma Chowk station at Ch: 3102 m has been proposed by NATM method and kept at a depth of 20.0 m below ground/road level.

- CST Metro station at Ch: 3956 m has been proposed at a depth of 15.0 m below ground/road level and proposed by cut & cover method. The integration with CST Railway station has also been planned through existing subway.

- Level grade from Ch: 2931 m to Ch: 3325 m has been provided for Hutatma Chowk station. Further, a series of vertical curves has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. A rising grade of

1.85% from Ch: 3631 m to Ch: 3766 m has been provided to bring the level to a depth of 15.0 m below ground level for CST Metro station. Level grade from Ch: 3766 m to Ch: 4158 m has been provided for CST Metro station.

- The alignment passes below the various multi-storey buildings from Ch: 3350 m to Ch: 3560 m. Care has to be taken while doing tunneling in this section.

- No major constraints in this section except permanent land for station services will be required.

4.5.2.2 CST Metro to Science Museum Section (Ch: 4000 m to Ch: 11000 m)

Ch: 4000 m to Ch: 5000 m

- The alignment continues to run along Mahapalika road and runs straight upto Ch: 4083 m. Further, the alignment follows a left hand curve of 300 m radius from Ch: 4083 m to Ch; 4234 m and passes below Azad Maidan. After a straight of 22 m, the alignment follows a right hand curve of 250m radius from Ch; 4256 m to Ch: 4498 m and aligns itself along JSS Road. Further, after a straight of 145 m, the alignment follows a left hand curve of 2000 m radius from Ch: 4643 m to Ch: 4712 m. The alignment runs straight for a length of 227 m i.e. upto Ch: 4939 m, thereafter, it follows a left hand curve of 1200 m radius from Ch; 4939 m to Ch: 5082 m.

- Kalbadevi station at Ch: 4891 m has been proposed in this section by NATM and has been kept at a depth of 20 m below the ground/road level.

- This station may be done by cut & cover method subjected to acquisition of 3500 sqm land and buildings. These buildings/structures are very old. After construction of station, the land can be revert back to land owner.

- A series of vertical curves between Ch: 4158 m and Ch: 4726 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Level grade from Ch; 4726 to Ch; 5100 m has been provided for Kalbadevi station.

- JSS road is heavily built-up on both sides. For station services, land will be permanently required. This will involve acquisition of buildings/structures.

Ch: 5000 m to Ch: 6000 m

- The alignment continues to run along JSS road. After a straight of 96 m, the alignment follows a left hand curve of 1000 m radius from Ch; 5178 m to Ch: 5298. Further, the alignment runs straight for a length of 411 m i.e. upto Ch: 5709 m, thereafter, it follows a left hand curve of 550 m radius from Ch; 5709 m to Ch: 5818 m. further, after a straight of 27 m, the alignment follows a right hand curve of 500 m radius from Ch; 5845 m to Ch; 5989 m.

- Girgaon station at Ch; 5616 m has been proposed by NATM and has been kept at a depth of 20 m below the ground/road level.

- This station may be done by cut & cover method subjected to acquisition of 3500 sqm land and buildings. These buildings/structures are very old. After construction of station, the land can be revert back to land owner.

- A rising garde of 0.71% from Ch; 5100 to Ch: 5241 m and a falling grade of 0.69% from Ch; 5241 m to Ch; 5400 m has been provided to maintain a minimum depth of 18 – 20 m below ground level. Level grade from Ch; 5400 m to Ch; 5925 m has been provided for Girgaon station.

- JSS road is heavily built-up on both sides. For station services, land will be required permanently. This will involve acquisition of buildings/structures.

Ch: 6000 m to Ch: 7000 m and Ch: 7000 m to Ch: 8000 m

- The alignment continues to run along JSS road and follows a left hand curve of 230 m radius from Ch; 5989 m to Ch; 6170 m. further, after a straight of 57 m, the alignment follows a right hand curve of 230 m radius from Ch; 6227 m to Ch; 6651 m and aligns along Lamington road. Further, the alignment follows a left hand curve of 250 m radius from Ch; 6652 m to Ch; 6824 m and runs straight for a length of 28 m i.e. upto Ch; 6852 m. Further, the alignment follows a right hand curve of 330 m radius from Ch: 6852 m to Ch; 7043 m and runs straight for a length of 369 m. Further, the alignment follows a right hand curve of 1000 m radius from Ch: 7412 m to Ch; 7574 m and runs straight for a length of 273 m i.e. upto Ch; 7847 m. Futher, the alignment follows a left hand curve of 450 m radius from Ch: 7847 m to Ch: 7968 m and aligns itself along Dr. AB Nair Marg.

- Grant Road Metro station at Ch: 7156 m has been proposed in this section. Both the construction methodology i.e. NATM and cut & cover are feasible. As station box is coming up to junction of the Grant road thus, for cut & cover construction, 4 to 5 buildings/structures (G+0 to G+2) needs to be temporarily acquired during construction period. The depth of station has been kept at a depth of 20 m below the ground/road level.

- A series of vertical curves between Ch: 5925 m and Ch: 6946 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Level grade from Ch; 5946 m to Ch; 7341 m has been provided for Grant Road Metro station. Further, a rising grade of 0.93% from Ch: 7341 m to Ch; 7491 m has been provided to maintain minimum level in mid section. Further, a rising grade of 0.99% from Ch; 7491 m to Ch; 7825 m has been provided to raise level for Mumbai Central Metro station.

- The alignment passes below the buildings on JSS road, so care has to be taken while doing tunneling by TBM.

- As Grant Road Metro station, land will need to be acquired permanently for its station services in BMC school open ground.

Ch: 8000 m to Ch: 9000 m

- The alignment continues to run along Dr. AB Nair Marg. After a straight of 254 m, the alignment follows a right hand curve of 500 m radius from Ch; 8221 m to Ch;

8365 m. Further, the alignment runs straight for a length of 95 m, thereafter, it follows a left hand curve of 600 m radius from Ch; 8460 m to Ch; 8570 m. After a straight of 29 m, the alignment follows a left hand curve of 800 m radius from Ch; 8599 to Ch; 8751 m. Further, after a straight of 176 m, the alignment follows a right hand curve of 250 m radius from Ch; 8927 m to Ch; 9104 m and aligns itself along Sane Guruji Marg.

- Mumbai Central Metro station at Ch; 8067 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- Level grade from Ch; 7825 m to Ch; 8295 m has been provided for Mumbai central Metro station. Further, a falling grade of 1.08% from Ch; 8295 m to Ch: 8651 m and level grade from Ch; 8651 m to Ch; 8816 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. A rising grade of 2.00% from Ch; 8816 m to Ch; 9016 m has been provided to raise the level to 15 m for Mahalaxmi Metro station.

- Land will need to be acquired permanently for station services.

Ch: 9000 m to Ch: 10000 m and Ch: 10000 m to Ch: 11000 m

- The alignment continues to be on Sane Guruji Marg and is straight upto Ch; 9340 m. Further, the alignment follows a left hand curve of 250 m radius from Ch: 9340 m to Ch; 9828 m and passes below Dhobi Ghat area. Further, after a straight of 71 m, the alignment follows a right hand curve of 250 m radius from Ch; 9899 m to Ch; 10089 m and aligns itself along Dr. E. Mosses Road and runs straight for a length of 1480 m i.e. upto Ch; 11569 m.

- Mahalaxmi Metro station at Ch: 9216 m proposed on Sane Guruji Marg and to be done by NATM. As this road is quite wide, this station can be done by cut & cover method also. The Integration with Jacob Circle Monorail station and Mahalaxmi Railway station has been proposed with this station.

- Science Museum at Ch: 10316 m has been provided and proposed by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- The alignment crosses western railway track from Ch: 9856 m to Ch: 9890 m at a depth of 23.00 m below the tracks. As tunneling is to be done by TBM, hence, there will not be any constraint for crossing the railway tracks.

- The proposed Metro alignment crosses the proposed underground EC alignment of western railways, at Mahalaxmi Railway station, at Ch: 9900. EC alignment is 14.00 m below the ground at Ch: 9900 m, accordingly depth of proposed Metro alignment has been kept 23.00 m below ground. Coordination with Western Railways will be required if any changes in the level of EC alignment occurs at this location.

- Level grade from Ch: 9016 m to Ch; 9431 m has been provided for Mahalaxmi Metro station. Falling grades of 2.76% from Ch: 9431 m to Ch: 9576 m and 1.38% from Ch: 9576 m to Ch: 9866 m has been provided to cross proposed EC alignment in Mahalaxmi. Further, a rising grade of 3.02% from Ch; 9866 m to Ch; 10127 m has been provided to maintain minimum level below ground in mid section. Level grade from Ch: 10127 m to Ch: 10625 m has been provided for Science Museum station. Further, a series of vertical curves between Ch: 10625 m and Ch: 11122 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- Monorail Corridor is proposed along Sane Guruji Marg. Pier arrangement of Monorail corridor has to be adjusted considering the alignment of proposed Colaba – SEEPZ corridor.
- Permanent land for station services will be required for both stations.

4.5.2.3 Science Museum to Mahim Section (Ch: 11000 m to Ch: 18000 m)

Ch: 11000 m to Ch: 12000 m

- The alignment continues to run straight along Dr. E. Mosses Road upto Ch: 11569 m, thereafter, it follows a right hand curve of 1200 m radius from Ch: 11569 m to Ch: 11663 m and aligns itself along Dr. Annie Basant Road. Further, the alignment runs straight for a length of 110 m, thereafter, it follows a left hand curve of 400 m radius from Ch: 11773 m to Ch: 11918 m and a right hand curve of 230 m radius from Ch: 11921 m to Ch: 12304 m.

- Acharya Atrey Chowk station at Ch: 11516 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- A rising grade of 2.50% from Ch: 11122 m to Ch: 11322 m has been provided to raise level before Acharya Atrey Chowk station. Level grade from Ch: 11322 m to Ch: 11697 m has been provided for Acharya Atrey Chowk station. Further, a falling grade of 0.67% from Ch: 11697 m to Ch: 11846 m and level grade from Ch: 11846 m to Ch: 12516 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- As Acharya Atrey Chowk station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

Ch: 12000 m to Ch: 13000 m

- The alignment continues to be on a right hand curve of 230 m radius upto Ch: 12304 m, thereafter, it runs straight for a length of 126 m. Further, the alignment follows a left hand curve of 250 m radius from Ch: 12430 m to Ch: 12603 m and runs straight for a length of 58 m. Further, the alignment follows a right hand curve of 400 m radius from Ch: 12661 m to Ch: 12792 m and runs straight afterwards.

- Worli station at Ch: 12924 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level. Due to any social/legal issue, this station may be done by NATM also.

- The alignment is on level grade upto Ch: 12516 m, thereafter, a rising grade of 0.28% from Ch: 12516 m to Ch: 12731 m has been provided to raise the level before

Worli station. Level grade from Ch: 12731 m to Ch: 13110 m has been provided for Worli station.

- As Worli station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

Ch: 13000 m to Ch: 14000 m and Ch: 14000 m to Ch: 15000 m

- The alignment continues to run along Dr. Annie Basant road and is straight upto Ch: 13137 m, thereafter, it follows a right hand curve of 600 m radius from Ch: 13137 m to Ch: 13524 m. Further, after a straight of 134 m, the alignment follows a left hand curve of 600 m radius from Ch: 13658 m to Ch: 13775 m and aligns itself along Veer Sarvarkar Road. Further, the alignment runs straight for a length of 369 m, thereafter, it follows a right hand curve of 230 m radius from Ch: 14144 m to Ch: 14386 m and passes below Sane Guruji garden and playground of Ravindra Natya Mandir. Further, after a straight of 220 m, the alignment follows a left hand curve of 275 m radius from Ch: 14606 m to Ch: 15057 m and passes below a few buildings west of Appasaheb Marathe Marg.

- Siddhi Vinayak station at Ch: 14479 m has been proposed in this section by cut & cover in Sane Guruji garden and playground of Ravindra Natya Mandir and has been kept at a depth of 15 m below the ground/road level. This station has been proposed near Siddhi Vinayak Temple.

- MMRDA has planned underground MTHL Metro corridor from Siddhi Vinayak temple to Sewri along Sayani Marg. Integration with the Siddhi Vinayak station of MTHL Metro corridor is also proposed.

- A falling grade of 1.92% from Ch: 13110 m to Ch: 13297 m and level grade from Ch: 13297 m to Ch: 14016 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Further, a rising grade of 1.91% from Ch: 14016 m to Ch: 14241 m has been provided to raise level before Siddhi Vinayak station. Level grade from Ch: 14241 m to Ch: 14691 m has been provided for Siddhi Vinayak station. Further a falling grade of 1.89% from Ch: 14691 m to Ch: 14866 m has been provided after the station.

- As Siddhi Vinayak station is proposed by Cut & cover, land in Sane Guruji garden and playground of Ravindra Natya Mandir will need to be acquired temporarily for station during construction and permanently for station services.

Ch: 15000 m to Ch: 16000 m and Ch: 16000 m to Ch: 17000 m

- The alignment is on left hand curve of 275 m radius upto Ch: 15057 m and aligns along Gokhale Marg. After a straight of 114 m, the alignment follows a right hand curve of 500 m radius from Ch: 15171 m to Ch: 15280 m. Further, the alignment runs straight for a length of 188 m, thereafter, it follows a right hand curve of 650 m radius from Ch: 15468 m to Ch: 15645 m. Further, the alignment runs straight for a length of 365 m i.e. upto Ch: 16010 m, thereafter, it follows a left hand curve of 250 m radius from Ch: 16010 m to Ch: 16189 m and aligns itself along lady Jamshedji

Marg. Further, after a straight of 583 m, the alignment follows a left hand curve of 1000 m radius from Ch: 16772 m to Ch: 16919 m and runs straight afterwards.

- Dadar Metro station at Ch: 15756 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level. Due to any social/legal issue, this station may be done by NATM also.

- Level grade from Ch: 14866 m to Ch: 15340 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Further, a rising grade of 1.49% from Ch: 15340 m to Ch: 15575 m has been provided before Dadar Metro station. Level grade from Ch: 15575 m to Ch: 15930 m has been provided for Dadar Metro station. Further, a falling grade of 1.76% from Ch: 15930 m to Ch: 16100 m and level grade from Ch: 16100 m to Ch: 17150 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- As Dadar Metro station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

Ch: 17000 m to Ch: 18000 m

- The alignment continues to run along Lady Jamshedji Marg and is straight upto Ch: 17027 m, thereafter, it follows a left hand curve of 1500 m radius from Ch: 17027 m to Ch: 17103 m. Further, the alignment runs straight for a length of 152 m, thereafter, it follows a left hand curve of 600 m radius from Ch: 17255 m to Ch: 17372 m and after a straight of 31 m, again follows a left hand curve of 1050 m from Ch: 17403 m to Ch: 17794 m and runs straight afterwards.

- Shitla Devi temple station at Ch: 17525 has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level. Due to any social/legal issue, this station may be done by NATM also. This station is proposed to be integrated with Mahim railway station through sky walk/subway.

- A rising grade of 2.27% from Ch: 17150 m to Ch: 17313 m has been provided to raise level before Shitla Devi Temple station. Level grade from Ch: 17313 m to Ch: 17700 m has been provided for Shitla Devi Temple station. Further, a falling grade of 2.00% from Ch: 17910 m to Ch: 17910 m and level grade from Ch: 17910 m to Ch: 18316 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- As Shitla Devi temple station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

4.5.3 Mahim to SEEPZ Section (Ch: 18000 m to Ch: 33575 m)

To describe Mahim – SEEPZ section the alignment has been divided into three parts;

a) Mahim to Airport Section (Ch: 18000 m to Ch: 25000 m)
b) Airport Region (Ch: 25000 m to Ch: 30000 m)

c) Airport to SEEPZ Section (Ch: 30000 m to Ch: 33575 m)

4.5.3.1 Mahim to Airport Section (Ch: 18000 m to Ch: 25000 m)

Ch: 18000 m to Ch: 19000 m

- The alignment continues to run straight on Lady Jamshed ji marg upto Ch: 18011, thereafter, it follows a right hand curve of radius 265 m from Ch: 18011 m to Ch: 18527 m and aligns itself along R. Hospital marg. Further, after a straight of 71 m, the alignment turns right with curve of radius 300 m from Ch: 18598 m to Ch: 18819 m. Further, after a straight of 58 m, the alignment follows a left hand curve of 300 m radius from Ch: 18877 m to Ch: 19089.

- The alignment crosses western railway track from Ch: 18776 m to Ch: 18808 m at a depth of 18.75 m below the tracks. As tunneling is to be done by TBM, hence, there will not be any constraint for crossing the railway tracks.

- A series of vertical curves has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- Western Railway is planning an elevated corridor from Churchgate to Virar with a height of 15.0 m from existing Rail level. The proposed underground Metro corridor is crossing the Railway track at TM No. 13/10-11. Coordination with Western Railway will be required for spanning arrangement of Elevated Corridor.

- The alignment crosses Mangroves forest area from Ch: 18819 m to Ch: 18965 m for which environment clearance will be necessarily required for tunneling.

Ch: 19000 m to Ch: 20000 m

- The proposed alignment is on left hand curve of radius 300 m upto Ch: 19089 m and aligns itself on the median of Mahim – Sion link road. After a straight of 355 m, the alignment turns with a left hand curve of radius 350m from Ch: 19444 m to Ch: 19840 m and is straight afterwards and passes through Mahim creek (Mithi River) from Ch: 19760 m onwards.

- Dharavi station at Ch: 19306 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- Level grade has been provided for Dharavi station from Ch: 19122 m to Ch: 19526 m. After Dharavi station, a falling grade of 1.91% and 2.09% from Ch: 19526 m to Ch: 19756 m and Ch: 19756 m to Ch: 19947 m respectively has been provided for crossing the Mahim creek.

- As Dharavi station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

Ch: 20000 m to Ch: 21000 m

- The alignment continues to be on straight upto Ch: 20700 m and follows a left hand curve of radius 250 m from Ch: 20700 m to Ch: 20969 m and is straight afterwards.

- The alignment crosses Mahim creek from Ch: 19760 m to Ch: 20860 m for a length of 1100 m, environment clearance will be necessary for tunneling.

- Level grade has been provided from 19947 m to Ch: 20778 m to cross Mahim creek. Further, a rising grade of 3.04% has been provided from Ch: 20778 m to Ch: 20992 m to maintain a minimum 15.0 m level below ground for Bandra Metro station.

- Govt. land (Garden) will be required temporarily during construction.

Ch: 21000 m to Ch: 22000 m

- In this stretch, the alignment is straight for a length of 456 m i.e. upto Ch: 21425, thereafter, it follows a right hand curve of radius 300 m from Ch: 21425 m to Ch: 21818 m and the alignment passes below the Bharat Nagar slum area.

- Bandra Metro station at Ch: 21225 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level where passengers interchange with ITO station of Metro line-2 (elevated) (Charkop – Bandra - Mankhurd) has been planned.

- Alignment crosses Metro line-2 (elevated) at Ch: 21134 m, while construction pier arrangement has to be planned considering the Colaba – SEEPZ alignment.

- For Bandra Metro station, level grade has been provided from Ch: 20992 m to Ch: 21522 m. A falling grade of 1.44% from Ch: 21522 to Ch: 21730 m and level grade from Ch: 21730 m to Ch: 22027 m has been provided to maintain minimum depth of 18 – 20 m below ground/road level in mid section.

- This station is planned as mid terminal at minimum 15.00 m below the ground/road level. One island and one side platform has been provided at this station with reversal facilities.

- As Bandra Metro station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

Ch: 22000 m to Ch: 23000 m

- The alignment in this section continues to be straight upto Ch: 22232 m and passes below Bharat Nagar and Valmiki Nagar at 18 - 20 m depth below ground/road level. The alignment enters Mumbai University, Kalina area at Ch: 22026 m. Further, the alignment follows a left hand curve of radius 175 m from Ch: 22232 m to Ch: 22537 m and runs straight for a length of 374 m i.e. upto Ch: 22912 m.

- Mumbai University, Kalina station at Ch: 22812 m has been proposed in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level. This will serve Kalina University as well as Vidya nagar.

- A rising grade of 1.76% from Ch: 22027 m to Ch: 22397 m has been provided to raise the level to a minimum depth of 15 m below GL/road level for Mumbai University, Kalina station. Level grade from Ch: 22397 m to Ch: 22997 m has been provided for Mumbai University, Kalina.

- Land will be required temporarily for cut & cover section i.e. from Ch: 22250 m to Ch: 22662 m for a length of 412 m and will be reverted back to university after construction.

- To follows the road geometric as well as providing the connectivity to stablining lines at Kalina University in future, a curve of 175 m radius has been introduced from Ch: 22232 m to Ch: 22537 m. As TBM will not work on radius less than 230 m radius, hence, this portion of alignment is proposed to be done by cut & cover method.

- As Mumbai University, Kalina station is proposed by Cut & cover, traffic diversion will be required on the road for construction of the station. Further, land will be required permanently for station services.

Ch: 23000 m to Ch: 24000 m

- The alignment follows a left hand curve of radius 260 m from Ch: 22912 m to Ch: 23126 m and aligns itself parallel to Santacruz – Chembur link road. The alignment comes out of Kalina University area at Ch: 23068 m. After a straight of 220 m, the alignment turns right with curve of radius 280 m from Ch: 23345 m to Ch: 23805 m and runs straight afterwards and aligns itself along the service road of western Express Highway on eastern side.

- A series of vertical curves has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- No major constraint in this section.

Ch: 24000 m to Ch: 25000 m

- The alignment in this section continues to be along the service road of Western Express Highway. After a straight of 376 m upto Ch: 24181 m, the alignment deflects towards left with a curve of radius 1150 m upto Ch: 24856 m. Further, after a straight of 33 m, the alignment follows a right hand curve of radius 325 m from Ch: 24889 m.

- Santacruz station has been proposed at Ch: 24027 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level which will mainly serve Santacruz (E).

- For Santacruz station level grade has been provided from Ch: 23837 m to Ch: 24232 m. Further, a falling grade of 1.91% from Ch: 24232 m to Ch: 24452 m has been provided due to change in ground profile. A series of vertical curves has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- As Santacruz station has been proposed by Cut and cover, hence, Dawri Nagar slum area along the service road is proposed to be acquired temporarily during construction period. After construction of station, this land will be returned back to their owners. Permanent land will be required only for station entry/exit, DG sets, AC chiller plant and ventilation shaft.

4.5.3.2 Airport Region (Ch: 25000 m to Ch: 30000 m)

The alignment in Airport area starts from Ch: 25044 m and ends at Ch: 29326 m.

Ch: 25000 m to Ch: 26000 m

- The alignment continues to be on right hand curve of radius 325 m from Ch: 24889 m to Ch: 25510 m and runs straight afterwards.

- A rising grade of 0.10% and 0.60% from Ch: 25152 m to Ch: 25652 m and Ch: 25652 m to Ch: 25902 m respectively have been provided in this section.

- There is no major constraint in this section.

Ch: 26000 m to Ch: 27000 m

- The alignment is straight upto Ch: 25989 m. Further, it turns left with a curve of radius 500 m from Ch: 25989 m to Ch: 26118 m. After a straight of 309 m, the alignment follows a left hand curve of radius 275 m from Ch: 26427 m to Ch: 26705 m. Further, after a straight of 175 m i.e. upto Ch: 26880 m, the alignment turns right with curve of radius 500 m.

- CSIA (Domestic) station has been proposed at Ch: 26299 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- The alignment in this section has been slightly modified as proposed by MIAL due to alignment curvature. The location of the CSIA (Domestic) station has also been slightly modified to locate the station on straight.

- The alignment is on rising grade of 1.00% from Ch: 25902 m to Ch: 26132 m. CSIA (Domestic) station has been provided on level grade from Ch: 26132 m to Ch: 26502 m. Further, a rising grade of 0.53% and 0.15% from Ch: 26502 m to Ch: 26727 m and Ch: 26727 m to Ch: 27052 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- There is no major constraint in this section.

Ch: 27000 m to Ch: 28000 m

- The alignment continues to be right hand curve of radius 500 m upto Ch: 27594 m and runs straight afterwards.
- Special care will be required during construction/tunneling as the alignment passes under the few buildings in this section. The alignment crosses Sahar road at Ch: 27761 m.

- Sahar road station has been proposed at Ch: 27906 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level. The location of this station has been kept same as proposed by MIAL.

- A rising grade of 0.85% and 0.88% from Ch: 27052 m to Ch: 27522 m and Ch: 27522 m to Ch: 27732 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Sahar Road station has been provided on level grade from Ch: 27732 m to Ch: 28082 m.

- No major constraint in this section except land for station services will be required which is to be provided by MIAL free of cost.

Ch: 28000 m to Ch: 29000 m

- The alignment continues to be on straight upto Ch: 28162 m. The alignment follows a right hand curve of radius 800 m from Ch: 28162 m to Ch: 28288 m. After a straight of 187 m, the alignment turns left with curve of radius 800 m from Ch: 28475 m to Ch: 28603 m and is straight afterwards.

- CSIA (International) station has been proposed at Ch: 28958 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- A series of vertical curves has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. CSIA (International) station has been proposed on level grade from Ch: 28783 m to Ch: 29233 m.

- No major constraints in this section.

Ch: 29000 m to Ch: 30000 m

- The alignment continues to be on straight upto Ch: 29095, thereafter, the alignment follows a left hand curve of radius 275 m from Ch: 29095 m to Ch: 29543 m. Thereafter, the alignment is straight for a length of 472m i.e. upto Ch: 30015 m.

- Mumbai Airport premises ends at Ch: 29326 m. After the Airport premises, the alignment pass through densely populated area of Chimat Pada Chal.

- Marol Naka station has been proposed at Ch: 29829 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level. This station will have passenger interchange with Marol Naka station (elevated) of Metro line - 1 (Versova- Andheri – Ghatkopar Corridor).

- Marol Naka station is proposed in densely populated area of Chimat Pada Chal. Station has been proposed to be done by Cut and cover method, hence, for locating the station this area will need to be acquired temporarily during construction period.
- Further, a falling grade of 1.14% from Ch: 29233 m to Ch: 29452 m and a rising grade of 1.75% from Ch: 29452 m to Ch: 29652 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Marol Naka station has been provided on level grade from Ch: Ch: 29652 m to Ch: 30000 m.

- Land will be required temporarily for station location and permanently for station entry/exit, DG sets, AC chiller plant and ventilation shaft in Chimat Pada hutment area.

4.5.3.3 Airport to SEEPZ Section (Ch: 30000 m to Ch: 33575 m)

Ch: 30000 m to Ch: 31000 m

- The alignment is straight upto Ch: 30020 m, thereafter, the alignment turns left with curve of radius 300 m from Ch: 30020 m to Ch: 30237 m and runs straight for a length of 601 m and passes underneath the MIDC area buildings. Further, the alignment follows a left hand curve of 275 m radius from Ch: 30838 m to Ch: 31120 m.

- A falling grade of 0.80% from Ch: 30000 m to Ch: 30250 m and rising grade of 0.67% from Ch: 30250 m to Ch: 30550 has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section. Further, a rising grade of 2.55% from Ch: 30550 m to Ch: 31040 m has been provided to raise the level for MIDC station.

- Special care will be required during construction/tunneling as the alignment passes under the buildings/structures.

Ch: 31000 m to Ch: 32000 m

- The alignment continues to be on left hand curve of 275 m radius upto Ch: 31120 m, thereafter, it runs straight for a length of 255 m i.e. upto Ch: 31375 m. Further, the alignment turns left with a curve of radius 275 m from Ch: 31375 m to Ch: 31781 m and aligns itself along the Karantiveer Lakhuji Salve Marg. Further, after a straight of 52 m, the alignment follows a right hand curve of radius 250 m from Ch: 31833 m to Ch: 32028 m and runs straight afterwards. In this stretch, the alignment runs below the SEEPZ area buildings.

- MIDC station has been proposed at Ch: 31225 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- Level grade from Ch: 31040 to Ch: 31450 m has been provided for MIDC station. Further, a falling grade of 1.00% from Ch: 31450 m to Ch: 31600 m and level grade from Ch: 31600 m to Ch: 32050 m has been provided to maintain a minimum depth of 18 - 20 m below GL/road level in mid section.

- Special care will be required during construction/tunneling as the alignment passes under the buildings/structures.

- As MIDC station is proposed by Cut & cover, land will need to be acquired temporarily for station during construction and permanently for its station services.

- An additional station, MIDC station has been proposed at Ch: 31225 m to serve MIDC area, as this area is densely populated and having high rise buildings. For the construction of station by Cut & Cover, the following area needs to be acquired.

  i) Senior Police Colony area

a) G+3 building – 2 Blocks
b) Sub station
c) Pump House

ii) Parking area of Employee Estate Insurance Corporation and their pump house
iii) Hutment area having building of G+0 and G+1 of Vikhroli village (2550 sqm).
iv) Water pipe lines to be supported during construction period.
v) Drain required to be diverted during construction period.

The Total area will be required = 26X300 m = 7800 sqm.

- Alternatively, if acquisition of above properties is not feasible, this station may be constructed by NATM and only an area of 30mx30m will be required at both ends of the station for construction of the shaft.

Ch: 32000 m to Ch: 33525 m

- The alignment in this section runs along the Krantiveer Lakhuji Salve Marg and continues to run straight till Ch: 33097 m. After crossing the Jeshwari – Vikhroli Link Road the alignment takes right turn of radius 250m from Ch:33097m to Ch:33421m to provide the entry to depot at Aarey Milk Colony where 26 hact. of land has been proposed to be acquired.

- SEEPZ station has been proposed at Ch: 32546 m in this section by cut & cover and has been kept at a depth of 15 m below the ground/road level.

- A rising grade of 2.15% has been provided from Ch: 32050 m to Ch: 32375 m to bring the level for SEEPZ station to minimum of 15 m below the ground/road level. For SEEPZ station as well as reversal/stabling facilities, level grade has been provided from Ch: 32375 m to Ch: 33050 m. A rising grade of 1.47% has been provided from Ch: 33050m to Ch: 33275m. Up to this loction the alignment is done by TBM method. A ramp with grade of 2.68% has been proposed from Ch: 33275m to Ch: 33525m for providing the at grade entry to depot.

- No constraint except temporary diversion of traffic during construction of SEEPZ station. Further, acquisition of permanent land for station entry/exit, DG sets, AC chiller plant and ventilation shaft will be required.

4.5.7 Major Roads along the Alignment

The alignment from Colaba to SEEPZ traverses along few major roads as indicated in **Table 4.5.**

Table 4.5: Major Roads along the Alignment

Sr. No.	Name of the Road	Stretch	
		From (m)	To (m)
1	Prakash Pethe Marg (Cuffe Parade Road)	-475	770
2	Jagannath Bhosle Marg	770	1225
3	Jamshedji Tata Marg	1970	2470
4	Veer Nariman Road	2570	2800
5	Dr. Dadabhai Naoroji Marg	2850	3725

Sr. No.	Name of the Road	Stretch	
		From (m)	To (m)
6	Mahapalika Marg	3725	4200
7	Jagannath Shankar Seth Road(JSS Rd)	4450	6325
8	Dr. Dadasaheb Bhadkamkar Road (Lamington Road)	6525	7880
9	Dr. A B Nair Marg	7880	8990
10	Sane Guruji Marg	8990	9365
11	Dr. E Mosses Road	10000	11655
12	Dr. Annie Besant Road	11655	13650
13	Veer savarkar Road	13650	14200
14	Gokhle Road	14925	16065
15	Lady Jamshedji Marg	16065	18140
16	R. Hospital Marg	18425	18725
17	Mahim Sion Link Road	18950	19760
18	Road to MMRDA Quarters	21010	21110
19	Sant Dyaneshwar Marg	21130	21580
20	Santracruz Chembur Link road	23060	23425
21	Western Express Highway	23705	24860
22	Road No. 7	31283	31458
23	Krantiveer Lakhuji Salve Marg	31683	33033

4.5.8 Major Roads across the Alignment

The alignment from Colaba to SEEPZ traverses across few major roads as indicated in **Table 4.6.**

Table 4.6: Major Roads across the Alignment

Sr. No.	Name of the Road	Chainage (m)
1	Sadhu Vaswani Road	-275
2	GD Somani Road	147
3	Wodehouse Road	780
4	Nathalal Parikh Road	1050
5	Free Press Journal Road	1590
6	Vidhan Bhawan Marg	1730
7	Madam Cama Road	1875
8	Dinshaw Vacha Road	2190
9	JTS Malani Marg	2385
10	Maharshi Karve Road	2525
11	Karmaveer Bhaurao Patil Marg	2732
12	Mahatma Gandhi Road	2850
13	Maharshi Dadhich Marg	3105
14	Sir Feroz shah Mehta Marg	3105
15	Walchand Hirachand Marg	3590
16	Princess Street	4740
17	Shamaldas Gandhi Road	4740
18	Dadiseth Agiyari Street	5202
19	Dr. Babasaheb Jaykar Marg	5616
20	RR Roy Marg	6200
21	Sardar Vallabh Bhai Patel Road	6505
22	Maulana Shaukatali Road	7050
23	Azim Premji Marg	7275

Sr. No.	Name of the Road	Chainage (m)
24	Patthe Bapurao Marg	7500
25	Belasis Road	7885
26	M. Sethi Marg	8255
35	Senapati Bapat Marg	10460
27	Ganapatrao Kadam Marg	11650
28	GM Bhosle Marg	11655
29	Pandurang Budhkar Marg	12650
30	Appasaheb Marathe Marg	13600
31	Sayani Marg	14320
32	NC Kelkar Road	16065
33	Takandas Kataria Marg	16810
34	Sitladevi Temple Road	17240
35	Mia Mohd Chhotani Road	17630
36	Senapati Bapat Marg	18730
37	Sulochna Shetty Road	19195
38	Sion Bandra link Road	19580
39	Bandra Kurla Complex Road	21130
40	Hans Mogra Marg	23100
41	Jawaharlal Nehru Road	24180
42	Station Road	24180
43	Sahar Road	27750
44	IA Project Road	28030
45	Mathuradas Vasanji Road	30001
46	Jeshwari – Vikhroli Link Road	33050

4.5.9 Curvature

There are a total of 67 curves provided on the entire length of the alignment. 46 curves are in Colaba to Mahim Section and 22 curves are in Mahim to SEEPZ section. Governing criteria for deciding the horizontal alignment is suitable location for the station from traffic integration as well as construction ability point of view. As far as possible, the alignment has been kept straight between the stations.

The abstract and details of horizontal curves are indicated in **Table 4.7 and 4.8** respectively.

Table 4.7: Abstract of Horizontal Curves

S. No.	Radius (m)	Colaba – Mahim		Mahim - SEEPZ	
		Nos of Occurrences	Length (m)	Nos of Occurrences	Length (m)
1	<100	0	0.00	0	0.00
2	>100 to 200	0	0.00	1	305.95
3	>200 to 500	23	5799.68	16	5450.98
4	>500 to 1000	12	1808.55	4	1097.55
5	>1000	11	1652.50	1	675.56
	Total	46	9260.73	21	7206.04

Table 4.8: Details of Horizontal Curves

Curve No	Direction	Radius	Deflection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
			D	M	S	In	Out				
Colaba – Mahim											
1	Left	1150	4	9	11	25	25	54.20	58.36	108.36	422.88
2	Right	600	7	28	22	35	35	56.69	43.25	113.25	27.30
3	Left	600	8	46	16	35	35	63.52	56.85	126.85	344.18
4	Left	250	21	21	18	55	55	74.72	38.18	148.18	185.67
5	Left	250	44	33	31	55	55	130.12	139.42	249.42	109.07
6	Right	1200	10	53	40	20	20	113.87	187.23	227.23	48.45
7	Right	300	56	3	32	55	55	187.43	238.52	348.52	310.43
8	Right	230	59	34	2	55	55	159.44	184.12	294.12	0.60
9	Left	242	64	19	54	55	55	180.01	216.72	326.72	182.73
10	Left	1200	4	20	32	25	25	57.99	65.94	115.94	159.50
11	Left	230	84	53	40	55	55	234.69	281.77	391.77	226.39
12	Left	300	18	21	30	55	55	76.04	41.12	151.12	21.94
13	Right	250	43	53	7	55	55	125.88	132.12	242.12	144.95
14	Left	2000	1	32	30	15	15	34.41	38.81	68.81	227.32
15	Left	1200	5	38	52	25	25	71.69	93.29	143.29	96.03
16	Left	1000	5	6	18	30	30	59.58	59.10	119.10	411.27
17	Left	550	7	12	14	40	40	54.63	29.15	109.15	26.92
18	Right	500	12	57	47	40	40	72.40	64.40	144.40	0.15
19	Left	230	31	18	39	55	55	92.10	70.69	180.69	57.06
20	Right	230	92	59	22	55	55	266.18	314.27	424.27	0.08
21	Left	250	26	48	38	55	55	87.19	61.98	171.98	28.00
22	Right	330	23	41	13	55	55	96.78	81.43	191.43	369.30
23	Right	1000	7	32	25	30	30	80.90	101.60	161.60	273.06
24	Left	450	9	37	33	45	45	60.40	30.60	120.60	253.73
25	Right	500	11	22	14	45	45	72.29	54.23	144.23	94.61
26	Left	600	7	9	15	35	35	55.01	39.92	109.92	29.37
27	Left	800	8	44	16	30	30	76.12	92.00	152.00	175.87
28	Right	250	28	53	43	55	55	89.70	66.72	176.72	236.08
29	Left	250	99	16	18	55	55	322.20	378.15	488.15	71.02
30	Right	250	31	56	53	55	55	96.84	80.04	190.04	1480.11
31	Right	1200	3	16	38	25	25	46.83	43.64	93.64	109.91
32	Left	400	14	19	8	45	45	72.77	54.96	144.96	3.21
33	Right	230	81	40	9	55	55	226.73	272.84	382.84	125.82
34	Left	250	27	12	9	55	55	88.10	63.69	173.69	57.60
35	Right	400	12	16	56	45	45	65.56	40.75	130.75	344.71
36	Right	600	33	39	5	35	35	198.97	317.40	387.40	133.74
37	Left	600	7	53	25	45	45	58.63	27.16	117.16	369.07
38	Right	230	46	33	25	55	55	126.67	131.89	241.89	220.33
39	Left	275	82	30	1	55	55	269.06	340.97	450.97	113.50
40	Right	500	8	57	26	40	40	54.78	29.44	109.44	187.63
41	Right	650	12	7	20	40	40	89.03	97.52	177.52	364.77
42	Left	250	28	21	9	55	55	90.77	68.71	178.71	582.92
43	Left	1000	6	43	37	30	30	73.77	87.41	147.41	108.24
44	Left	1500	2	8	50	20	20	38.11	36.22	76.22	151.83
45	Left	600	8	51	11	35	35	58.69	47.24	117.24	30.62
46	Left	1050	20	58	2	25	25	197.34	340.92	390.92	216.74
Mahim – SEEPZ											
47	Right	265	99	46	36	55	55	342.62	406.48	516.48	71.24
48	Right	300	31	31	19	55	55	112.28	110.05	220.05	58.03
49	Left	300	30	5	5	55	55	108.23	102.52	212.52	355.35
50	Left	350	55	48	44	55	55	213.05	285.94	395.94	859.33

Curve No	Direction	Radius	Deflection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
			D	M	S	In	Out				
51	Left	250	49	3	49	55	55	141.82	159.08	269.08	456.35
52	Right	300	64	37	16	55	55	217.49	283.36	393.36	413.02
53	Left	175	82	9	44	55	55	180.67	195.95	305.95	374.23
54	Left	260	35	5	16	55	55	109.84	104.22	214.22	219.51
55	Right	280	82	44	32	55	55	274.49	349.36	459.36	375.79
56	Left	1150	32	24	44	25	25	346.75	625.56	675.56	32.59
57	Right	325	99	49	29	55	55	414.07	511.24	621.24	479.31
58	Left	500	10	8	16	40	40	64.36	48.47	128.47	308.90
59	Left	275	46	27	12	55	55	145.70	167.96	277.96	175.03
60	Right	500	77	16	52	40	40	419.83	634.41	714.41	567.75
61	Right	800	7	55	18	30	30	63.38	66.65	126.65	187.01
62	Left	800	7	1	15	30	30	64.08	68.03	128.03	492.03
63	Left	275	81	42	55	55	55	265.74	337.21	447.21	472.46
64	Left	300	30	54	32	55	55	110.55	106.84	216.84	601.24
65	Left	275	47	10	12	55	55	147.75	171.40	281.40	255.00
66	Right	275	73	12	12	55	55	232.08	296.35	406.35	51.85
67	Right	250	32	4	54	55	55	99.51	84.98	194.98	1005.20
68	Right	250	61	39	03	55	55	176.97	214.00	324.00	1069.42

4.5.10 Gradients

While designing vertical alignment for the entire corridor efforts have been made to maintain box of stations completely in rock. However, depth at stations is kept as minimum as required from construction ability point of view. In running section, downward grades have been provided just outside of station limits in order to maintain the alignment as deeper as possible to minimize possibility of any damage to the structures over it.

A total of 60 changes of gradients have been provided in Colaba – Mahim section and 46 in Mahim – SEEPZ section. Flattest gradient is level provided on the stations and steepest is 3.04% provided for a length of 214 m. Largest length on same grade is between Ch: 16100 m and Ch: 17150 m for a length of 1050 m on level grade. The abstract and details of gradients are given in **Table 4.9 and 4.10** respectively.

Table 4.9: Abstract of Gradients

S. No.	Description	Colaba – Mahim		Mahim - SEEPZ	
		Nos of Occurrences	Length (m)	Nos of Occurrences	Length (m)
1	Level (0%)	26	11415.29	15	6595.00
2	>0% to 1%	13	2835.79	12	3792.29
3	>1% to 2%	14	3163.25	12	2811.71
4	>2% to 3%	6	1115.29	6	1779.04
5	>3%	1	261.33	1	214.00
	TOTAL	60	18790.96	44	14717.04

Table 4.10: Details of Gradients

Sr. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
Colaba – Mahim							
1	-475.00	200.00	675.00	-12.30	-12.30	0.00	Level
2	200.00	450.00	250.00	-12.30	-15.00	-1.08	Fall
3	450.00	650.00	200.00	-15.00	-15.00	0.00	Level
4	650.00	832.00	182.00	-15.00	-12.00	1.65	Rise
5	832.00	1175.00	343.00	-12.00	-12.00	0.00	Level
6	1175.00	1425.00	250.00	-12.00	-16.50	-1.80	Fall
7	1425.00	1800.00	375.00	-16.50	-16.50	0.00	Level
8	1800.00	2100.00	300.00	-16.50	-19.50	-1.00	Fall
9	2100.00	2575.00	475.00	-19.50	-19.50	0.00	Level
10	2575.00	2772.29	197.29	-19.50	-14.00	2.79	Rise
11	2772.29	2930.96	158.67	-14.00	-14.35	-0.22	Fall
12	2930.96	3325.00	394.04	-14.35	-14.35	0.00	Level
13	3325.00	3450.96	125.96	-14.35	-13.50	0.67	Rise
14	3450.96	3630.96	180.00	-13.50	-12.50	0.56	Rise
15	3630.96	3765.96	135.00	-12.50	-10.00	1.85	Rise
16	3765.96	4157.96	392.00	-10.00	-10.00	0.00	Level
17	4157.96	4390.96	233.00	-10.00	-13.50	-1.50	Fall
18	4390.96	4523.46	132.50	-13.50	-13.50	0.00	Level
19	4523.46	4725.96	202.50	-13.50	-15.00	-0.74	Fall
20	4725.96	5100.00	374.04	-15.00	-15.00	0.00	Level
21	5100.00	5240.96	140.96	-15.00	-14.00	0.71	Rise
22	5240.96	5400.00	159.04	-14.00	-15.10	-0.69	Fall
23	5400.00	5925.00	525.00	-15.10	-15.10	0.00	Level
24	5925.00	6197.96	272.96	-15.10	-16.00	-0.33	Fall
25	6197.96	6737.96	540.00	-16.00	-17.00	-0.19	Fall
26	6737.96	6945.96	208.00	-17.00	-17.90	-0.43	Fall
27	6945.96	7340.96	395.00	-17.90	-17.90	0.00	Level
28	7340.96	7490.96	150.00	-17.90	-16.50	0.93	Rise
29	7490.96	7825.00	334.04	-16.50	-13.20	0.99	Rise
30	7825.00	8295.00	470.00	-13.20	-13.20	0.00	Level
31	8295.00	8650.96	355.96	-13.20	-17.00	-1.07	Fall
32	8650.96	8815.96	165.00	-17.00	-17.00	0.00	Level
33	8815.96	9015.96	200.00	-17.00	-13.00	2.00	Rise
34	9015.96	9430.96	415.00	-13.00	-13.00	0.00	Level
35	9430.96	9575.96	145.00	-13.00	-17.00	-2.76	Fall
36	9575.96	9865.96	290.00	-17.00	-21.00	-1.38	Fall
37	9865.96	10127.29	261.33	-21.00	-13.10	3.02	Rise
38	10127.29	10625.00	497.71	-13.10	-13.10	0.00	Level
39	10625.00	10800.00	175.00	-13.10	-16.00	-1.66	Fall
40	10800.00	11122.29	322.29	-16.00	-16.00	0.00	Level
41	11122.29	11322.29	200.00	-16.00	-11.00	2.50	Rise
42	11322.29	11697.29	375.00	-11.00	-11.00	0.00	Level
43	11697.29	11845.96	148.67	-11.00	-12.00	-0.67	Fall
44	11845.96	12515.96	670.00	-12.00	-12.00	0.00	Level
45	12515.96	12730.96	215.00	-12.00	-11.40	0.28	Rise
46	12730.96	13110.00	379.04	-11.40	-11.40	0.00	Level
47	13110.00	13297.29	187.29	-11.40	-15.00	-1.92	Fall
48	13297.29	14015.96	718.67	-15.00	-15.00	0.00	Level
49	14015.96	14240.96	225.00	-15.00	-10.70	1.91	Rise
50	14240.96	14690.96	450.00	-10.70	-10.70	0.00	Level
51	14690.96	14865.96	175.00	-10.70	-14.00	-1.89	Fall
52	14865.96	15340.00	474.04	-14.00	-14.00	0.00	Level

Sr. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
53	15340.00	15575.00	235.00	-14.00	-10.50	1.49	Rise
54	15575.00	15930.00	355.00	-10.50	-10.50	0.00	Level
55	15930.00	16100.00	170.00	-10.50	-13.50	-1.76	Fall
56	16100.00	17150.00	1050.00	-13.50	-13.50	0.00	Level
57	17150.00	17313.00	163.00	-13.50	-9.80	2.27	Rise
58	17313.00	17700.00	387.00	-9.80	-9.80	0.00	Level
59	17700.00	17910.00	210.00	-9.80	-14.00	-2.00	Fall
60	17910.00	18315.96	405.96	-14.00	-14.00	0.00	Level
Mahim – SEEPZ							
61	18315.96	18555.96	240.00	-14.00	-15.50	-0.63	Fall
62	18555.96	18845.96	290.00	-15.50	-15.50	0.00	Level
63	18845.96	19122.29	276.33	-15.50	-10.60	1.77	Rise
64	19122.29	19525.96	403.67	-10.60	-10.60	0.00	Level
65	19525.96	19755.96	230.00	-10.60	-15.00	-1.91	Fall
66	19755.96	19947.29	191.33	-15.00	-19.00	-2.09	Fall
67	19947.29	20778.00	830.71	-19.00	-19.00	0.00	Level
68	20778.00	20992.00	214.00	-19.00	-12.50	3.04	Rise
69	20992.00	21522.29	530.29	-12.50	-12.50	0.00	Level
70	21522.29	21730.00	207.71	-12.50	-15.50	-1.44	Fall
71	21730.00	22027.07	297.07	-15.50	-15.50	0.00	Level
72	22027.07	22397.29	370.22	-15.50	-9.00	1.76	Rise
73	22397.29	22997.29	600.00	-9.00	-9.00	0.00	Level
74	22997.29	23275.00	277.71	-9.00	-15.00	-2.16	Fall
75	23275.00	23597.29	322.29	-15.00	-16.50	-0.47	Fall
76	23597.29	23837.07	239.78	-16.50	-12.30	1.75	Rise
77	23837.07	24232.07	395.00	-12.30	-12.30	0.00	Level
78	24232.07	24452.07	220.00	-12.30	-16.50	-1.91	Fall
79	24452.07	24872.07	420.00	-16.50	-15.50	0.24	Rise
80	24872.07	25152.07	280.00	-15.50	-14.00	0.54	Rise
81	25152.07	25652.07	500.00	-14.00	-13.50	0.10	Rise
82	25652.07	25902.07	250.00	-13.50	-12.00	0.60	Rise
83	25902.07	26132.07	230.00	-12.00	-9.70	1.00	Rise
84	26132.07	26502.07	370.00	-9.70	-9.70	0.00	Level
85	26502.07	26727.07	225.00	-9.70	-8.50	0.53	Rise
86	26727.07	27052.07	325.00	-8.50	-8.00	0.15	Rise
87	27052.07	27522.07	470.00	-8.00	-4.00	0.85	Rise
88	27522.07	27732.07	210.00	-4.00	-2.15	0.88	Rise
89	27732.07	28082.07	350.00	-2.15	-2.15	0.00	Level
90	28082.07	28327.07	245.00	-2.15	-9.00	-2.80	Fall
91	28327.07	28539.41	212.33	-9.00	-9.00	0.00	Level
92	28539.41	28783.41	244.00	-9.00	-5.00	1.64	Rise
93	28783.41	29233.41	450.00	-5.00	-5.00	0.00	Level
94	29233.41	29452.07	218.67	-5.00	-7.50	-1.14	Fall
95	29452.07	29652.07	200.00	-7.50	-4.00	1.75	Rise
96	29652.07	30000.00	347.93	-4.00	-4.00	0.00	Level
97	30000.00	30250.00	250.00	-4.00	-6.00	-0.80	Fall
98	30250.00	30550.00	300.00	-6.00	-4.00	0.67	Rise
99	30550.00	31040.00	490.00	-4.00	8.50	2.55	Rise
100	31040.00	31450.00	410.00	8.50	8.50	0.00	Level
101	31450.00	31600.00	150.00	8.50	7.00	-1.00	Fall
102	31600.00	32050.00	450.00	7.00	7.00	0.00	Level
103	32050.00	32375.00	325.00	7.00	14.00	2.15	Rise
104	32375.00	33050.00	658.00	14.00	14.00	0.00	Level
105	33050.00	33275.00	225.00	14.00	17.34	1.47	Rise
106	33275.00	33525.00	250.00	17.34	24.00	2.68	Rise
107	33525.00	33575.00	50.00	24.00	24.00	0.00	Level

4.6 GEOTECHNICAL INVESTIGATIONS

4.6.1 General Geology & Related Characteristics:

a) **Location-** The Geological investigations were carried out from Colaba to Mahim for about 18.475km and Mahim to SEEPZ for about 15.525 Km during preparation of DPR for Colaba – Bandra Metro (line – 3) and Mahim – Kanjur Marg Metro (line – 6). As per scope of present study, no new GT investigation is to be carried out and data available from both the earlier DRR's will be used for finalisation of construction methodology.

b) **Physiography and Climate**-The RL along the route varies from 1.730 to 64.20 m above mean sea level. The highest temperature in this city is around 35°C and the minimum temperature is around 15°C. The period between January to April and December is the dry period in this region. The Southwest monsoon period, between June and October, is the main rainy season. The average annual rainfall is about 2000mm.

c) **General Geology-** Mumbai and Konkan coastal area of Maharashtra is underlain by Deccan Trap Basalts. These rocks are believed to be formed by a series of vast lava flows following volcanic eruptions towards the close of the Cretaceous period or early Tertiary era. The total thickness of the Deccan Traps is very variable, reaching an estimated maximum of 3000 metres along the coast.

A very wide variety of basalts and associated rocks such as volcanic Breccias, black tachylytic basalts, red tachylytic basalts seen at the surface as 'Red Bole' occur in the area covered by Deccan Trap basalts. All these volcanic rocks are hydrothermally weathered near the surface. The residual material resulting from the breakdown of the rock is known locally as "murrum" the properties of which vary in consistency and texture according to the degree of weathering and disintegration. On complete weathering of rock the soil becomes stiff yellow silty clay.

Marine Clays of Mumbai

Marine clays cover extensive areas in Mumbai/Coastal region, which are found along the shore as well as in creeks, tidal flats and formerly submerged areas. On the eastern front of Mumbai, island and coastal region, thick deposits of marine clays are found overlying murrum tuff and basaltic rock. The marine clay deposits vary in thickness from 2m to 20m. These soils are characterized by their high compressibility, low co-efficient of consolidation and very low shear strength. Above the bedrock, the residual 'murrum' often occurs along with gravel and weathered boulders.

4.6.2 Seismicity

Mumbai lies in seismic zone III and also adjacent to zone IV. Suitable seismic coefficient may be adopted in the design of structures to commensurate with the Indian Standard seismic zoning of the country IS.1893-2002 which is revised after the occurrence of Gujarat Earthquake in January' 2001.

4.6.4 SECTION – I (Colaba to Mahim)

4.6.4.1 Selection of Bore Hole Locations

The locations of bore holes were distributed in such a way so as to cover the entire alignment of the proposed Metro project. In general bore hole locations were planned at an interval of 1000 m (approx.) each. Localize changes in bore locations have been effected depending upon the site difficulties as well as underground utilities constraints. Individual locations of bore holes have also been marked in the drawing. The details of boreholes along the corridor are shown in **Table 4.11.**

Table 4.11: Details of Boreholes(Colaba-Mahim)

BOREHOLE NUMBER	CHAINAGE (in m)	Ground R.L. (m)	GROUND WATER TABLE DEPTH (m)	DEPTH OF INVESTIGATION (in m)			RQD between 10m to 20m depth (%)
				In SOIL	In ROCK (soft/hard)	TOTAL	
BH 1	-271	2.900	2.50	4.6	15.4	20	54-82
BH 2	-151	2.610	2.50	5.5	14.5	20	64-83
*BH-1RLY	949	3.361	2.50	4.80	9.30	14.10	
*BH-2 RLY	1708	3.747	2.50	8.60	4.4	13	
*BH-3 RLY	1915	3.767	2.50	4.90	8.30	8.3	
*BH-4RLY	2543	3.871	2.50	3.60	21.8	25.4	
*BH-5 RLY	2904	3.731	2.50	3.60	2.8	6.4	
*BH-6 RLY	3271	4.877	2.50	3.60	2.8	6.4	
BH 3	3523	5.480	3.50	5.0	9.3	14.3	20-34
*BH-7 RLY	3928	6.960	3.00	9.50	2.0	11.5	
BH 4	4622	5.770	4.10	8.8	10.4	19.2	35-87
BH 5	5122	5.674	5.80	6.95	6.8	13.75	92-99
BH 6	5566	5.190	6.50	8.5	6.25	14.75	98-100
BH 7	5949	5.016	7.10	9.6	11.4	21	15-86
BH 8	6433	5.743	4.75	11	12	23	16-60
BH 9	6446	3.750	4.10	9.45	17.05	26.5	14-66
BH 10	6958	2.123	4.50	9	15.4	24.4	46-81
BH 11	7863	2.230	4.20	4	13.7	17.7	36-92
BH 12	8444	1.787	4.00	4	14.1	18.1	20-100
BH 13	9090	1.990	2.00	6	18.55	24.55	12-75
BH 14	9449	2.451	2.00	2.4	14.1	16.50	48-95
*BH-8 RLY	10064	3.418	2.35	6.31	6.31	12.62	
*BH-9RLY	10086	2.347	2.120	7.50	7.50	15.0	
BH 15	11110	2.328	2.75	5.50	6.80	12.30	60-90
BH 16	11993	2.079	3.00	7.50	17.05	24.55	0-65
BH 17	12307	2.140	4.00	3.50	14	17.50	10-90
BH 18	12753	2.301	3.50	4	19.50	23.50	10-34
BH 19	13162	3.244	3.00	5	15	20	42-85
*BH-10 RLY	13931	4.258	4.20	8.50	10.5	19	
BH 20	14256	7.197	2.50	8.50	13.50	22	14-68
BH 21	14553	3.800	2.00	10	7.70	17.70	15-89
BH 22	15058	3.334	1.80	8.50	8.90	17.40	10-65
BH 23	15568	4.310	2.00	12.8	5.90	18.70	30-100
BH 24	16041	4.535	1.00	11.50	6.30	17.80	32-75
BH 25	16551	4.895	2.00	11.25	6.45	17.70	40-98
BH 26	17008	4.656	2.00	7.50	6.50	14	72-100
BH 27	17519	4.809	2.50	11.60	5	16.60	22-92
BH 28	17986	5.216	2.50	11	5.85	16.85	22-97
BH 29	18389	5.537	1.50	13	9	22	20-90
BH 30	18845	5.634	4.00	6.50	13.50	20	15-93
*BH-11 RLY	19198	4.428	4.0	8.0	8.0	16.0	

4.6.4.2 Engineering Design Parameters

Based upon investigation done and the analysis made thereafter, following design parameters have been finalised.

4.6.4.3 Design Parameters and subsoil strata

The sub-soil strata at the proposed site comprise of nine types of layers (based on field tests & laboratory test result data). Description of each layer along with various engineering parameters is as shown in **Table 4.12.**

Table 4.12: Layer Type and Description for BH 1 To BH 30

Layer	Description	Classification as per IS : 1498-1970	Relative Density/ Consistency	Observed in Bore Hole Nos.
I	Road material & Backfill	-	-	BH 1 to BH 30
II	Silty Sand	SM-SC, SP-SC, SM, SC	Medium dense to dense	BH 3 to BH 9, BH 16, BH 21 to BH 28
III	Silty Sand	SP-SC, SM	Very dense	BH 26, BH 29
IV	Sandy Clay	-	Soft	BH 20, BH 29
V	Silty Clay	CH	Medium stiff to stiff	BH 7, BH 8, BH 8, BH 10, BH 11, BH 13 to Bh 15, , BH 18, BH 21 TO BH 25,BH 27 to BH 29,
VI	Silty Sandy Clay with gravel	CH, CI	Very stiff to hard	B 19, BH 20, BH 22, BH 25, BH 27, To BH 30.
VII	Completely weathered rock	CI, CH, GM	-	BH 16 , BH 17,
VIII	Highly to moderately weathered SANDSTONE/ BRECCIA/ BASALT	-	-	BH 2 to BH 5, BH 7 to BH 13, BH 15 to BH 20, BH 22 to BH 26, BH 28 to BH 30
IX	Slightly weathered to fresh BRECCIA/ SHALE/ LIMESTONE	-	-	BH 1 to BH 14, BH 16, BH 17, BH 19 to BH 21, BH 23, BH 25 to BH 30.

4.6.4.4 Assessment of Liquefaction

Liquefaction is the sudden loss of shear strength of the loose fine-grained sands due to earthquake-induced vibration under saturated conditions. The liquefaction generally takes place in loose fine-grained sands with N value less than 15 and soil classification under SP. At this site generally silty clay is observed. Medium dense to very dense sand is also obtained and the ‘N’ value is generally greater than 15. Hence this site does not seem susceptible to liquefaction.

4.6.4.5 Construction Methodology

Type of Foundation- Considering the insitu conditions (sample disturbance), confinement aspect do play a major role in transfer of loads to the bearing stratum. In the light of recovery pattern, the visual inspection of samples covering the texture, fracture and weathering aspect we recommend that the foundations may be laid based on chiseling criteria. IS: 2911 (Part-I/Sec2)-1999 provide design approach in weathered rock stratum for bored cast insitu piles.

Depth of Foundation- A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure.

Keeping in view the type of the proposed structure and the subsoil strata, the length of pile should be 10 to 30m as the piles are to be socketted in rock.

Pile termination depth and bearing capacity - For the prevailing soil conditions and type of structures, the capacity of bored cast-in-situ piles of 1200 mm or 1500 mm diameter have been worked out.

Piles transmit foundation loads through soil strata of low bearing capacity to deeper soil having a higher bearing capacity value. Piles carry loads as a combination of side friction and point bearing resistance. The minimum diameter of pile should be 1000mm.

Piles are suitable due to the following specific advantages over spread footings/raft foundation:

- Completely non-displacement.
- Carry the heavy superstructure loads into or through a soil stratum. Both vertical and lateral loads may be involved.
- Controls settlements when spread footing/raft foundation is on a marginal soil.
- Can resist uplift, or overturning.
- Applicable for a wide variety of soil conditions.

Recommended safe vertical load carrying capacity of piles of different lengths below the ground level are as shown in Table 4.13 and the minimum pile lengths (borehole wise) are indicated in Table 4.14.

Table 4.13: Pile Capacity (in T)

for 1.00m dia pile	for 1.20m dia pile	for 1.50m dia pile
353 T	508 T	795 T

Table 4.14: Borehole wise pile Lengths below Existing Natural Ground Level (in m)

Bore Hole No	Minimum Pile Length Required (in m)	Pile termination depth (in m.)		
		For 1m dia	For 1.20m dia	For 1.50m dia
BH-1	5.0+3D	8.00	8.60	9.50
BH-2	7.0+3D	10.00	10.60	11.50
BH-3	7.7+3D	10.70	11.30	12.20
BH-4	12.2+3D	15.20	15.80	16.70
BH-5	8.50+3D	11.50	12.10	13.00
BH-6	8.50+3D	11.50	12.10	13.00
BH-7	14.30+3D	17.30	17.90	18.80
BH-8	12.50+3D	15.50	16.10	17.00
BH-9	16.0+3D	19.00	19.60	20.50
BH-10	15.30+3D	18.30	18.90	19.80
BH-11	4.0+3D	7.00	7.60	8.50
BH-12	14.0+3D	17.00	17.60	18.50
BH-13	22.0+3D	25.00	25.60	26.50
BH-14	3.70+3D	6.70	7.30	8.20
BH-15	5.50+3D	8.50	9.10	10.00

Bore Hole No	Minimum Pile Length Required (in m)	Pile termination depth (in m.)		
		For 1m dia	For 1.20m dia	For 1.50m dia
BH-16	19.0+3D	22.00	22.60	23.50
BH-17	13.0+3D	16.00	16.60	17.50
BH-18	18.50+3D	21.50	22.10	23.00
BH-19	14.70+3D	17.70	18.30	19.20
BH-20	16.0+3D	19.00	19.60	20.50
BH-21	14.0+3D	17.00	17.60	18.50
BH-22	11.20+3D	14.20	14.80	15.70
BH-23	13.40+3D	16.40	17.00	17.90
BH-24	12.50+3D	15.50	16.10	17.00
BH-25	12.0+3D	15.00	15.60	16.50
BH-26	7.50+3D	10.75	11.35	12.25
BH-27	12.60+3D	15.60	16.20	17.10
BH-28	11.0+3D	14.00	14.60	15.50
BH-29	13.0+3D	16.00	16.60	17.50
BH-30	17.25+3D	20.25	20.85	21.75

4.6.5 SECTION – II (Mahim to SEEPZ)

4.6.5.1 Selection of Bore Hole Locations

The locations of bore holes were distributed in such a way so as to cover the entire alignment of the proposed Metro project. The locations were planned at an interval of 1000 m (approx.) each. Localised changes in bore locations have been effected depending upon the site difficulties as well as underground utilities constraints. Individual locations of bore holes have also been marked in the drawing. The details of boreholes along the corridor are shown in **Table 4.15.**

Table 4.15: Details of Boreholes (Mahim-Seepz)

S. No.	Bore hole number	Chainage (m)	Ground level (m)	Ground water table depth (m)	Depth of investigation (in m)			RQD between 10m to 20m depth (%)
					In soil	In rock (soft/ hard)	Total	
1	BH 7	On JVLR	26.839	1.10	2.45	8.55	11.00	10-72
2	BH 8	32200	30.442	1.00	4.30	15.70	20.00	72-93
3	BH 9	31300	24.400	1.80	5.00	7.50	12.50	69-98
4	BH 10	29975 On airport road	11.871	1.90	2.10	7.40	9.50	31-65
5	BH 11	28960 On Sahar road	10.000	2.30	6.00	9.50	15.50	32-52
6	BH 12	24315	2.752	2.10	3.00	6.50	9.50	19-100
7	BH 13	25500	6.875	2.10	3.00	14.70	17.70	14-86
8	BH 14	23065	4.054	2.60	4.00	5.00	9.00	29-100
9	BH 15	22000	3.614	2.70	3.00	11.00	14.00	18-52
10	BH 16	21240	3.500	2.40	8.50	8.00	16.50	32-52
11	BH 17	20700	2.300	2.20	7.10	9.90	17.00	7-17
12	BH 18	19415	4.160	2.70	4.10	5.90	10.00	28-72
13	BH 19	18300	3.500	2.90	10.00	10.00	20.00	8-83

4.6.5.2 Field Investigations

Standard Penetration Tests

This test was carried out using a Terzaghi spoon sampler driven by a 63.50 kg. Hammer weight falling freely through a height 750 mm. The refusal of the test has been considered when the penetration is not possible with no. of blows. The actual values of SPT such as (N2 + N3) have been reported. Refusals have been indicated in boreholes by mentioning 'R' in the SPT Value column. The SPT values help in assessing the stratum strength in general.

The field tests conducted covers the Standard Penetration Tests. The results of the same are summarized in **Table 4.16.**

Table 4.16: Standard Penetration Test Results

BH No.	Sr. No.	Depth of test (m)	N' Value (No. of blows per 30 cm)	Remarks
8	1	1.50 --- 2.10	02-03-04-06	07 Brownish Soil
	2	3.00 --- 3.60	05-08-10-12	18 Brownish Soil
9	1	1.50 --- 2.10	02-04-01-06	05 Brownish Soil
	2	4.00 --- 4.60	03-02-05-07	07 Brownish Soil
10	1	1.95 --- 2.10	15-24 (10 cm)	R Refusal
11	1	3.00 --- 3.60	03-05-06-09	11 Brownish Soil
	2	4.45 --- 5.05	04-06-08-11	14 Brownish Soil
12	1	3.00 --- 3.60	07-08-10-11	18 Residual Material
13	1	3.00 --- 3.00	40 (0 cm)	R Refusal
14	1	2.00 --- 2.60	03-04-06-07	10 Fill Material
	2	4.00 --- 4.00	50 (0 cm)	R Refusal
15	1	1.50 --- 2.10	02-03-04-07	07 Fill Material
	2	3.00 --- 3.00	35 (0 cm)	R Refusal
16	1	3.00 --- 3.60	03-04-05-06	09 Residual Soils
	2	4.50 --- 5.10	02-03-04-05	07 Residual Soils
	3	6.00 --- 6.60	03-04-04-06	08 Residual Soils
	4	7.50 --- 8.10	03-08-10-12	18 Residual Soils
17	1	3.00 --- 3.60	02-03-02-04	05 Residual Soil
	2	4.50 --- 5.10	02-03-04-06	07 Residual Soils
	3	6.00 --- 6.60	02-04-04-05	08 Residual Soils
18	1	3.00 --- 3.60	01-02-02-03	04 Residual Soils
	2	4.50 --- 5.10	02-03-04-04	07 Residual Soils
19	1	3.00 --- 3.60	01-02-02-03	04 Fill Material
	2	4.50 --- 5.10	02-03-04-04	07 Residual Soils
	3	6.00 --- 6.60	02-03-02-04	05 Residual Soils
	4	7.50 --- 8.10	03-04-04-06	08 Residual Soils
	5	9.00 --- 9.60	03-04-06-08	10 Residual Soils
	2	3.50 --- 3.95	03-05-07	12 Sandy Clay

4.6.5.3 Construction Methodology

Type of Foundation- Considering the insitu conditions (sample disturbance), confinement aspect do play a major role in transfer of loads to the bearing stratum. In the light of recovery pattern, the visual inspection of samples covering the texture, fracture and weathering aspect we recommend that the foundations may be laid based on chiseling criteria (as specified in subsequent paras). IS: 2911 (Part-I/Sec2)-1999 provide design approach in weathered rock stratum for bored cast insitu piles.

Depth of Foundation- A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Keeping in view the type of the proposed structure and the subsoil strata, the length of pile should be 8 m to 10 m as the piles are to be socketted in rock.

Pile termination depth and bearing capacity - For the prevailing soil conditions and type of structures, the capacity of bored cast-in-situ piles of 1000 mm, 1200 mm and 1500 mm diameter have been worked out. Actual socket length in completely weathered rock will be 3 times the pile diameter . However for design purpose only 0.5 times diameter length is considered. Piles transmit foundation loads through soil strata of low bearing capacity to deeper rock stratum having a higher bearing capacity value. Piles carry loads as a combination of side friction and point bearing resistance. The minimum diameter of pile should be 1000 mm.

Recommended safe vertical load carrying capacity of piles of different lengths below the ground level are as shown in **Table 4.17**.

Table 4.17: Pile Capacity (in T)

For 1.00m dia pile	For 1.20m dia pile	For 1.50m dia pile
350 T	508 T	795 T

Table 4.18: Borehole wise Pile Lengths below Ground Level

Sr. No.	BH No.	Minimum Pile Length	Pile termination depth BGL (in m)		
			For 1m dia	For 1.20m dia	For 1.50m dia
1	8	6.00 + 3.D	9.00	9.60	10.50

In almost all cases rock stratum is of completely highly weathered type. Hence determination of termination depth of pile is based on chiseling criteria only. Accordingly, there is possibility that actual socketing may be more than specified. However for design purpose only specified thickness of socket will be considered for pile strength.

4.7 UTILITY IDENTIFICATION

4.7.1 Introduction

- Large number of sub-surface, surface and overhead utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, Overhead power transmission lines, power cables, traffic signals, etc. exists all along the proposed alignment.

- In addition, a water tunnel of 6 m dia. running from Modaksagar dam (Vaitarna) upto south Mumbai is under construction by MCGM. A tentative alignment earmarked in satellite sheets showing various shafts in en-route are enclosed. Few of these shafts are located in vicinity of proposed underground Metro Rail corridor.

During the discussions with MCGM officials, we were given to understand that the water tunnel is below 60 m from the Ground level. Whereas proposed Metro corridor is generally 18 to 20 m below the Ground level. Therefore, an available clear cushion of 35 m is more than the required cushion of 6 m as per design criteria. As such there will be no hindrance in construction of u/g tunnel except for the stations which need to be done with properly safeguarding the shaft of water tunnel as mentioned above.

- As the detailed horizontal profile of water tunnel is not made available by the MCGM, consultants were unable to indicate the same in the alignment plan of Metro Rail Corridor.

- These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. Meticulous planning therefore will have to be taken in tackling the issue of protection/diversion of these utility services.

- Accordingly, the following engineering items have been studied and described in this chapter:

  i) Existing utilities and planning for their diversion during construction, if necessary.
  ii) Land acquisition necessary for diversion both on permanent as well as on temporary basis, including its break up between Government and private ownership.

4.7.2 Utilities and Services

The utility details of line 3 available with MMRDA are reviewed by the consultants. The details of line 6 were already obtained by the consultants at the stage of DPR. Wherever, the details were missing (especially in detouring) - additional details were collected from the concerned authorities. For the purpose of description of utilities, the alignment has been divided into two parts

i) Colaba – Mahim (Ch: (-)475 m to Ch: 18000 m)
ii) Mahim – SEEPZ via Airport (Ch: 18000 m to Ch: 33525 m)

Organizations/Departments with concerned utility services in Mumbai are mentioned in **Table 4.19.**

Table 4.19: Utility Responsibility Departments

Sr. No.	ORGANIZATION/DEPARTMENT	AREA	UTILITY SERVICES
1	Municipal Corporation of Greater Mumbai (MCGM) Div. 1, Div. 2	Colaba – Bandra (BKC) – SEEPZ	Water Pipe line lines

Sr. No.	ORGANIZATION/DEPARTMENT	AREA	UTILITY SERVICES
2	Municipal Corporation of Greater Mumbai (MCGM) Div. 1, Div. 2	Colaba – Bandra (BKC) – SEEPZ	Underground sewer line and Drainage system
3.	Municipal Corporation of Greater Mumbai (MCGM) Div. 1, Div. 2, Div. 3	Colaba – Bandra (BKC) – SEEPZ	Storm water drainage
4.	BEST (Bombay Electric Supply & Transportation)	Colaba – Bandra (BKC) – SEEPZ	Power cables underground and overheads
5.	Mahanagar Telephone Nigam Ltd. (MTNL)	Colaba – Bandra (BKC) – SEEPZ	PIJF cables & Optical Fiber cables.
6.	Mahanagar Gas Ltd. (MGL)	Colaba – Bandra (BKC) – SEEPZ	Gas pipe lines
7.	GAIL	Colaba – Bandra (BKC) – SEEPZ	As discussed, it was informed by M/s Gail Ltd. that there is no gas pipe line along / across in Mahim – BKC- Kanjur Marg metro corridor – Phase-II Alignment.
8.	Reliance Energy/ Ltd.	Colaba – Bandra (BKC) – SEEPZ	Electrical lines, H.T and L.T lines
9.	TATA Power Co. Ltd.	Colaba – Bandra (BKC) – SEEPZ	Electrical lines H.T. and L.T. lines,
10	MSEDCL	Colaba – Bandra (BKC) – SEEPZ	H.T and L.T cables

Assessment of the type and location of underground utilities running along and across the proposed route alignment has been undertaken with the help of data available with concerned authorities, who generally maintain plans and data of such utility services. Particulars of main utilities i.e. trunk and main sewers/drainage conduits, water mains, OH & UG Electric cable, Telecom cable etc. have been marked on alignment plans. The Details of various utilities have been collected from concerned agencies/organizations directly.

4.7.3 Diversion of Underground Utilities

While planning for diversion of underground utility services viz. sewer lines, water pipelines, cables, etc., during construction of MRTS, following guidelines have been adopted:

- Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.

- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.

- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.

4.7.4 Sewer Lines, Storm Water Drains and Water Lines

The sewer, storm water drains and water pipe lines generally exists either side of under main carriageway or at some places on the central verge, as a result of subsequent road widening.

The major sewer, storm water drains and water pipe lines mains running across the alignment and likely to be affected due to construction of stations are proposed to be taken care of by proper supporting arrangements. Where, this is not feasible, lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility service lines**.** Details of sewer lines & storm water drains and water pipe lines affected in cut & cover construction of stations along with their diversion proposals are indicated in **Table 4.14 to 4.16, Table 4.22 to 4.24 and Table 4.29 to 4.31.**

4.7.5 Gas Pipe Lines

Few gas pipe lines with varying diameters belonging to GAIL and Mahanagar gas Limited (MGL), Mumbai are running along and across the roads along which the metro alignment is proposed. Though, the alignment is planned almost along the road en-route, few pipelines running across and along the alignment likely to be affected by the alignment is detailed in **Table 4.25**. All these pipelines are placed at a depth of about 1.00 - 1.50 meter below the ground.

The pipelines running along the proposed alignment needs to be diverted in few stretches. At the time of project execution, the pipe line authorities should be contacted for necessary diversions and sufficient care should be taken to ensure their safety.

4.7.6 Above Ground Utilities

Above ground utilities namely Power transmission lines, street light poles, traffic signal posts, telecommunication posts, junction boxes, etc. are also required to be modified/shifted and relocated suitably during construction of stations planned by cut and cover method. Details of these are as under.

Section	**Lp**	**EP**	**Tsp**	**Tp**	**Jbe**	**JBt**	**Tr**	**Py**	**FL**
Colaba- Bandra	150	-	75		125	50	-	-	09
Bandra- SEEPZ (via Airport)	1248	103	130	05	NA	115	01	NA	NA

Lp - Light Post EP - Electric Post Tsp - Traffic Signal Post
Tp - Telephone Post Jbe - Electrical Junction Box Tr – Transformers
Py - Pylon (electric mast) FL - Flood Light Post JBt - Telephone Junction Box

4.7.7 HT- Electric cables along the Corridor

At several places, 11kV/22kV/33kV/66kv underground power cables belonging to BEST are running along and across the proposed alignment stretch of corridor from Colaba – Bandra- SEEPZ and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are indicated in **Table 4.17, 4.19, 4.24 and 4.29**. These lines need to be modified/shifted or cabled well in advance before the construction along this route.

4.7.8 Telecom Cables

At several places, telecom cables of MTNL and TATA Tele Services (OFC)/ are also running along and across the proposed alignment from Colaba –BKC- SEEPZ and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are shown in **Table 4.18 & 4.20**. Detailed proposals for tackling these lines need to be prepared in consultation with the concerned agencies. However, tentative provision has been made in cost estimates.

4.7.9 Corridor

4.7.9.1 Colaba to Mahim

The corridor is fully underground for a length of 33.508 km and having switchover portion of about 800 mtrs for at grade Depot. As indicated in the previous chapters the entire length of underground section is proposed to be constructed with tunneling (TBM) keeping a minimum cover of about 8.50 m above the tunnel. There are 27 stations proposed and proposed to be construction by NATM/ cut & cover method as per site constraint and legal aspects. Hence, the utility services existing in above ground or below ground position are not likely to be affected except at station locations which are proposed for construction by cut & cover method. Details of such affected utility services at station locations are indicated in **Table 4.20 to Table.4.27** and are placed at the end of this section.

Table 4.20: Details of Sewer Lines

S.No.	Chainage	Affected Length (in m.)	Dia (mm)	Position w.r.t alignment	Remarks
1	Cuffe Parade(00) (-) 150 - (+) 150	300	450	Along	A
2	Badwar Park(1000) (850-1150)	300	450	Along	A
3	Vidhan Bhavan(1600)	NIL	NIL	NIL	NIL
4	Churchgate Metro (2285)	Nil	Nil	Nil	Nil
5	Hutatma Chowk (3102)	NIL	NIL	NIL	NIL
6	CST Metro(3956) (6178-6363)	NIL	NIL	NIL	NIL
7	Kalbadevi (4891) (4741-5041)	1X300	300	Along	B
8	Girgaon(5616) (5466-5766)	2X300	230	Along	B
9	Grant Road Metro(7156) (7376-7561)	1x300	1600	Along	B
		1x300	680		
10	Mumbai Central Metro(8067) (7917-8217)	2X300	230	Along	A
11	Mahalaxm Metro (9216) (9066-9366)	1X300	230	Along	A
12	Science Museum(10316)	2X300	300	Along	A
	Ch.11399 across)	1X30	150	Across	A
13	Acharya Atrey Chowk(11516) (Ch.11666)	2x300	100	Along	A
		2x50	230	Across	A
14	Worli (12924)	Nil	Nil	Nil	Nil
15	Siddhi Vinayak(14479)				
16	Dadar Metro(15756)	Nil	Nil	Nil	Nil
17	Shitla devi Temple(17525)	NIL	NIL	NIL	NIL

Note : 1. The depth of Sewer lines was reported as 2 to 3 m.(app.) below ground.

"A'' Sewer line running along / across the alignment are proposed to be diverted away from the alignment or supported property before work is taken in hand at each location.

"B" Sewer line running align / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.21: Details of Water Supply Lines

S.No.	Station /Chainage	Affected Length (in m.)	Dia (mm)	Position w.r.t alignment	Remarks
1	Cuffe Parade(00) (-150- (+) 150)	300	450	Along	A
		300	300	Along	A
2	Badhwar Park (1000) 850 – 1150 (West)	300	450	Along	A
	850-1150 (Centre)	300	300	Along	A
	850-1150 (East)	300	300	Along	A
3	Vidhan Bhavan (1600)	NIL	NIL	NIL	NIL
4	Churchgate Metro (2050-2235)	300	250	Along	B
		300	250	Along	B
		300	450	Along	B
		300	750	Along	B
5	Hutatma Chowk (2645-2830)	30	1200	Across	B
		40	600	Across	B
6	CST Metro(3956) (6178-6363)	30	300	Along	A
		40	250	Along	A
		20	450	Along	A
		50	350	Along	A
7	Kalbadevi (4891) (4741-5041)	4 x 300	150	Along	B
	Across CH 4875	2x30	150	Across	B
	Across/4980	1x10	150	Across	B
	Across	*1x10*	100	Across	B
8	Girgaon(5616) (5466-5766)	*1X30*	250	Across	B
		1X30	750	Across	B
		1X30	800	Across	B
		2X300	150	Along	B
		1X300	450	Along	B
		1X300	300	Along	B
		1X300	600	Along	B
9	Grant Road Metro(7156) (7376-7561)	1x300	100	Along	B
		1x300	300	Along	B
		1x300	250	Along	B
	Across corridor (Ch.7290)	1x20	900	Across	B
		1x45	300	Across	B
		1x55	250	Across	B
10	Mumbai Central Metro(8067) (7917-8217)	1X300	550	Along	A
		1X300	250	Along	A
		1X300	900	Along	A
11	Mahalaxmi Metro (9216) (9066-9366)	1X300	550	Along	A
		1X300	750	Along	A
		1X300	100	Along	A
12	Science Museum (Ch 10150 – 10450)	1X300	600	Along	A
		1X300	300	Along	A
		1X300	150	Along	A
	Across Ch.10458	1x30	450	Across	`A
	Across Ch.10445	1x30	1450	` Across	A
	Across Ch.10440	1x30	1800	Across	A

S.No.	Station /Chainage	Affected Length (in m.)	Dia (mm)	Position w.r.t alignment	Remarks
	Across Ch.10450 (Skew)	1x35	1450	Across	A
13	Acharya Atrey Chowk (11516) (11350-11650)	1X300	1450	Along	A
		1X300	300	Along	A
		1X300	450	Along	A
		1X300	150	Along	A
		1X300	600	Along	A
14	Worli (12924) (12758-13058)	1X300	1450	Along	A
		1X300	300	Along	A
		1X300	450	Along	A
		1X300	150	Along	A
		1X300	600	Along	A
	Ch.12968	1x30	150	Across	A
15	Siddhi Vinayak (14480-14665)	Nil	Nil	Nil	Nil
16	Dadar Metro (15756) (15606)	2 x 70	1450	Along	A
		4 X 10	125	Across	A
	15606 - 15906	1x300	150	Along	A
	15606 - 15906	2x300	1450	Along	A
	15606 - 15906	1x300	600	Along	A
	15606 - 15906	1x300	300	Along	A
17	Shitaladevi Temple(17525) (17375-17675)	3X300	150	Along	A
	Across (Ch17450-17600)	4x30	150	Across	A
		1X300	250	Along	A

Note: 1. The depth of Water lines was reported as 1.5 to 2m.(app.) below ground.

"A" Water pipe line running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" Water pipe line running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.22: Details of Gas Pipe Lines (Mahanagar Gas)

S.No.	Station/Chainage	Affected Length (m)	Approx. Depth	Type & Dia (In mm)	Position w.r.t alignment	Remarks
1	Cuffe Parade(00) (- 150- (+) 150)	Nil	Nil	Nil	Nil	Nil
2	Badwar Park (850-1035)	185	1.0	150 Steel gas P/L	Along	A
3	Vidhan Bhavan (1600)	NIL	NIL	NIL	NIL	NIL
4	Churchgate (2050-2235)	Nil	Nil	Nil	Nil	Nil
5	Hutatma Chowk (2645-2830)	50	1.0	150 Steel gas P/L	Across	A
6	CST Metro (3843-4028)	70	1.0	150 Steel gas P/L	Along	A
7	Kalbadevi (4891) (4741-5041)	1x300	1.0	150 steel gas P/L	Along	B
8	Girgaon(5616) (5466-5766)	1X300	1.0	150 Steel gas P/L	Along	B
9	Grant Road Metro(7156) (7376-7561)	1x300	1.0	150 mm steel gas P/L	Along	B

S.No.	Station/Chainage	Affected Length (m)	Approx. Depth	Type & Dia (In mm)	Position w.r.t alignment	Remarks
10	Mumbai Central Metro (8067) (7917-8217)	1X300	1.0	200 mm steel gas P/L	Along	A
11	Mahalaxmi Metro (9216) (9066-9366)	1X300	1.0	300 mm steel gas P/L	`Along	A
12	Science Museum (10150-10450)	1X300	1.0	300 mm steel gas P/L	Along	A
13	Acharya Atre Chowk (11612-11797)	Nil	Nil	Nil	Nil	Nil
14	Worli (12908-13093)	Nil	Nil	Nil	Nil	Nil
15	Siddhi Vinayak (14480-14665)	Nil	Nil	Nil	Nil	Nil
16	Dadar Metro(15756)	NIL	NIL	NIL	NIL	NIL
17	Shitaladevi Temple (17525)	NIL	NIL	NIL	NIL	NIL

“A” MGL Gas pipe line running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

“B” MGL Gas pipe line running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.23: Details of BEST Power Lines

S.No.	Station / Chainage	Affected length (in m.)	Type	Position w.r.t alignment	Remarks
1	Cuffe Parade (00) (-150-(+) 150)	2X300	33KV	Along	A
	190	40	33KV	Across	B
	327	40	33KV	Across	B
2	Badhwar Park (850- 1030)	180	33KV	Along	A
	(1017-1073)	57	33KV	Along	A
	850	-	33KV	Across	A
3	Vidhan Bhavan (1600)	NIL	NIL	NIL	NIL
4	Churchgate (2050-2235)	2X300	33KV	Along	A
		40	33KV	Across	B
		40	33KV	Across	B
		40	33KV	Across	B
		40	33KV	Across	B
5	Hutatma Chowk (2645-2830)	2X4 X 50	33KV	Across	B
6	CST Metro(3956) (6178-6363)	2 X 750	33KV	Along	A
		1x35	33kv	Across	A
		1 X 30	33KV	Skew	A
7	Kalbadevi (4891) (4741-5041)	NIL	NIL	NIL	NIL
8	Girgaon(6178-6363)	4 X 30	33KV	Across	B
9	Grant Road Metro(7156) (7376-7561)	2 X 300	33KV	Along	B
10	Mumbai Central Metro (8067) (7917-8217) (Ch 8975/8125/8200)	2X300	33KV	Along	A
		1x30	33KV	Across	A
		1x30	33KV	Across	A

S.No.	Station / Chainage	Affected length (in m.)	Type	Position w.r.t alignment	Remarks
		1x30	33KV	Across	A
11	Mahalaxmi Metro (9216) (9066-9366)	2 x 300	33KV	Along	A
	Across(skew)Ch 9050	1x15	33kv	Across/skew	A
	Across(9100-9120)	1x20	33kv	across	A
12	Science Museu(10150-10450)	2X300	33Kv	Along	A
13	Acharya Atre Chowk (11350-11650) (Across 11588)	2 x 300	33kv	Along	A
		1 x 30	33KV	Across	A
14	Worli Station (12758-13058) Ch.13074 (across)	2 x 300	33kv	Along	A
		1 x 70	33KV	Across	A
15	Siddhi Vinayak (14480-14665)	Nil	Nil	Nil	Nil
16	Dadar(15831/15945)	1x 30	33kv	Across	B
		1 x 30	33KV	Along	A
	(15710-16010)	1X300	33kv	Along	A
17	Shitaladevi Temple(17525) (17378-17678)	2X300	33 KV	Along	A

Note : 1. The depth of Power Cables was reported upto 1m.(app.) below ground.

"A" BEST Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" BEST Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines

Table 4.24: Details of TATA Power Lines

S.No.	Station / Chainage	Affected length (in m.)	Type	Position w.r.t alignment	Remarks
1	Cuffe Parade(00) (-150-(+) 185)	Nil	Nil	Nil	Nil
2	Badwar Park (1000) (850-1045)	195	66KV	Along	A
	(1045- 1055)	30	66KV	Across	A
3	Vidhan Bhavan (1600)	NIL	NIL	NIL	NIL
4	Mantralaya (2050-2235)	Nil	Nil	Nil	Nil
5	Hutatma Chowk (2645-2830)	40	66KV	Across	B
6	CST Metro (3843-4028)	Nil	Nil	Nil	Nil
7	Kalbadevi (4891) (4741-5041)	Nil	Nil	Nil	Nil
8	Girgaon (6178-6363)	Nil	Nil	Nil	Nil
9	Grant Road Metro(7156) (7376-7561)	1X300	66KV	Along	B
10	Mumbai Central Metro (8067) (7917-8217)	1x300	66KV	Along	A
11	Mahalaxmi Metro(9216) (9066-9366)	1X300	6.6 Kv	Along	A
12	Science Museum (10150-10450)	2X300	22KV	Along	A
13	Acharya Atre Chowk (11516)	Nil	Nil	Nil	Nil
14	Worli Station (12908-13093)	Nil	Nil	Nil	Nil
15	Siddhi Vinayak (14480-14665)	Nil	Nil	Nil	Nil

S.No.	Station / Chainage	Affected length (in m.)	Type	Position w.r.t alignment	Remarks
16	Dadar(15710-16010)	2X300	22KV	Along	B
17	Shitladevi Temple (17525)	1X300	22KV	Along	A

Note : 1. The depth of Power Cables was reported upto 1m.(app.) below ground.

"A" TATA Power Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" TATA Power Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.25: Details of Affected Reliance Power Cables

S. No.	Station / Chainage	Affected Length (In m.)	Type	Position w.r.t Alignment	Remarks
1	Cuffe Parade(00) (-150- (+)150)	Nil	Nil	Nil	Nil
2	Badwar Park(1000)	Nil	Nil	Nil	Nil
3	Vidhan Bhavan(1600)				
4	Churchgate (2285)	Nil	Nil	Nil	Nil
5	Hutatma Chowk (3102)	Nil	Nil	Nil	Nil
6	CST Metro (3956)	Nil	Nil	Nil	Nil
7	Kalbadevi (4891)	Nil	Nil	Nil	Nil
8	Girgaon(5616)	Nil	Nil	Nil	Nil
9	Grant Road Metro(7156)	Nil	Nil	Nil	Nil
10	Central (Metro) (8067)	Nil	Nil	Nil	Nil
11	Mahalaxmi Metro(9216)	Nil	Nil	Nil	Nil
12	Science Museum(10316)	Nil	Nil	Nil	Nil
13	Acharya Atre Chowk (11516)	Nil	Nil	Nil	Nil
14	Worli (12924)	Nil	Nil	Nil	Nil
15	Siddhi Vinayak (14479)	Nil	Nil	Nil	Nil
16	Dadar Metro (15756)	Nil	Nil	Nil	Nil
17	Shitladevi Temple(17525)	Nil	Nil	Nil	Nil

Note: 1.The depth of Power cables was reported upto 1 m.(app.) below ground.

"A" Reliance HT Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" Reliance HT Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.26: Details of TATA OFC Cables

S.No.	Station /Chainage	Affected Length (in m.)	Type	Position w.r.t Alignment	Remarks
1	Cuff Parade (00) (-150-150)	210	Tata OFC	Along	A
2	Badwar Park(1000) (850-1036)	186	Tata OFC	Along	A
	(1036-1050) (skew)	26	Tata OFC	Across	A
	(1028-1150)	122	Tata OFC	Along	A
3	Vidhan Bhavan(1600)	NIL	NIL	NIL	NIL
4	Churchgate(2285)	1X300	Tata OFC	Along	A

S.No.	Station /Chainage	Affected Length (in m.)	Type	Position w.r.t Alignment	Remarks
	(2135-2435)				
5	Hutatma Chowk (3102)	Nil	Nil	Nil	Nil
6	CST Metro (3956)	Nil	Nil	Nil	Nil
7	Kalbadevi (4891) (4741-5041)	1X300	Tata OFC	Along	B
8	Girgaon(5616) (5466-5766)	1X300	Tata OFC	Along	B
9	Grant Road Metro(7156) (7376-7561)	Nil	Nil	Nil	Nil
10	Mumbai Central Metro (8067) (7917-8217)	1x300	Tata OFC	Along	A
11	Mahalaxmi Metro(9216) (9066-9366)	1X300	Tata OFC	Along	A
12	Science Museum (10150-10450)	1X300	Tata OFC	Along	A
13	Acharya Atre Chowk (11516) (11366-11666)	1x300	Tata OFC	Along	A
14	Worli Station(12924) (12774- 13074)	1x300	Tata OFC	Along	A
15	Siddhi Vinayak (14479)	Nil	Nil	Nil	Nil
16	Dadar Metro(15756) (15606-15906)	300	Tata OFC	Along	A
17	Shitladevi Temple(17525)	NIL	NIL	NIL	NIL

Note : 1. The depth of OFC Cables was reported upto 1m.(app.) below ground.

"A" TATA OFC Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" TATA OFC Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.27: Details of MTNL Cables

S.No.	Chainage	Affected Length (m)	Approx. Depth Below (m)	Type /Dia (In mm)	Position w.r.t Alignment	Remarks
1	Cuff Parade (-92.5-185)	300	1.0	Cable duct	Along	A
2	Badwar Park (1000) (1000)	300	1.0	Cable duct	Along	A
3	Vidhan Bhavan					
4	Churchgate (2050-2235)	300	1.0	Cable duct	Along	A
5	Hutatma Chowk (2645-2830)	2 x 40	1.0	Cable duct	Across	B
6	CST Metro(3956) (3843-4028)	70	1.0	Cable duct	Along	A
7	Kalbadevi (4891) (4741-5041)	70	1.0	Cable duct	Along	A
8	Girgaon (5616)	70	1.0	Cable duct	Along	A
9	Grant Road Metro(7156) (7376-	NIL	NIL	NIL	NIL	NIL

S.No.	Chainage	Affected Length (m)	Approx. Depth Below (m)	Type /Dia (In mm)	Position w.r.t Alignment	Remarks
	7561)					
10	Mumbai Central Metro (8067) (8170-8355)	70	1.0	Cable duct	Along	A
11	Mahalaxmi Metro(9216)	NIL	NIL	NIL	NIL	NIL
12	Science Museum (10316)	NIL	NIL	NIL	NIL	NIL
13	Acharya Atre Chowk	NIL	NIL	NIL	NIL	NIL
14	Worli (12924)	Nil	Nil	Nil	Nil	Nil
15	Siddhi Vinayak(14479)	Nil	Nil	Nil	Nil	Nil
16	Dadar(15756)	Nil	Nil	Nil	Nil	Nil
17	Shitladevi Temple(17525)					

Note : 1. The depth of MTNL Cables was reported upto 1m.(app.) below ground.

"A" Reliance HT Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" Reliance HT Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

4.7.9.2 Mahim to SEEPZ

The underground section of this corridor is for a length of 15.575 Km from Mahim (Ch: 18000 m) to SEEPZ (Ch. 33575 Km). The entire length of underground section is proposed to be constructed by TBM keeping a minimum cover of about 8.50 m above the tunnel. Mostly underground section utilities are running 1.50 m to 4.00 m below the ground level and are not likely to be affected except at station locations. Details of such affected utility services at station locations are indicated in **Table 4.28 to 4.34**.

Table 4.28: Details of Sewer Lines

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
Shitla Devi Temple – Dharavi						
1	Dharavi(19306)		70	230	Along	A
Dharavi – Bandra						
2	Bandra Metro(21271)		1x5.0	Span 5.0	Across	Pipe culvert temp.to be diverted for cut & cover const.of station
Bandra – Kalina						
3	22458	22843	385	300 mm Φ	Across and along right and left side of alignment across at Ch. 22635 & 22843	B
Kalina- Santacruz						
4	23073	23164	91	300 mm Φ	Across and along left side of alignment	B
5	23758	24458	700	48 Φ	Along left side of alignment	A
Santacruz-CSIA (Domestic)						
6	24223	24224	1	600 mm Φ	Across	B
7	24238	24239	1	1000 mm Φ	Across	B

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
				in progress by micro tunneling		
Marol Naka- SEEPZ						
8	31375	31638	263	400 mm Φ	Along left side of alignment & Across at Ch. 31375	B
9	31638	33008	1370	500 mm Φ 450 mm Φ 400 mm Φ 350 mm Φ 230 mm Φ	Along left side of alignment	A
10	32108	32109	1	300 mm Φ	Across	B
11	32278	32279	1	300 mm Φ	Across	B

"A'' Sewer line running along / across the alignment are proposed to be diverted away from the alignment or supported property before work is taken in hand at each location.

"B" Sewer line running align / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.29: Details of Storm Water Drains

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
RITES have approached the concerned Utility Department and have also given drawings for the proposed alignment for marking the utilities, but no information have been received from them so far. **However, broad details of existing culvert of span 3.20 meters & a kachha road of c/way 3.50 m between Ch.31070 to 31120 running across the proposed MIDC station is indicated in alignment plan & in utility report**						

Table 4.30: Details of Water Pipe Line

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
Shitla Devi Temple – Dharavi						
1	Dharavi (19306)		2 x 300	150	Along	A
Dharavi – Bandra						
2	Bandra Metro (21271)		1X300	600	Along	A
Bandra- Kalina						
3	21270	21271	1	600mm Φ	Across Ch. 21270	B
4	21270	21683	413	600mm Φ	Along with right side of Alignment Across at Ch. 21658	B
5	21568	21728	160	250mm Φ	Along right side of Alignment	A
6	21931	21965	34	1200mm Φ	Across at Ch. 21948	B
7	22000	22007	7	450mm Φ 450mm Φ 300mm Φ 250mm Φ	Across from Ch. 22000 to 22007 4 nos. Of pipe lines crossings	B
Kalina – Santacruz						
8	23158	23177	19	2 No pipe 600mm Φ	Across at Ch. 23161 to 23175	B

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
9	23828	24258	430	1 No of pipe 250 mm Φ	Across and along right side of align. across at Ch. 23870	B
Santacruz- Short of CSIA (Domestic)						
10	24230	24229	1	1 No of pipe 600 mm Φ	Across	B
11	24250	24250	1	1 No of pipe 300 mm Φ	Across	B
12	24230	24231		300 mm	Across and along right side of alignment across at Ch. 24318	A
MIDC						
13	31070	31120	1X30	1800	Across	A
14	31070	31120	1X30	1200	Across	A

"A" Water pipe line running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" Water pipe line running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.31: Details of Best Cables

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
Shitla Devi Temple – Dharavi						
1	Dharavi(19306) (19268-19475)		1X207	33KV	Across	A
	(19622-19648)		1X26	33KV	Along left side of alignment & across at Ch.19658	A
	(19636-19637)		1X1	33KV	Across	A
Dharavi – Bandra						
2	Bandra Metro(21271)		Nil	Nil	Nil	Nil

"A" BEST Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" BEST Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.32: Details of MGL Gas pipe line

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Depth (m)	Dia/Size	Position w.r.t. Alignment	Remarks
Shitla Devi Temple – Dharavi							
1	Dharavi (19306)		NIL	NIL	NIL	NIL	NIL
Dharavi – Bandra							
2	Bandra Metro(21271) (21121-21421)		1x30	1.0	150 Steel gas P/L	Across	A
Bandra-Kalina University							
3	21303	21306	3	1.00-1.50		Across two pipe	B

"A" MGL Gas pipe line running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" MGL Gas pipe line running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.33: Details of Reliance HT cables

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
1	20963	21243	280	2 cables	Along left side of alignment and across at Ch. 3385	B
2	21075	21298	223	2 Cables	Along left side alignment & across at Ch. 21243 and along right side alignment	B
3	21290	21291	1	3 cables	Across alignment	B
4	21158	21290	132	1 cable	Along left side alignment	A
5	21553	21793	240	2 cables	Along right side alignment and across at Ch. 21643 than along left side alignment	B
6	22151	22152	1	3 cables	Across alignment	B
Santacruz- Short of CSIA (D)						
7	24278	24279	1	2 cables	Across alignment	B
8	24498	24499	1	2 cables	Across alignment	B
9	24616	24617	1	1 Cable	Across alignment	B
10	24828	24829	1	1 cable	Across alignment	B
Beyond CSIA (I) – Marol Naka						
11	29265	29266	1	1 cable	Across alignment	B
12	29605	29606	1	4 cables	Across alignment	B
13	29615	29616	1	7 cables	Across alignment	B
14	29618	29718	100	2 cables	Across and along with right side alignment	B
15	29773	29916	143	2 cables	Along right side alignment and across at Ch. 29916	B
Marol Naka – SEEPZ						
16	29916	29917	1	3 cables	Across Alignment	B
17	30191	30309	118	1 cable	Across and along with left side alignment than across at Ch. 30303 than right side alignment and across at Ch. 12451	B
18	30303	30309	1	1 cable	Across alignment	B
19	30456	30485	29	2 cables	Across and along with left side alignment.	B
20	30652	30853	201	1 cable	Along with left side alignment	A
21	30833	31203	370	2 cables	Across and along with left side alignment.	B

"A" Reliance HT Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" Reliance HT Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Table 4.34: Details of Reliance LT cables

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
Bandra- Kalina University						
1	20600	20601	1	1 cable	Along with left side alignment	A
2	21538	21543	5	4 cables	Along with left side alignment	A
3	21548	21549	1	2 cables	Across alignment	B
4	21551	21563	12	2 cables	Along with left side alignment	A
5	21553	21554	1	5 cables	Along with right side alignment	A
6	21553	21573	20	1 cables	Along with left side alignment and across at Ch. 21573	B
7	21603	21660	57	5 cables	Along with left side alignment	A
8	21616	21617	1	3 cables	Along with right side alignment	A
9	21618	21619	1	21 cables	Along with right alignment	A
10	21618	21670	52	4 cables	Along with right side alignment and across at Ch. 21636 than along with left side alignment and across at Ch. 21668	B
11	21655	21656	1	1 cable	Across alignment	B
12	21668	21673	5	7 cables	Across alignment	B
13	21700	21703	3	3 cables	Across alignment	B
14	21708	21709	1	1 cable	Across alignment	B
15	21703	21808	105	38 cables	Along with left side alignment	A
16	21718	21719	1	1 cable	Across alignment	B
17	21720	21721	1	1 cable	Across alignment	B
18	21727	21728	1	1 cable	Across alignment	B
19	21756	21757	1	1 cable	Across alignment	B
20	21868	21888	20	6 cables	Along with right side alignment	B
21	21883	21884	1	1 cable	Across alignment	B
22	21893	21894	1	2 cables	Across alignment	B
23	21908	21909	1	4 cables	Along with left side alignment	A
24	21928	21929	1	1 cable	Along with left side alignment	A
25	21935	21938	3	1 cable	Along with left side alignment	A
26	21998	21999	1	4 cables	Across alignment	B
27	22006	22007	1	1 cable	Across alignment	B
28	22008	22033	25	14 cables	Along with left side alignment	A
29	22008	22038	30	12 cables	Along with right side alignment	A
30	22018	22033	15	1 cable	Across alignment and along with left side alignment and across at Ch. 22023 than along with right side alignment and across at Ch. 22033	B
31	22058	22074	16	5 cables	Along with left side alignment	A
32	22058	22078	20	10 cables	Along with right side alignment	A
33	22074	22075	1	1 cable	Across alignment	B
34	22074	22118	44	4 cables	Along with left side alignment	A
35	22093	22094	1	1 cable	Across alignment	B
36	22395	22396	1	1 cable	Along with right side alignment	A
37	22298	22306	8	3 cables	Along with right side alignment	A
38	22303	22304	1	2 cables	Across alignment	B
Kalina University- Santacruz						
39	23303	23603	300	1 cable	Across alignment and along with left side alignment than across at Ch. 23603	B
40	23558	23606	48	10 cables	Along with right side alignment	A
41	23603	23623	20	1 cable	Across alignment and along with left side alignment	B
42	23603	23604	1	2 cables	Across alignment	B
43	23605	23606	1	1 cable	Across alignment	B

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
44	23605	23623	18	2 cables	Along with left side alignment	A
45	23613	23615	2	7 cables	Along with right side alignment	A
46	23620	23638	18	5 cables	Along with left side alignment	A
47	23623	23624	1	4 cables	Across alignment	B
48	23628	23629	1	1 cable	Across alignment	B
49	23628	23629	1	5 cables	Along with right side alignment	A
50	23648	23659	11	12 cables	Along with right side alignment	A
51	23873	23874	1	1 cable	Across alignment	B
52	23883	23884	1	1 cable	Across alignment	B
53	23883	23938	55	1 cable	Along with right side alignment	A
54	23998	24028	30	8 cables	Along with right side alignment	A
55	24018	24088	70	14 cables	Along with right side alignment	A
56	24018	24093	75	2 cables	Along with right side alignment	A
Santacruz- Short of CSIA(D)						
57	24033	24143	110	6 cables	Along with right side alignment	A
58	24093	24143	50	5 cables	Along with right side alignment	A
59	24093	24113	20	5 cables	Along with right side alignment	A
60	24093	24158	65	1 cable	Along with right side alignment	A
61	24153	24203	50	21 cables	Along with right side alignment	A
62	24153	24154	1	1 cable	Across alignment	B
63	24155	24243	88	1 cable	Across alignment and along with left side alignment	B
64	24156	24198	42	1 cable	Along with left side alignment	A
65	24173	24178	5	3 cables	Along with right side alignment	A
66	24178	24218	40	1 cable	Across alignment and Along with left side alignment	B
67	24193	24193	1	1 cable	Across alignment	B
68	24198	24223	25	1 cable	Along with left side alignment and across at Ch. 24223	B
69	24198	24228	30	4 cables	Along with left side alignment	A
70	24214	24215	1	1 cable	Across alignment	B
71	24175	24233	58	1 cable	Along with right side alignment	A
72	24198	24243	45	1 cable	Along with left side alignment	A
73	24198	24263	65	1 cable	Along with left side alignment and across at Ch. 24263	B
74	24233	24248	15	7 cables	Along with right side alignment	A
75	24243	24244	1	1 cable	Across alignment	B
76	24273	24274	1	1 cable	Across alignment	B
77	24278	24338	60	2 cables	Along with right side alignment	A
78	24343	24344	1	2 cables	Across alignment	B
79	24344	24398	54	1 cable	Across alignment and along with left side alignment than across at Ch. 24398	B
80	24348	24349	1	1 cable	Across alignment	B
81	24348	24408	60	2 cables	Along with left side alignment and across at Ch. 24408	B
82	24349	24408	59	2 cables	Along with left side alignment	A
83	24408	24418	10	1 cable	Across alignment and along with right side alignment than across at Ch. 24414 and along with left side alignment than across at Ch. 24418	B
84	24410	24417	7	1 cable	Across alignment and along with right side alignment than across at Ch. 24139 and along with left side alignment than across at Ch. 24417	B
85	24413	24414	1	1 cable	Across alignment	B

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
86	24414	24415	1	1 cable	Across alignment	B
87	24415	24428	13	2 cable	Across alignment and along with left side alignment and across at Ch. 24428	B
88	24438	24439	1	1 cable	Across alignment	B
89	24448	24473	25	5 cables	Along with left side alignment	A
90	24478	24498	20	2 cables	Along with left side alignment	A
91	24497	24498	1	3 cables	Across alignment	B
92	24498	24499	1	5 cables	Across alignment	B
93	24508	24509	1	2 cables	Across alignment	B
94	24508	24548	40	5 cables	Along with right side alignment	A
95	24528	24608	80	5 cables	Along with right side alignment	A
96	24548	24549	1	1 cable	Across alignment	B
97	24643	24644	1	1 cable	Across alignment	B
98	24653	24654	1	1 cable	Across alignment	B
99	24663	24664	1	1 cable	Across alignment	B
100	24703	24704	1	1 cable	Across alignment	B
101	24704	24723	19	3 cables	Along with left side alignment	A
102	24708	24738	30	3 cables	Along with right side alignment	A
103	24714	24738	24	3 cables	Along with left side alignment	A
104	24733	24734	1	1 cable	Across alignment	B
105	24743	24753	10	2 cables	Along with right side alignment	A
106	24743	24773	30	14 cables	Along with left side alignment	A
107	24743	24783	40	3 cables	Along with right side alignment	A
108	24753	24754	1	1 cable	Across alignment	B
109	24773	24778	5	1 cable	Along with left side alignment	A
110	24778	24779	1	1 cable	Across alignment	B
111	24803	24804	1	1 cable	Across alignment	B
112	24808	24809	1	1 cable	Across alignment	B
113	24813	24843	30	6 cables	Along with right side alignment	A
114	24833	24834	1	1 cable	Across alignment	B
115	24838	24839	1	1 cable	Across alignment	B
116	24838	24868	30	1 cable	Along with left side alignment	A
117	24843	24868	25	1 cable	Across alignment and Along with left side alignment	B
118	24847	24848	1	1 cable	Across alignment	B
119	24848	24873	25	1 cable	Across alignment and Along with left side alignment	B
120	24848	24878	30	5 cables	Along with left side alignment	A
121	24858	24893	35	6 cables	Along with right side alignment	A
122	24858	24868	10	2 cables	Along with right side alignment	A
123	24863	24864	1	1 cable	Across alignment	B
124	24863	24888	25	2 cables	Along with left side alignment	A
125	24864	24870	6	1 cable	Along with left side alignment	A
126	24868	24869	1	2 cables	Across alignment	B
127	24873	24874	1	2 cables	Across alignment	B
128	24883	24893	10	1 cable	Along with right side alignment	A
129	24913	24923	10	1 cable	Along with right side alignment	A
130	24918	24919	1	1 cable	Across alignment	B
131	24963	24983	20	1 cable	Along with left side alignment	A
Short of Marol Naka- SEEPZ						
132	29488	29493	5	1 cable	Along with right side alignment	A

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
133	29518	29548	30	8 cables	Along with left side alignment	A
134	29528	29529	1	1 cable	Across alignment	B
135	29528	29548	20	1 cable	Along with right side alignment	A
136	29548	29558	10	3 cables	Along with right side alignment	A
137	29553	29568	15	1 cable	Along with right side alignment and across at ch. 29568	B
138	29553	29563	10	8 cables	Along with left side alignment	A
139	29568	29578	10	2 cables	Across alignment and Along with right side alignment	B
140	29568	29608	40	1 cable	Across alignment and Along with right side alignment	B
141	29568	29578	10	3 cables	Along with left side alignment	A
142	29568	29603	35	4 cables	Along with left side alignment	A
143	29583	29608	25	2 cables	Along with right side alignment	A
144	29583	29603	20	2 cables	Along with left side alignment	A
145	29593	29608	15	7 cables	Along with left side alignment	A
146	29603	29613	10	1 cables	Across alignment and Along with right side alignment	B
147	29613	29614	1	3 cables	Across alignment	B
148	29653	29723	70	1 cables	Along with left side alignment	A
149	29753	29754	1	1 cable	Across alignment	B
150	29773	29813	40	6 cables	Along with right side alignment	A
151	29863	29923	60	7 cables	Along with right side alignment	A
152	29873	29874	1	1 cable	Across alignment	B
153	29883	29893	10	1 cable	Along with left side alignment	A
154	29923	29948	25	4 cables	Along with left side alignment	A
155	29938	29939	1	1 cable	Across alignment	B
156	29958	29959	1	1 cable	Across alignment	B
157	29958	29988	30	3 cables	Along with right side alignment	A
158	29973	29993	20	2 cables	Along with left side alignment	A
159	30003	30323	20	3 cables	Along with right side alignment	A
160	30068	30108	40	2 cables	Along with right side alignment	A
161	30118	30119	1	1 cable	Across alignment	B
162	30133	30208	75	14 cables	Along with right side alignment	A
163	30138	30143	5	1 cable	Along with left side alignment	A
164	30178	30203	1	2 cables	Across alignment	B
165	30198	30203	5	2 cables	Along with left side alignment	A
166	30258	30303	45	5 cables	Along with right side alignment	A
167	30273	30274	1	2 cables	Across alignment	B
168	30293	30294	1	3 cables	Across alignment	B
169	30308	30333	25	3 cables	Across alignment and Along with left side alignment	B
170	30318	30319	1	2 cables	Across alignment	B
171	30318	30363	45	10 cables	Along with left side alignment	A
172	30253	30354	1	1 cable	Across alignment	B
173	30433	30453	20	2 cables	Along with right side alignment and across at Ch.30453	B
174	30453	30454	1	4 cable	Across alignment	B
175	30508	30543	35	3 cables	Along with right side alignment	A
176	30633	30634	1	1 cable	Across alignment	B
177	30753	30803	50	5 cables	Along with right side alignment	A
178	30763	30764	1	1 cable	Across alignment	B
179	30778	30779	1	3 cables	Across alignment	B
180	30783	30828	45	6 cables	Along with right side alignment	A

S. No	From Ch. (m)	To Ch. (m)	Affected Length (M)	Dia/Size	Position w.r.t. Alignment	Remarks
181	30828	30829	1	1 cable	Across alignment	B
182	30833	29953	880	2 cables	Along with right side alignment and across at Ch. 29953	B
183	30833	30858	25	3 cables	Across alignment and Along with right side alignment	B
184	30838	30853	15	3 cables	Along with left side alignment	A
185	30853	30943	90	2 cables	Across alignment and Along with left side alignment	B
186	30878	30893	15	3 cables	Along with right side alignment	A
187	30938	30939	1	3 cables	Across alignment	B
188	30943	30948	5	1 cable	Along with left side alignment	A
189	30943	30993	50	1 cable	Along with left side alignment	A
190	30968	30993	25	1 cable	Along with left side alignment	A
191	31063	31103	40	1 cable	Across alignment and Along with left side alignment	B
192	31018	31103	85	2 cables	Along with left side alignment	A
193	31073	31083	10	2 cables	Along with right side alignment	A
194	31103	31193	90	1 cable	Along with left side alignment	A
195	31113	31114	1	1 cable	Across alignment	B
196	31188	31189	1	1 cable	Across alignment	B
197	31190	31194	4	1 cable	Across alignment and Along with right side alignment than across at Ch. 31194	B
198	31190	31203	13	3 cables	Across alignment and Along with right side alignment	B
199	31193	31194	1	1 cable	Across alignment	B
200	31193	31198	5	2 cables	Across alignment and Along with right side alignment than across at Ch. 31198	B
201	31193	31263	70	2 cables	Along with left side alignment and across at Ch. 31263	B

"A" Reliance LT Cables running along / across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

"B" Reliance LT Cables running along / across the alignment is not proposed for diversion. But due care will be taken to avoid any damage to above lines.

4.8 HERITAGE ISSUES

4.8.1 Buildings/Artefacts/Structures /Precincts of Heritage importance

Buildings/Artefacts/Structures /Precincts of Heritage importance of Mumbai area are covered by Heritage Regulations for Greater Mumbai issued in 1995.Government of Maharashtra vide Government Resolution No. DCR 1090/3197/RDP/UD-II dated 21.4.95 issued Regulation no 67 regarding conservation of listed buildings, Artefacts, Structures and Precincts of historical, aesthetical ,architectural and cultural values. Definition, objectives, scope for changes, procedure for Listed Buildings/ Precincts of heritage importance of three identified types of Heritage Grades I, II and III are given in **Table 4.35**.

Table 4.35: Heritage Grades I,II and III

Sr. No	Heritage Grade-I	Heritage Grade-II(A & B)	Heritage Grade-III
A	**Definition**		
	Comprises of buildings and precincts of national or historical importance, embodying excellence in architectural style, design, technology and material usage: they may be associated with a great historical event, personality, movement or institution. They have been and are, the prime landmarks of the City.	Comprises of buildings, of regional or local importance, possessing special architectural or aesthetical merit, cultural or historical value, through of a lower scale than in Heritage Grade. They are local landmarks, contributing to the image and identity of the City. They may be the work of mast at craftsmen, or may be models of proportion and ornamentation, or designed to suit particular climate.	Comprises of buildings, and precincts of importance for town scape; they evoke architectural aesthetic or sociological interest though not as much as in Heritage Grade –II. These contribute to determine the character of the locally, and can be representative of life style of a particular community or region and, may also be distinguished by setting on a street-line, or special character of the façade and uniformity of height, width and scale.
B	**Objective**		
	Richly deserves careful preservation.	Deserves intelligent Conservation.	Deserves protection of unique features and attributes.
C	**Scope for Changes-**		
	No interventions would be permitted either on the exterior or interior unless it is necessary in the interest of strengthening, and prolonging, the life of the buildings or precincts or any part or features thereof. For this purpose, absolutely essential and minimal changes allowed and they must accordance with the original.	Grade-II (A) Internal changes, and adaptive reuse will be generally allowed, but external changes will be subject to scrutiny. Care would be taken to ensure the conservation of all special aspects for which it is included in Heritage Grade-II	External and internal changes and adaptive reuse would generally be allowed. Changes can includes extensions, additional buildings in the same plot or compound provided that extension/additional building is in harmony with and does not detract from the existing heritage building/precinct especially in terms of height and/or façade. Reconstruction may be allowed when the building is structurally weak or unsafe or when it has been affected by accidental fire or any other calamity or if reconstruction is required to consume the permissible FSI and no option other than reconstruction is available Reconstruction may also be allowed in case of those buildings which attract the provisions of Regulations 33 (6), 33 (7) 33 (9) and Appendix II and Appendix III of Development Control Regulations, 1991. Reconstruction may be allowed in those buildings being repaired/ reconstructed by MHADA. However, unless absolutely essential, nothing should spoil or destroy any special features or attributes for which it is placed in the Heritage List.
D	**Procedure**		
	Development permission for the changes would be given by the planning Authority on the advice the Heritage Conservation Committee to be appointed by ---	Development permission for the changes would be given by the Planning Authority in consultation with sub- committee of the Heritage Conservation Committee.	Development permission would be given for changes by the Planning Authority itself but in consonance with guidelines, which are to be laid down by Government in Consultation with the Heritage Conservation Committee.

Sr. No	Heritage Grade-I	Heritage Grade-II(A & B)	Heritage Grade-III
	Government.		
E	**Vistas/ Surrounding Development**		
	Developments in areas surround Heritage Grade-I Shall be regulated and controlled, ensuring that does not mar the grandeur of views from. Heritage Grade-I		

Subsequently, Government enlisted total of 633 entities and 20 Precincts and brought under regulator's control for preservation vide resolution dated 24.4.95.

As per heritage regulation, the powers to approve changes were given to Commissioner, MCGM (Municipal Corporation of Greater Mumbai) who has to act on advice of/in consultation with the Heritage Conservation Committee but has the powers to overrule the recommendation of committee.

The lists of Heritage Structures lying along the corridor are given in **Table 4.36** and **4.37**.

Table 4.36: Lists of Grade – I Heritage Structures along the corridor

S. N.	Name of Heritage Buildings/ Monuments	Grade	Location	Ownership	Usage	Special features	Date	Classification	State of preservation
1	Victoria Terminus (Bori Bunder)	World Heritage	Dr. DN road	Central Govt.	Railway Terminus and Central Railway H.Q.	Italian Gothic	1888	A(arc), A(his) B(des), I(sce), B(per), C(seh), E,V,H(tec)	Good
2	Western Railway H.Q offices (Old building) (Formly) BB and I. Rly. H.Q	I	M. Karve Road	Central Govt.	Railway offices	Blue basalt stone building with multiple domes B(per), C (seh)	1899	A(arc), B (des) E, A(his).	Good
3	Oval maidan	I	Bhavrao Patil Marg and M Karve Marg and Md. Cama Road	State Govt	Public open space	Reflects colonical pattern 'esplanda". Buffer between two architectural period styles	19th C	I (sce.), J	Good
4	Parsee well near Flora Fountain (Bhika Behram Well)	I	Near Churchgate Railway Station	Trust	Drinking water well for humun beings and draught animals.	It continuous to be popular and venerated Social Node in the city	1725		Good
5	Willingdon Ambulance building	I	At the edge of Azad madian	BMC	Head Quarter of St. John, Ambulance Brigade for Charitable Social Service	This Building's architectural components typefy an adaptive marriage between new technology and vernaqular sentiment with use of Indian Forms such as mildly Indo- Saracenic pointed window arches and with cantilevered chajjas overhanging the open entrance stairway and the side access doorway.	1932		Good
6	Flora Fountain	I	Hutatma Chowk	BMC	Fountain	Named after Sir Bartle Frcre Impotant Portland stone carved fountain	1867	A (cul), E, D (bio),B(per), I (sce), A (his), B(des), G(grp),F	Good

Table 4.37: Lists of Grade – II & III Heritage Structures along the corridor

S. N.	Name of heritage buildings/ Monuments	Grade	Location	Ownership	Usage	Special features	Date	Classification	State of preservation
1	Damani House	III	Capt. P. Pethe Marg	Private	Residential	Typical sea-front villa	1800's	A(arc),G(grp)	Good
2	Bombay High Court (Inclusive of well)	II-A	Bhavrao Patil Marg	State Govt.	High court	Early gothic style in grey stone	1879	A(arc)	Good
3	All buildings on Dadabhai Naroji Road with a special focus on Fort House	II-A	Dr. Dadabhai Naroji Road	Private	Commercial	Colonial style was the town house of Sir Jamsetji Jeejeebhoy. But Burnt out	19th cent.	A(arc), B(des), D(bio), B(per), E	Poor
4	Anand Bhavan	II-A	Dr. Dadabhai Naroji Road	Private	Educational and Commercial	Shares group value with whole arcaded street front	20th cent	G (grp), F, E, I (sce)	Good
5	Dadyseth Agiary	II-B	Dr. Dadabhai Naroji Road	Trust	Worship	Vernacular style	19th cent.	A (arc), A (cul), C(seh), G(grp), B(des), D(bio), B(per), F	Good
6	Alice Building Stone Arch	III	Dr. Dadabhai Naroji Road	PWD	Office	Only stone arch remains	19th cent.	F	Fair
7	Thomas Cook Building	II-A	Dr. Dadabhai Naroji road	Private	Offices	Colonial style	19th cent.	A(arc), B(des), B(per), C(seh) G(grp) E, F	Good
8	Sir Jamsetjee Jeejeebhoy Parsi Benevolent Institute	II-A	Dr. D. N Road	Trust	School	Distinctive stone Renaissance revival street façade, historical inscription	1873	A(arc), D(bio), B(per), A(his), I(sec), C(seh), B(des), E, F, G(grp)	Good
9	Jamsetjee Nessarwanji Petit Institute	II-A	Dr. D.N Road	Trust	Educational	Striking polychromatic public building	1898 Extended in 1938	G(grp), A(arc), A(his), B(per), A(cul), B(des) E, F, I(sce)	Good
10	Piramal mansion /Peninsula House	II-A	Dr. D.N Road	Private	Office	Part of the arcaded street front characterising development plan for this road.		A(arc), C(seh), B(des), G(grp), F	Good
11	Eruchshaw building	II-A	Dr. D.N Road	Private	Office	Cast iron structure and detailing glazed tiling engraved glass , period lift-cage and sacred well in interior courtyard	1817	A(arc), E, F I(sce), B(per), G(grp), B(des), H(tec)	Good

S. N.	Name of heritage buildings/ Monuments	Grade	Location	Ownership	Usage	Special features	Date	Classification	State of preservation
12	Standard building	II-A	Dr. D.N Road	Private	Commercial	Shares group value as part of arcaded street front.	1900's	G(grp), F, I(sce)	Good
13	Watcha Agiary	II-A	Dr. D.N Road	Trust	Worship	Assyrian stone façade	1910's	A(his), C(seh))	good
14	Whiteway Laidlaw building (Khadi Emporium)	II-A	Dr. D.N Road	Private	Commercial	Colonical style	19th cent.	A(arc), B(des)F, B(per), E G(grp), I(sce)	Good
15	Badri Mahal	II-A	Dr. D.N Road	Private	residential	Haveli style	1930's	A(arc), E, G(grp), B(des), B(per), F, I(sce)	Good
17	Capital Cinema	II-B	Dr. D.N Road	Private	Cinema	Grey stone building with decorative moulding, first western style theatre in the Fort since demolition of Bombay Green Theatre	1879	A(arc), B(des),A (his),C(seh), B(per), A(cul), E, F, I(sec)	Good
18	Bombay Muncipal Coroporation	II-A	Mahapalika Marg	BMC	Offices	Oriental gothic style	1893	A(his), I(sce), C(seh), A(arc), B(per), B(des), F	Good
19	Cama and Albess hospital	II-B	Mahapalika Marg	State Governme nt	Hospital	Grey stone neo- gothic	1886	A(arc), B(per), B(des), E, D(bio), F, J, I(sce)	
20	Presidency Migistrate's Court	II-B	Mahapalika Marg	State Governme nt	Law Court	Greystone building defaced by construction of lift shaft but with outstanding carved façade detailing by local craftsman	1889	A(arc), B(per), A(his), E, F, I(sce), B(des)	Fair
21	St. Xavier's College	II-B	Mahapalika Marg	Mission	Educational	Grey stone neo gothic	1890	A(arc), B(des), A(cul), E, F, J, I(sce), B(per), C(seh)	Good
22	Elphinstone technical Institute	II-B	Mahapalika Marg	State Govt.	Educational	Grey stone with broad flight of steps, Neo-gothic	1877	I(sce), B(per), C(seh), D(bio), B(per), E, F	Good
16	Metro cinema	II-A	Dhobi Talao	Private	Cinema	Interior typical art decorative grandeur	1930	B(des), C(seh), A(his), G(grp)	Good
23	Framji Cawasji Institute(Old) Wellington Theatre)	III	Dhobi Talao	Trust	Library	Colonial style, Formerly site of F, Cawasji Tank commencrated with Standing Memorial Plaque	1862,6 5 Rebuilt in 1925	A(arc), A(his), E, C (seh), D(bio), I(sce)	Good

S. N.	Name of heritage buildings/ Monuments	Grade	Location	Ownership	Usage	Special features	Date	Classification	State of preservation
24	Aidum building	III	J . Shankarsheth Marg	Private	Residential and Commercial	Domed roof finial characteristic stone and cast iron balconied structures with stained glass transoms	1928	A(arc), E, F, B(per), B(des)	Good
25	Zaoba Ram Mandir	III	J . Shankarsheth Marg	Trust	Worship	Vernacular style with unique decorative features	19th cent.	A(arc), B(des), A(cul).	Fair
26	Bhaskar Mansion (Narotamdas)	II	Dr. Dadasaheb Bhadkamkar Marg	Private	Residential	Stone faced, balconied building with rustication detailing. Its open balconies exemplifying Bombay climate parameter	1916	B(des), B(per), A(arc) G(grp), F	Good
27	Nair Building (Bhau Jewellrs	III	Dr. Dadasaheb Bhadkamkar Marg	Private	Residential	An intersecting corner structure, wooden balconied façade.	Early	B(des), I(sce), G(grp), B(per)	Good
28	Pyaav for Animals	III	Gokhele Road	B.M.C.	Pyaav for animals	Donated by Anand Vithal Kohli	1929	D(bio), B(per) F,, B(des), C(seh), I(sce)	Good
29	Podar Hospital and Ayurvedic College Complex.	III	Dr. Annie Besant Road	Trust	Hospital Medical College Research Institute.	Stone building with gardens	1940's	A(arc), D(bio), B(des), I(sce), B(per) J.	Good
30	Sitala Devi Temple Complex	IIB	Lady Jamshedji Road	Trust	Religious	Grey stone building with deep stambha (Konkana style).	18th cent.	A(arc), B(per) I(sce), C(seh) A(cul) E , F.	Good

The alignment will be passing through following Heritage Precincts.

i) Oval Maidan Precinct
ii) University Precinct
iii) Esplanade Precinct
iv) BMC Precinct

The proposed corridor is fully underground and does not affect any Listed Heritage Structure so as to seek approval for the execution and operation of Metro Corridor. However, corridor is passing through/along above mentioned Heritage Precincts and Huatatma Chowk and CST Metro stations are located in these Precincts, approval of Commissioner, MCGM through MHCC (Maharashtra Heritage Conservation Committee) will have to be obtained.

4.8.2 Procedure of Approval

The plan of Heritage Precincts duly marked with the proposed new stations is to be submitted to MHCC. A presentation will be arranged by committee and minutes of discussions issued. Modifications in detailing as suggested by MHCC, if any to be incorporated in plan and revised plan submitted to MHCC for conveying approval of Commissioner, MCGM.

4.9 LAND REQUIREMENT

4.9.1 Land will be required for the following Main Components

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Radio Towers
- Temporary Construction Depots and work sites.

4.9.2 Land for Underground stretches

No land at surface is required permanently for underground section, except for small areas for entry/exit structures, traffic integration and ventilation shafts/other maintenance utilities at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road. All the stations are planned with island platforms. Bandra Metro station has been planned as Mid terminal station with one island and one side platform.

4.9.3 Land for Traffic integration

No land acquisition is proposed exclusively for traffic integration purpose.

4.9.4 Land for Maintenance Depot

About 26 Hectares of open land has been proposed for Depot in Aarey Milk Colony. The land is presently vacant.

The project will require additional land of about 12 – 15 Ha to create additional stabling and maintenance facilities, as the traffic grows. The details of this land could be firmed up at a later date.

4.9.5 Land for TSS, RSS, ASS and DG Sets

Three TSS have been proposed on the corridor at Cuffe Parade, Race Course and Dharavi. An area of 2000 sqm has been proposed for each TSS**.** ASS and DG Sets are required at all stations. Details of land required for TSS and depot are shown in **Table 4.38.**

Table 4.38: Detail of Land Required Permanently for TSS

Sr. No	Plot No	Station	Details	Land Ownership	Area In Sqm
1	TSS-1	Cuffe Parade Station to Badhwar Park	Open BMC	Govt	2000
2	TSS-2	Science Museum Station to Acharya Atrey Chowk Station	Stables, Builtup	Pvt.	2000
3	TSS-3	Between Dharavi & Bandra Metro	Hut & Marble Store	Govt	2000
				Total	**6000**

4.9.6 Land Requirement for Stations and Running Sections

As the entire alignment is proposed underground, no land will be required for running section.

To the extent possible the Entry and Exit points of stations were planned on the foot paths. But, for locating other station facilities such as water tanks, generator room, fire room etc., land/property acquisition is proposed.

The details of land permanently and temporarily required for stations are indicated in the **Tables 4.39, 4.40** and **4.41** respectively.

Table 4.39: Details of Land permanently required for Stations (Colaba – Mahim)

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
1	ST-1A	Cuffe Parade Station	BMC Park	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
2	ST-1B	Cuffe Parade Station	BMC Park	Govt	162	Ventilation Shaft
3	ST-1C	Cuffe Parade Station	BMC Park	Govt	30	Entry/Exit
4	ST-1D	Cuffe Parade Station	BMC Park	Govt	94	Entry/Exit & Escalator,
5	ST-1E	Cuffe Parade Station	BMC Park	Govt	162	Ventilation Shaft
6	ST-1F	Cuffe Parade Station	BMC Park	Govt	35	Entry/Exit & lift etc,
7	ST-1G	Cuffe Parade Station	footpath, BMC	Govt	56	Escalator
8	ST-1H	Cuffe Parade Station	footpath, BMC	Govt	70	Entry/Exit
9	ST-1I	Cuffe Parade Station	footpath, BMC	Govt	70	Entry/Exit & Escalator,

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
		Cuffe Parade Station	Open	Pvt	24	
10	ST-1J	Cuffe Parade Station	footpath, BMC	Govt	24	Entry/Exit & Escalator,
		Cuffe Parade Station	Open	Pvt	70	
11	ST-2A	Badhwar Park Station	Open, BMC	Govt	162	Ventilation Shaft
12	ST-2B	Badhwar Park Station	Open, BMC	Govt	30	Entry/Exit
13	ST-2C	Badhwar Park Station	footpath, BMC	Govt	30	Entry/Exit
		Badhwar Park Station	Open	RLY	40	
14	ST-2D	Badhwar Park Station	footpath, BMC	Govt	45	Escalator
		Badhwar Park Station	Open	Pvt	11	
15	ST-2E	Badhwar Park Station	BMC Park	Govt	94	Entry/Exit & Escalator,
16	ST-2F	Badhwar Park Station	BMC Park	Govt	665	Chillar Plant, Water Tank, Fuel Tank& DG Set etc
17	ST-2G	Badhwar Park Station	BMC Park	Govt	30	Entry/Exit
18	ST-2H	Badhwar Park Station	Open, BMC	Govt	56	Escalator
19	ST-2I	Badhwar Park Station	footpath, BMC	Govt	70	Entry/Exit
20	ST-2J	Badhwar Park Station	BMC Park	Govt	162	Ventilation Shaft
21	ST-3A	Vidhan Bhawan Station	Bhimalaya Party office	Govt	162	Ventilation Shaft
22	ST-3B	Vidhan Bhawan Station	footpath, BMC	Govt	20	Entry/Exit & Escalator.
		Vidhan Bhawan Station	Treasury office	Govt	74	
23	ST-3C	Vidhan Bhawan Station	Treasury office	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
24	ST-3D	Vidhan Bhawan Station	Treasury office compound	Govt	30	Entry/Exit
25	ST-3E	Vidhan Bhawan Station	footpath, BMC	Govt	30	Entry/Exit & Escalator
		Vidhan Bhawan Station	Pvt Open	Pvt	64	
26	ST-3F	Vidhan Bhawan Station	footpath, BMC	Govt	94	Entry/Exit & Escalator
27	ST-3G	Vidhan Bhawan Station	footpath, BMC	Govt	70	Entry/Exit
28	ST-3H	Vidhan Bhawan Station	Open, BMC	Govt	162	Ventilation Shaft
29	ST-4A	Churchgate Metro Station	footpath, BMC	Govt	162	Ventilation Shaft
30	ST-4B	Churchgate Metro Station	footpath, BMC	Govt	70	Entry/Exit
31	ST-4C	Churchgate Metro Station	footpath, BMC	Govt	30	Entry/Exit & Escalator.
		Churchgate Metro Station	Open	Pvt	64	
32	ST-4D	Churchgate Metro Station	footpath, BMC	Govt	30	Entry/Exit
33	ST-4E	Churchgate Metro Station	footpath, BMC	Govt	56	Escalator
34	ST-4F	Churchgate Metro Station	footpath, BMC	Govt	40	Entry/Exit & Escalator
		Churchgate Metro Station	Open	Pvt	54	
35	ST-4G	Churchgate Metro Station	Perol Pump, BMC	Govt	162	Ventilation Shaft
36	ST-4H	Churchgate Metro Station	Perol Pump, BMC	Govt	94	Entry/Exit & Escalator
37	ST-4I	Churchgate Metro Station	footpath, BMC	Govt	35	Entry/Exit & lift etc,
38	ST-4J	Churchgate Metro Station	open, Play ground	Pvt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
39	ST-5A	Hutatma Chowk Station	footpath, BMC	Govt	30	Entry/Exit
40	ST-5B	Hutatma Chowk Station	BMC Park	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
41	ST-5C	Hutatma Chowk Station	BMC Park	Govt	162	Ventilation Shaft
42	ST-5D	Hutatma Chowk Station	footpath, BMC	Govt	56	Escalator
43	ST-5E	Hutatma Chowk Station	footpath, BMC	Govt	35	Entry/Exit

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
44	ST-5F	Hutatma Chowk Station	open Pvt	Pvt	35	Entry/Exit
45	ST-5G	Hutatma Chowk Station	footpath, BMC	Govt	56	Escalator
46	ST-5H	Hutatma Chowk Station	open Pvt	Pvt	80	Entry/Exit & Escalator
		Hutatma Chowk Station	footpath, BMC	Govt	14	
47	ST-5I	Hutatma Chowk Station	open Pvt	Pvt	70	Entry/Exit
48	ST-5J	Hutatma Chowk Station	footpath, BMC	Govt	10	Entry/Exit & lift etc,
		Hutatma Chowk Station	Builtup	Pvt	25	
49	ST-5K	Hutatma Chowk Station	open Pvt	Pvt	30	Entry/Exit
		Hutatma Chowk Station	footpath, BMC	Govt	40	
50	ST-5L	Hutatma Chowk Station	open Pvt	Pvt	56	Escalator
51	ST-6A	CST Metro Station	Footpath Green	Govt	162	Ventilation Shaft
52	ST-6B	CST Metro Station	footpath, BMC	Govt	30	Entry/Exit
53	ST-6C	CST Metro Station	Open BMC	Govt	94	Entry/Exit & Escalator
54	ST-6D	CST Metro Station	Open BMC	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
55	ST-6E	CST Metro Station	Open BMC	Govt	94	Entry/Exit & Escalator
56	ST-6F	CST Metro Station	footpath, BMC	Govt	30	Entry/Exit & Escalator
57	ST-6G	CST Metro Station	Open BMC	Govt	64	Entry/Exit & Escalator
58	ST-6H	CST Metro Station	footpath, BMC	Govt	94	Entry/Exit & Escalator
59	ST-6I	CST Metro Station	footpath, BMC	Govt	35	Entry/Exit & lift etc,
60	ST-7A	Kalbadevi Station	Builtup, Parsi Temple	Pvt Comm	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
61	ST-7B	Kalbadevi Station	Builtup	Pvt Comm	120	Ventilation Shaft
		Kalbadevi Station	footpath, BMC	Govt	42	
62	ST-7C	Kalbadevi Station	footpath, BMC	Govt	10	Entry / Exit
		Kalbadevi Station	Builtup, Parsi Temple	Pvt Comm	20	
63	ST-7D	Kalbadevi Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
64	ST-7E	Kalbadevi Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
65	ST-7F	Kalbadevi Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
66	ST-7G	Kalbadevi Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
67	ST-7H	Kalbadevi Station	Builtup	Pvt Comm	35	Entry/Exit & lift etc,
68	ST-7I	Kalbadevi Station	Builtup	Pvt Comm	80	Ventilation Shaft
		Kalbadevi Station	Builtup	Pvt Comm	82	
69	ST-8A	Girgaon Station	Builtup	Pvt Comm	82	Ventilation Shaft
		Girgaon Station	Builtup	Pvt Comm	80	
70	ST-8B	Girgaon Station	Builtup	Pvt Comm	35	Entry/Exit & lift etc,
71	ST-8C	Girgaon Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
72	ST-8D	Girgaon Station	Builtup	Pvt Comm	70	Entry/Exit
73	ST-8E	Girgaon Station	Builtup	Pvt Comm	56	Escalator
74	ST-8F	Girgaon Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
75	ST-8G	Girgaon Station	Builtup	Pvt Comm	94	Entry/Exit & Escalator
76	ST-8H	Girgaon Station	footpath, BMC	Govt	20	Entry/Exit & lift etc,
		Girgaon Station	Builtup	Pvt Comm	15	
77	ST-8I	Girgaon Station	Builtup	Pvt Comm	162	Ventilation Shaft
78	ST-8J	Girgaon Station	Builtup	Pvt.	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
79	ST-9A	Grant Road Metro Station	footpath, BMC	Govt	56	Escalator
80	ST-9B	Grant Road Metro Station	footpath, BMC	Govt	70	Entry/Exit

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
81	ST-9C	Grant Road Metro Station	footpath, BMC	Govt	35	Entry / Exit , Lift
82	ST-9D	Grant Road Metro Station	footpath, BMC	Govt	47	Entry/Exit & Escalator
		Grant Road Metro Station	Open BMC	Govt	47	
83	ST-9E	Grant Road Metro Station	Open BMC	Govt	162	Ventilation Shaft
84	ST-9F	Grant Road Metro Station	Open BMC	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
85	ST-9G	Grant Road Metro Station	Open	Pvt	94	Entry/Exit & Escalator
86	ST-9H	Grant Road Metro Station	footpath, BMC	Govt	20	Entry/Exit
		Grant Road Metro Station	Builtup	Pvt	50	
87	ST-9I	Grant Road Metro Station	footpath, BMC	Govt	28	Escalator
		Grant Road Metro Station	footpath, BMC	Govt	28	
88	ST-9J	Grant Road Metro Station	footpath, BMC	Govt	10	Entry / Exit , Lift
		Grant Road Metro Station	Builtup	Pvt	25	
89	ST-9K	Grant Road Metro Station	Builtup	Pvt	162	Ventilation Shaft
90	ST-10A	Mumbai Central Metro Station	Open	Rly	94	Entry/Exit & Escalator
91	ST-10B	Mumbai Central Metro Station	Open	Rly	162	Ventilation Shaft
92	ST-10C	Mumbai Central Metro Station	Open	Rly	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
93	ST-10D	Mumbai Central Metro Station	footpath, BMC	Govt	35	Entry / Exit , Lift
94	ST-10E	Mumbai Central Metro Station	footpath, BMC	Govt	94	Entry/Exit & Escalator
95	ST-10F	Mumbai Central Metro Station	footpath, BMC	Govt	94	Entry/Exit & Escalator
96	ST-10G	Mumbai Central Metro Station	footpath, BMC	Govt	35	Entry / Exit , Lift
97	ST-10H	Mumbai Central Metro Station	footpath, BMC	Govt	30	Entry/Exit & Escalator
		Mumbai Central Metro Station	Open , BMC	Govt	64	
98	ST-10I	Mumbai Central Metro Station	Open , BMC	Govt	162	Entry/Exit & Escalator
99	ST-11A	Mahalaxmi Metro Station	Green footpath, BMC	Govt	485	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
		Mahalaxmi Metro Station	open	Pvt	180	
100	ST-11B	Mahalaxmi Metro Station	Green footpath, BMC	Govt	92	Ventilation Shaft
101	ST-11C	Mahalaxmi Metro Station	Open	Pvt	70	Ventilation Shaft
102	ST-11D	Mahalaxmi Metro Station	Open	Pvt	84	Entry/Exit & Escalator
		Mahalaxmi Metro Station	footpath, BMC	Govt	10	
103	ST-11E	Mahalaxmi Metro Station	Open	Pvt	35	Entry / Exit , Lift
104	ST-11F	Mahalaxmi Metro Station	Open	Pvt	94	Entry/Exit & Escalator
105	ST-11G	Mahalaxmi Metro Station	footpath, BMC	Govt	40	Entry/Exit & Escalator
		Mahalaxmi Metro Station	Open	Pvt	54	
106	ST-11H	Mahalaxmi Metro Station	Open , BMC	Govt	35	Entry / Exit , Lift
107	ST-11I	Mahalaxmi Metro Station	footpath, BMC	Govt	56	Escalator
108	ST-11J	Mahalaxmi Metro Station	footpath, BMC	Govt	70	Entry Exit
109	ST-11K	Mahalaxmi Metro Station	Park , BMC	Govt	162	Ventilation Shaft

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
110	ST-12A	Science Museum Station	footpath, BMC	Govt	50	Ventilation Shaft
		Science Museum Station	Open	Pvt	112	
111	ST-12B	Science Museum Station	footpath, BMC	Govt	25	Entry / Exit , Lift
		Science Museum Station	Open	Pvt	10	
112	ST-12C	Science Museum Station	footpath, BMC	Govt	40	Entry/Exit & Escalator
		Science Museum Station	open, Race Cource	Govt	54	
113	ST-12D	Science Museum Station	footpath, BMC	Govt	40	Entry/Exit & Escalator
		Science Museum Station	Open	Pvt	54	
114	ST-12E	Science Museum Station	footpath, BMC	Govt	30	Entry/Exit & Escalator
		Science Museum Station	open, Race Cource	Govt	64	
115	ST-12F	Science Museum Station	Open	Pvt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
116	ST-12G	Science Museum Station	footpath, BMC	Govt	35	Entry / Exit , Lift
117	ST-12H	Science Museum Station	footpath, BMC	Govt	40	Entry/Exit & Escalator
		Science Museum Station	Open	Pvt	54	
118	ST-12I	Science Museum Station	footpath, BMC	Govt	30	Ventilation Shaft
		Science Museum Station	Open	Pvt	132	
119	ST-13A	Acharya Atrey Chowk Station	Built up	Pvt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
120	ST-13B	Acharya Atrey Chowk Station	Open	Govt	162	Ventilation Shaft
121	ST-13C	Acharya Atrey Chowk Station	Footpath BMC	Govt	35	Entry/Exit & lift etc,
122	ST-13D	Acharya Atrey Chowk Station	Built up	Pvt	94	Entry/Exit & Escalator,
123	ST-13E	Acharya Atrey Chowk Station	Petro Pump	Govt	162	Ventilation Shaft
124	ST-13F	Acharya Atrey Chowk Station	Petro Pump	Govt	35	Entry/Exit & lift etc,
125	ST-13G	Acharya Atrey Chowk Station	Petro Pump	Govt	94	Entry/Exit & Escalator,
126	ST-13H	Acharya Atrey Chowk Station	Built up	Pvt	94	Entry/Exit & Escalator,
127	ST-13I	Acharya Atrey Chowk Station	Temp builtup	BMC	94	Entry/Exit & Escalator,
128	ST-14A	Worli Station	Open Institute	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
129	ST-14B	Worli Station	Open Institute	Govt	162	Ventilation Shaft
130	ST-14C	Worli Station	Open	Pvt	35	Entry/Exit & lift etc,
131	ST-14D	Worli Station	Open	Pvt	70	Entry/Exit
132	ST-14E	Worli Station	Open	Pvt	162	Ventilation Shaft
133	ST-14F	Worli Station	Open	Pvt	35	Entry/Exit & lift etc,
134	ST-14G	Worli Station	Open	Pvt	56	Escalator
135	ST-14H	Worli Station	Open	Pvt	94	Entry/Exit & Escalator,
136	ST-14I	Worli Station	Open	Pvt	94	Entry/Exit & Escalator,
137	ST-14J	Worli Station	Open	Pvt	94	Entry/Exit & Escalator,
138	ST-15A	Siddhi Vinayak Station	Open Playground	Govt	665	Chillar Plant, Water

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
						Tank, Fuel Tank & DG Set etc
139	ST-15B	Siddhi Vinayak Station	Open Playground	Govt	162	Ventilation Shaft
140	ST-15C	Siddhi Vinayak Station	Open Playground	Govt	35	Entry/Exit & lift etc,
141	ST-15D	Siddhi Vinayak Station	Open Playground	Govt	94	Entry/Exit & Escalator,
142	ST-15E	Siddhi Vinayak Station	Open Playground	Govt	162	Ventilation Shaft
143	ST-15F	Siddhi Vinayak Station	Open Playground	Govt	35	Entry/Exit & lift etc,
144	ST-15G	Siddhi Vinayak Station	Open Playground	Govt	94	Entry/Exit & Escalator,
145	ST-15H	Siddhi Vinayak Station	Open Playground	Govt	94	Entry/Exit & Escalator,
146	ST-15I	Siddhi Vinayak Station	Open Playground	Govt	94	Entry/Exit & Escalator,
147	ST-16A	Dadar Metro Station	Open	Pvt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
148	ST-16B	Dadar Metro Station	Open	Pvt	162	Ventilation Shaft
149	ST-16C	Dadar Metro Station	BMC footpath	Govt	35	Entry/Exit & lift etc,
150	ST-16D	Dadar Metro Station	BMC footpath	Govt	94	Entry/Exit & Escalator,
151	ST-16E	Dadar Metro Station	Petrol Pump	Govt	162	Ventilation Shaft
152	ST-16F	Dadar Metro Station	BMC footpath	Govt	35	Entry/Exit & lift etc,
153	ST-16G	Dadar Metro Station	BMC footpath	Govt	56	Escalator
154	ST-16H	Dadar Metro Station	BMC footpath	Govt	56	Escalator
155	ST-16I	Dadar Metro Station	BMC footpath	Govt	70	Entry/Exit
156	ST-16J	Dadar Metro Station	BMC footpath	Govt	70	Entry/Exit
157	ST-16K	Dadar Metro Station	BMC footpath	Govt	94	Entry/Exit & Escalator,
158	ST-16L	Dadar Metro Station	BMC footpath	Govt	94	Entry/Exit & Escalator,
159	ST-17A	Shitla Devi temple Station	Petrol Pump	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
160	ST-17B	Shitla Devi temple Station	Petrol Pump	Govt	162	Ventilation Shaft
161	ST-17C	Shitla Devi temple Station	Petrol Pump	Govt	162	Ventilation Shaft
162	ST-17D	Shitla Devi temple Station	Footpath BMC	Govt	56	Escalator
163	ST-17E	Shitla Devi temple Station	Footpath BMC	Govt	56	Escalator
164	ST-17F	Shitla Devi temple Station	Footpath BMC	Govt	56	Escalator
165	ST-17G	Shitla Devi temple Station	Footpath BMC	Govt	56	Escalator
166	ST-17H	Shitla Devi temple Station	Footpath BMC	Govt	70	Entry/Exit
167	ST-17I	Shitla Devi temple Station	Footpath BMC	Govt	70	Entry/Exit
168	ST-17J	Shitla Devi temple Station	Footpath BMC	Govt	70	Entry/Exit
169	ST-17K	Shitla Devi temple Station	Footpath BMC	Govt	70	Entry/Exit
				Total land	**24478**	

Table 4.40: Details of Land permanently required for Stations (Mahim-SEEPZ)

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
1	ST-18A	Dharavi Station	Temp Builtup	Pvt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
2	ST-18B	Dharavi Station	Temp Builtup	Pvt	162	Ventilation Shaft
3	ST-18C	Dharavi Station	Open BMC	Govt	35	Entry/Exit
4	ST-18D	Dharavi Station	Open BMC	Govt	94	Entry/Exit & Escalator,
5	ST-18E	Dharavi Station	Open & Drain	Govt	162	Ventilation Shaft
6	ST-18F	Dharavi Station	Drain	Govt	35	Entry/Exit & lift etc,
7	ST-18G	Dharavi Station	Open BMC	Govt	94	Entry/Exit & Escalator,
8	ST-18H	Dharavi Station	Temp Builtup	Pvt	94	Entry/Exit & Escalator,

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
9	ST-18I	Dharavi Station	Open	Pvt	94	Entry/Exit & Escalator,
10	ST-18J	Dharavi Station	Open	Govt	94	Entry/Exit & Escalator,
11	ST-19A	Bandra Station	Pvt Open	Pvt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
12	ST-19B	Bandra Station	Open	Govt	162	Ventilation Shaft
13	ST-19C	Bandra Station	Open	Govt	35	Entry/Exit
14	ST-19D	Bandra Station	Open	Govt	94	Entry/Exit & Escalator,
15	ST-19E	Bandra Station	Open	Govt	162	Ventilation Shaft
16	ST-19F	Bandra Station	footpath	Govt	35	Entry/Exit & lift etc,
17	ST-19G	Bandra Station	Open	Govt	94	Entry/Exit & Escalator,
18	ST-19H	Bandra Station	footpath	Govt	94	Entry/Exit & Escalator,
19	ST-20A	Mumbai University, Kalina Station	Open area of university	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
20	ST-20B	Mumbai University, Kalina Station	Open area of university	Govt	162	Ventilation Shaft
21	ST-20C	Mumbai University, Kalina Station	Open area of university	Govt	35	Entry/Exit
22	ST-20D	Mumbai University, Kalina Station	Open area of university	Govt	94	Entry/Exit & Escalator,
23	ST-20E	Mumbai University, Kalina Station	Open area of university	Govt	162	Ventilation Shaft
24	ST-20F	Mumbai University, Kalina Station	Open area of university	Govt	35	Entry/Exit & lift etc,
25	ST-20G	Mumbai University, Kalina Station	Open area of university	Govt	94	Entry/Exit & Escalator,
26	ST-20H	Mumbai University, Kalina Station	Open area of university	Govt	94	Entry/Exit & Escalator,
27	ST-20I	Mumbai University, Kalina Station	Open area of university	Govt	94	Entry/Exit & Escalator,
28	ST-21A	Santacruz Station	Temp Builtup	Pvt	94	Entry/Exit & Escalator,
29	ST-21B	Santacruz Station	Footpath BMC	Govt	94	Entry/Exit & Escalator,
30	ST-21C	Santacruz Station	Footpath BMC	Govt	94	Entry/Exit & Escalator,
31	ST-21D	Santacruz Station	Footpath BMC	Govt	94	Entry/Exit & Escalator,
32	ST-21E	Santacruz Station			1978	Permanently requires for Cut and Cover for Chillar Plant, Water Tank, Fuel Tank & DG Set, Ventilation Shaft and emergency Entry Exit etc
33	ST-25A	Marol Naka Station	Temp Builtup	Govt	8886	Entry/ Exit 2 no's, Chillar Plant, Water Tank, Fuel Tank & DG Set & Shaft & station facilities Area 8886 sqm, Compensation for loss of structures
34	ST-25B	Marol Naka Station	Temp Builtup Govt	Govt	162	Ventilation Shaft
35	ST-25C	Marol Naka Station	Temp Builtup Govt	Govt	162	Ventilation Shaft
36	ST-25D	Marol Naka Station	Footpath BMC	Govt	56	Escalator
37	ST-25E	Marol Naka Station	Footpath BMC	Govt	70	Entry/Exit
38	ST-26A	MIDC Station	Temp House	Pvt. Res	2501	Chillar Plant, Water Tank, Fuel Tank & DG Set etc , Ventilation shaft and entry/exit
39	ST-26B	MIDC Station	Police Colony	Govt. res.	1712	
40	ST-26C	MIDC Station	Temp House	Pvt. Res.	212	

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Purpose
41	ST-26D	MIDC Station	Pump House, Employee Estate Insurance Co.	Govt.	893	Entry/exit and escalator, and Ventilation shaft
42	ST-27A	SEEPZ Station	Built up	Govt	665	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
43	ST-27B	SEEPZ Station	Open BEST	Govt	162	Ventilation Shaft
44	ST-27C	SEEPZ Station	Footpath BMC	Govt	35	Entry/Exit
45	ST-27D	SEEPZ Station	Open SEEPZ	Pvt	94	Entry/Exit & Escalator,
46	ST-27E	SEEPZ Station	Open , Power Grid Corporation	Govt	162	Ventilation Shaft
47	ST-27F	SEEPZ Station	Open SEEPZ	Pvt	35	Entry/Exit & lift etc,
48	ST-27G	SEEPZ Station	Open SEEPZ	Pvt	94	Entry/Exit & Escalator,
49	ST-27H	SEEPZ Station	Open , Power Grid Corporation	Govt	94	Entry/Exit & Escalator,
50	ST-27I	SEEPZ Station	Open BEST	Govt	94	Entry/Exit & Escalator,
				Total land	**22748**	

Summary of Permanent Land Requirement for Stations

Description	Colaba - Mahim	Mahim - SEEPZ
	Area (in Sqm)	**Area (in Sqm)**
Govt. Land	16200	16060
Pvt. Land	8268	6688
Total	**24478**	**22748**

Note : The details of additional land of about 12 – 15 Ha that will be required for stabling/ maintenance, as traffic picks up, will be finalized at a later date

Table 4.41: Details of Land temporarily required for Stations

S No	Plot No	Station/Location	Details	Land Ownership	Area In Sqm	Purpose
1	Temp-1	Cuffe Parade Road	BMC Park	Govt	5999	For Cut and Cover of station block
2	Temp-2	Bandra Metro	Mangroves, Maharastra Govt.	Govt	2672	For Cut and Cover of station block
3	Temp-3	Bandra Metro	Open Land Yashree Appt.	Pvt	31	For Cut and Cover of station block
4	Temp-4	Bandra Metro	Temp colony Sant Dynashwar Nagar	Pvt	203	For Cut and Cover of station block
5	Temp-5	Mumbai University, Kalina	Open & Road, state Govt	Govt	9029	For Cut and Cover of station block
6	Temp-6	MIDC	Open Land IDBI and Mumbai Bazar	Pvt	235	For Cut and Cover of station block
7	Temp-7	SEEPZ	Open	Pvt	158	For Cut and Cover of station block
8	Temp-8	SEEPZ	Open, Western Power Grid	Govt	330	For Cut and Cover of station block
9	Temp-9	SEEPZ	Open, SEEPZ	Govt	376	For Cut and Cover of station block
				Total Land	**19033**	

Summary of Temporary Land Requirement for Stations

Description	Area (in Sqm)
Pvt. Land	**627**
Govt. Land	**18406**
Total	**19033**

4.9.7 Temporary Construction Depot

During construction period, huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored and sufficient land is required for storage of these materials.

Since the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose is identified throughout the corridor, in the vicinity of the stations on temporary acquisition basis. The areas proposed for such purpose are indicated in **Table 4.42.** These sites will be obtained on lease temporarily for the construction period. After completion of construction, these will be handed over back to the land owning agency.

About **12.19 Hac** land is proposed for construction depots along the corridor. The proposed sites are presently vacant. The areas are identified based on availability as vacant on date. At the time of construction, depending upon the need, area requirements, the location and size can be reassessed and temporary land acquisitions can be made accordingly.

For the stations proposed to be constructed by NATM, requirement of about 800 sqm of property/land at suitable locations at either end of station would have to be met during construction for the purpose of locating Excavation Shafts.

Table 4.42: Details of Land temporarily required for Construction Depot

S No	Plot No	Station	Details	Land Ownership	Area In Sqm
1	CD-1	Before Cuffe Parade Road Station	Open Land ,MIDC	Govt.	9861
2	CD-2	Before Cuffe Parade Road Station Near World Trade Centre	Open Land, Matralaya	Govt.	9890
3	CD-3	Between Badhwar Park and Vidhan Bhawan	Open Land,BMC	Govt.	3918
4	CD-4	Between Mumbai Central and Mahalaxmi	Open Land,BMC	Govt.	12725
5	CD-5	Between Science Museum and Achray Atray Nahr	Open Land Race Cource	Govt.	3904
6	CD-6	Dharavi to Bandra Metro	Open land drive in theatre, BMC	Govt.	23508
7	CD-7	Dharavi to Bandra Metro	BMC Open	Govt.	30729

S No	Plot No	Station	Details	Land Ownership	Area In Sqm
8	CD-8	CSIA (International)	Casting yard, Airport Authority of India	Govt.	15000
9	CD-9	Between SEEPZ and Aarey Milk Colony	Open	Pvt	12370
				Total	**121905**

4.9.8 Segment Casting Yard

Large numbers of pre-cast tunnel segments are required for construction of tunnels for which a large open area is required for setting up of casting yard. As far as possible, this area should be in temporary construction depot.

4.9.9 Summary of Land Requirements

Abstract of land requirements for different components of corridor are given in **Table 4.43 and 4.44.** However, the land requirement is summarized below:

Govt. Land of 27.89 Hac and Private land of 3.43 Hac is permanently required for stations, Depot, and TSS.

Govt. Land of 12.79 Hac and Private land of 1.30 Hac is temporarily required for cut & cover of stations and construction depot.

Table 4.43: Summary of Permanent Land Requirement

	Stations		TSS		Depot	Total
	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ		
Pvt Land	16200	16060	2000	0	0	**34260**
Govt Land	8268	6688	2000	2000	260000	**278956**
Total	**24468**	**22748**	**4000**	**2000**	**200000**	**313216**

Table 44: Summary of Temporary Land Requirement

	Temp. Land		Construction Depot		Total
	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ	
Pvt Land	0	627	0	12370	**12997**
Govt Land	5999	12407	40298	69237	**127941**
Total	**5999**	**13034**	**40298**	**81607**	**140938**

4.10 CONSTRUCTION METHODOLOGY

4.10.1 Introduction

- The entire construction is to be carried out in heavily built up urban area with alignment passing adjacent to many important Landmarks and Heritage structures. Due to constraints of land, private properties, non-availability of roads of adequate width, and very importantly, existence of Heritage buildings, underground construction is the only viable option.
- The underground construction is proposed to be carried out using Tunnel Boring Machine (TBM) between stations. The stations are proposed to be constructed using Cut and Cover /NATM method of construction.

- **Geotechnical Characteristics of Strata along the proposed alignment**
  Depth of rock below GL = 2.0 to 10 m
  Nature of rock = Soft / hard
  Depth of water table below GL = 2.0 to 7.0 m

  From the bore hole data and the geological maps, it is seen that the top layer consists of filled up soil underlain by overburden soil of different composition, grain size, texture, plasticity etc. which is Alluvium of Quaternary age. This is underlain by Agglomerates and tuff/Inter trappen beds. This consists mainly of rhyolites the top portion of which is weathered, degree of weathering decreasing from highly weathered to fresh rock as the depth increases

  Rhyolite is an igneous, volcanic (extrusive) rock, of felsic (silica-rich) composition (typically > 69% SiO_2 — see the TAS classification). It may have any texture from glassy to aphanitic to porphyritic. The mineral assemblage is usually quartz, alkali feldspar and plagioclase (in a ratio > 1:2). Biotite and hornblende are common accessory minerals.

  Rhyolite can be considered as the extrusive equivalent to the plutonic granite rock, and consequently, outcrops of rhyolite may bear a resemblance to granite. Due to their high content of silica and low iron and magnesium contents, rhyolite melts are highly polymerized and form highly viscous lavas. They can also occur as breccias or in volcanic plugs and dikes. Rhyolites that cool too quickly to grow crystals form a natural glass or vitrophyre, also called obsidian. Slower cooling forms microscopic crystals in the lava and results in textures such as flow foliations, spherulitic, nodular, and lithophysal structures. Some rhyolite is highly vesicular pumice. Many eruptions of rhyolite are highly explosive and the deposits may consist of fallout tephra/tuff or of ignimbrites.

  Underlying rhyolite, basalt flows of Deccan trap of Upper Cretaceous to Lower Eocene age may be encountered at greater depths which may be intruded with basic dykes of a few metre width at places. Numerous joints are also expected in the rock mass some tight and some filled with calcite, quartz and soil. Hence the rock classification may vary from site to site and has to be taken into account in the detailed design after thorough Geotechnical Investigation.

The brief construction methodology is discussed below for following activities

a) Underground Station by Cut and Cover
b) Underground Stations by NATM
c) Temporary Traffic decking arrangements for busy streets
d) Underground Subways by Pipe Jacking method
e) Underground tunnel between stations by TBM (Tunnel Boring Machine)

4.10.2 Building Condition Survey

- The proposed alignment is through heavily built up area where some of the buildings are quite old and have outlived their designed life. Also in these buildings with time and commercial needs considerable changes have taken place in the form of additional structures, projection to the existing buildings without adequate consideration to good engineering practice and capacity of the supporting structures. Also, most of these buildings are not well maintained.

- Structural records of original construction or subsequent additions / alterations to buildings and structures are generally not available. Before taking up the construction work in these areas, a detailed building condition survey work is essential to plan for suitable construction methodology, strengthening measures and monitoring systems to ensure minimum risks to such vulnerable buildings.

- All the buildings falling within 75 m on either side of centerline of tunnels are proposed to be surveyed. The physical condition of each building is undertaken by visual inspection. The mapping of all major defects and photographs of existing signs of distress such as cracks, spalling, wall bulging, missing bricks, exposed rebars, deteriorating timber elements, etc. is undertaken. After this exercise all the buildings are assigned the category to indicate the degree of severity of the defects based on Burland (1977) Classification of Visible Damages to Buildings. (Include Burland Classification).

- During design stage these buildings are assessed based on likely settlement. Based on condition of buildings and likely impact due to settlement these buildings are classified in three groups:

a) Buildings, which require repairs before undertaking any construction activity.

b) Buildings, which require regular monitoring during excavation and dewatering.

c) Buildings, which are in good condition and which will require only occasional inspection.

Table 4.45: Building Damage Classification

Building Damage Classification After Burland et al, 1977 and Boscardin and Cording, 1989				
Risk Category	**Description of Degree of Damage**	**Description of Typical Damage and Likely Form of Repair for Typical Masonry Buildings**	**Approx[2] Crack Width (mm)**	**Max Tensile Strain %**
0	Negligible	Hairline cracks.		Less than 0.05
1	Very Slight	Fine cracks easily treated during normal redecorations. Perhaps isolated slight fracture in building. Cracks in exterior brickwork visible upon close inspection.	0.1 to 1	0.05 to 0.075
2	Slight	Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible : some repointing may be required for weather tightness. Doors and windows may stick slightly.	1 to 5	0.075 to 0.15
3	Moderate	Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Tack-pointing and possibly replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Water tightness often impaired.	5 to 15 or a number of cracks greater than 3	0.15 to 0.3
4	Severe	Extensive repair involving removal and replacement of sections of walls, especially over doors and windows required. Windows and doors frames distorted. Floor slopes noticeably. Walls lean on bulge noticeably, some loss of bearing in beams. Utility services disrupted.	15 to 25 but also depends on number of cracks	Greater than 0.3
5	Very Severe	Major repair required involving partial or complete reconstruction. Beams lose bearing, walls lean badly and require shoring. Windows broken by distortion. Danger of instability.	Usually greater than 25 but depends on number of cracks	

- The repair / strengthening schemes of these buildings may be got ratified by independent agencies such as Central Building Research Institute (CBRI), an independent government body, having expertise in such works. Such agencies should also be engaged for frequent inspections of vulnerable buildings during excavation.

- The proposed precondition survey is very helpful in:

a) Designing the construction methodology, temporary / permanent support system.

b) Individual building gets attention during construction and therefore minimising the risk.

c) Avoids unnecessary claims by the owners / occupants.

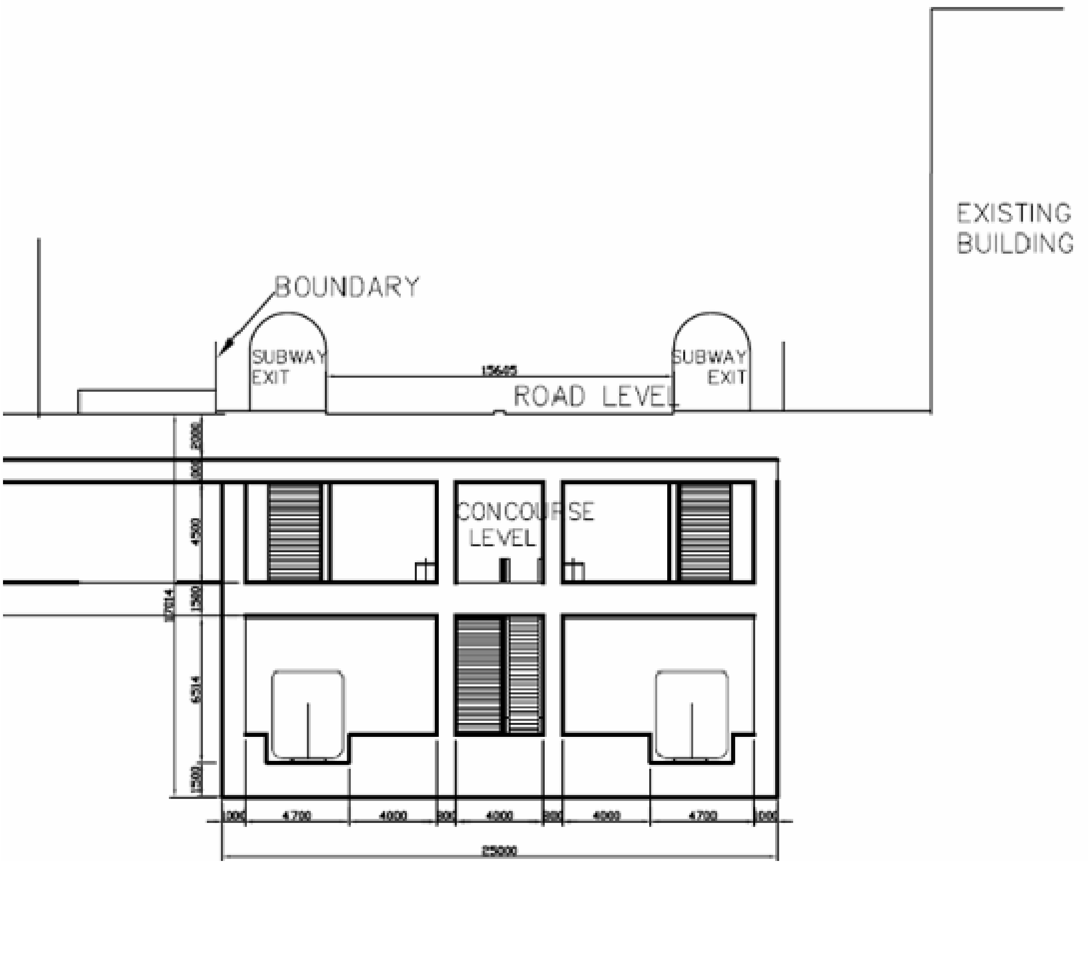
The building survey, monitoring during construction phase and necessary repairs, if required, are to carried out by respective contractors.

4.10.3 Underground Stations by Cut and Cover/NATM Method

There are in all 27 stations proposed along the corridor. While most of stations are proposed by preferred Cut and Cover method, NATM technique is proposed to be used for few stations. Due to peculiarity of high density urban area coupled with presence of high water table, high surcharge load and high rise buildings, all excavation should be protected with continuous water tight and rigid walls to settlement at ground to acceptable minimal values. This would require continuous dewatering and recharging provisions.

A typical cross section of station is shown in **Figure 4.1** which has Platform and Tracks at G-2 level and Passenger Concourse at G-1 level.

Figure 4.1: Typical Cross Section of Station



4.10.4 Stations by Cut and Cover Method

Cut – and- cover is a simple method of construction where a trench is excavated and roofed over. A strong overhead support system is required to carry the load of the covering material, roads, streets or other transportation systems. The Cut & Cover Method consists of 5 sequences

i) Diversion of investigated utilities
ii) Construction of support walls
iii) Excavation of the space between the support walls and simultaneously stiffening the open Cut with struts
iv) Construction of the permanent floors and buildings and removal of the temporary struts
v) Backfilling and reconstructing of the surface

4.10.4.1 Two basic forms of cut- and- cover method are:

Bottom-up method: A trench is excavated, with ground support as necessary, and the opening is constructed within. The construction may be of in situ concrete, precast concrete and corrugated steel and with brickwork used in early days. The trench is then backfilled, with precautions regarding balancing compaction of the backfill material, and the surface is reinstated.

Top-down method:

Cut and Cover phased top-down method is the most suitable method for construction of underground stations of the corridor (**Figure 4.2**). The salient features of this method are as given below:

- Use of permanent D-walls and floors progressively helps to maintain retention of the surrounding soil and ground water.

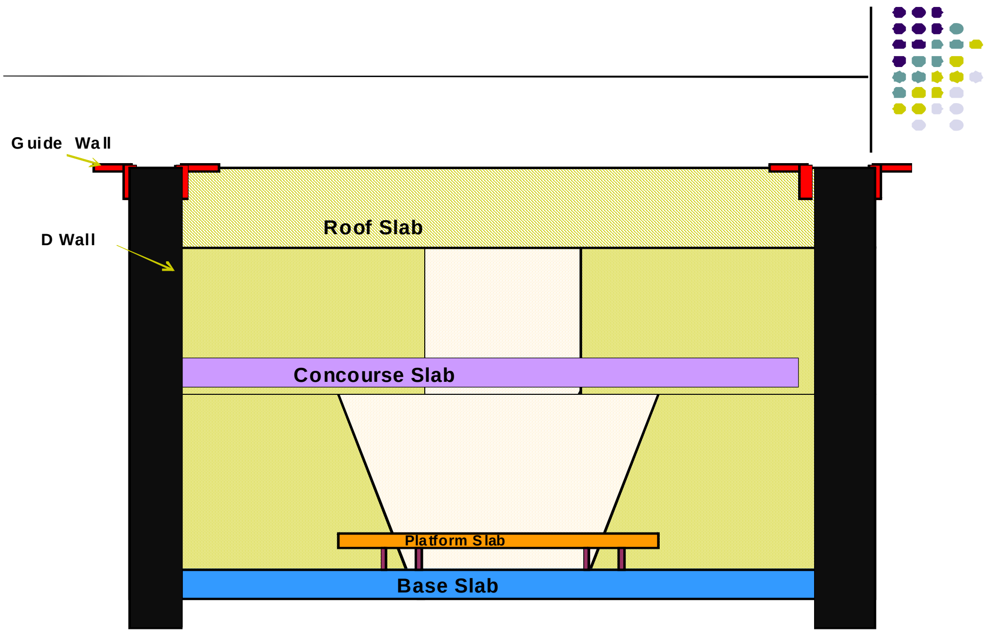
- The advantage of this method is the reduction in the extent of temporary work

- Less ground movements and traffic can be opened after construction of top slab.

- The sequence of top down requires structural plunge column installation below the final excavation. (A plunge column is a structural steel (occasionally concrete) section embedded in a freshly poured concrete pile, thus eliminating the need for base plates and holding-- down bolts).

- This method is useful where ground water is high and where ground cannot be engaged for construction to longer time.

Figure 4.2: Top Down Excavation Method with Diaphragm Walls



4.10.4.2 Diapharagm Walls

Diaphragm walls are underground structural elements commonly used for retention systems and permanent foundation walls. They can also be used as deep groundwater barriers. The technique involves excavating a narrow trench that is kept full of an engineered fluid or slurry. The slurry experts hydraulic pressure against the trench walls and acts as shoring to prevent collapse. Slurry trench excavations can be constructed in all types of soil, even below the ground water table.

4.10.4.3 Sheet Pile Walls

Sheet pile walls are constructed by driving prefabricated sections into the ground. Soil conditions may allow for the sections to be driven into ground vibrated instead of it being hammer. The full wall is formed by connecting the joints of adjacent sheet pile sections in sequential installation. Sheet pile walls provide structural resistance by utilizing the full section. Steel sheet piles are most commonly used in seep excavations, although reinforces concrete sheet piles have also being used successfully.

4.10.4.4 Bored Pile Walls

Bored piles are cast in place cylindrical piles excavated either by use of rotary equipment operated augers, buckets, under static drilling fluid or large drill bit (for hard rock) with reverse circulation, with chisel grab and casing oscillator for boulder ground, with large diameter DTH hammers and compressed air (drilled piles), among others. Most common large diameter bored piles, are installed through an overburden of cohesive or cohesion less soil strata, with or without water tale, down to firmer ground, to achieve the design bearing capacity by skin friction, base bearing or both, to serve as foundation piles for residential, commercial, institutional buildings, industrial complexes or infrastructures.

4.10.4.5 Construction Sequence: Top Down Method

The construction of underground station shall be done in stages as described below:

1) (One half of the road is blocked while traffic continues on the other half)

- Traffic diversion for one half of the road width. Traffic on the other half will not be affected and can continue.
- Barricading along the road for the length of the station for half width of the road.
- Diversion of utilities and site installation.
- Construction of soldier piles and diaphragm walls.
- Excavation upto desired level.
- Construction of temporary columns to support the top slab.
- Construction of top slab for the blocked width of the road.
- Backfilling on the blocked width and traffic restored.

2) (Other half of the road is blocked and traffic restored on the first half)

- Traffic diversion for other half of the road width. Traffic on the first half restored.
- Barricading along the road for the length of the station for half width of the road.
- Construction of soldier piles and diaphragm walls.
- Excavation upto desired level.
- Construction of top slab for the blocked width of the road.
- Demolition of temporary columns.
- Backfilling on the blocked width and traffic restored.

3) Continue excavation upto the bottom level of the station.

4.10.5 NATM (New Austrian Tunneling Method)

About 10-12 stations along the corridor are proposed to be constructed using NATM. NATM is a method where the surrounding rock- or soil formation of a tunnel are integrated into an overall ring like support structure. The connection to the surface for entry / exit is generally provided by means of two shafts located at both ends of the station, which may also house plant and equipment rooms and ticketing facilities. The present section deals with construction methodology for an underground station by NATM. Detailed design of station, however, shall be site specific depending upon geology and location of shafts etc.

General

NATM has following important features :

- Mobilization of the strength of rock mass - The method relies on the inherent strength of the surrounding rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.

- Shotcrete protection - Loosening and excessive rock deformation must be minimised. This is achieved by applying a thin layer of shotcrete immediately after face advance.

- Measurements - Every deformation of the excavation must be measured. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground, and boreholes.

- Flexible support - The primary lining is thin and reflects recent strata conditions. Active rather than passive support is used and the tunnel is strengthened not by a thicker concrete lining but by a flexible combination of rock bolts, wire mesh and steel ribs.

- Closing of invert - Quickly closing the invert and creating a load-bearing ring is important. It is crucial in soft ground tunnels where no section of the tunnel should be left open even temporarily.

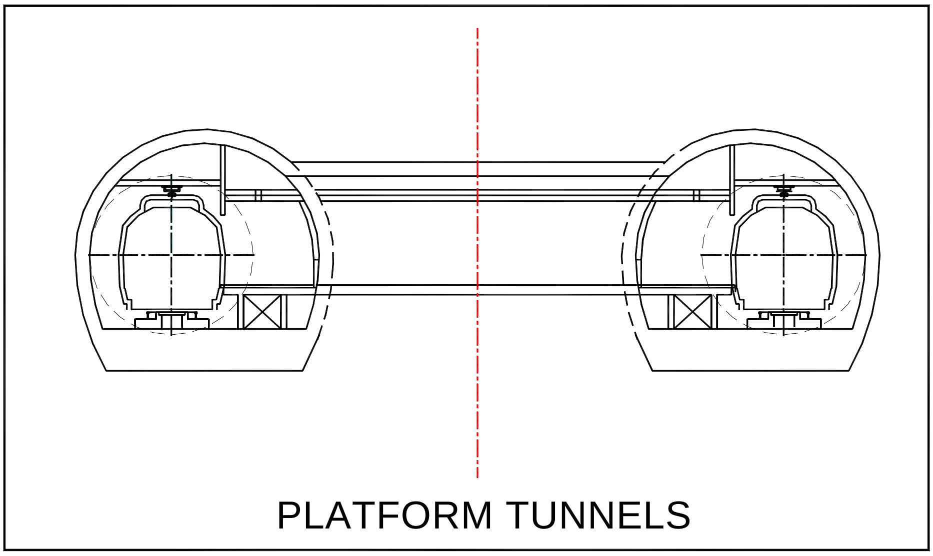
- Contractual arrangements - Since the NATM is based on monitoring measurements, changes in support and construction method are possible. This is possible only if the contractual system enables those changes.

- Rock mass classification determines support measures - There are several main rock classes for tunnels and corresponding support systems for each. These serve as the guidelines for tunnel reinforcement.

  Generally, two separate tunnels each accommodating a track and platform are constructed for two tracks and these two platform tunnels are interconnected by cross passages at regular interval so that both the platforms are accessed through a common set of stair cases and escalators provided at two shafts. In fact, these two platforms interconnected with number of cross passages act as an island platform. A typical cross section is shown in **Figure 4.3.**

Figure 4.3: Typical Cross Section of Tunnels after Enlargement

(With Cross Passages Linking Two Platforms)



Construction of Shafts

Generally the shafts meant for entry / exits are constructed by Cut and Cover method. Due to presence of buildings very close to excavation area rigid support system in the form of Diaphragm Walls and Secant Pile Walls is proposed to be adopted for the braced excavation in the soil. However, the excavation in rock is usually done by stabilizing the rock face by means of shotcrete and rock dowels. A combination of two may be necessary where diaphragm wall / secant pile is provided in the over burden soil and rock excavation is done below. It is proposed to construct permanent diaphragm wall duly socketed into the rock and excavation below the diaphragm wall level be done by supporting rock face by shotcrete / rock bolting depending on the rock conditions. Once the excavation proceeds in rock diaphragm wall can be extended below by jacketing. For this it is proposed to use couplers in the diaphragm wall reinforcement. In some cases, however, where it is considered risky to do trenching for diaphragm wall panel on account of poor soil conditions and proximity to the building temporary secant pile or diaphragm wall with shorter panels may be adopted.

Construction of Platform Tunnels & Cross Passages

The platform tunnels and cross passages connecting these platform tunnels are constructed by New Austrian Tunnelling Method (NATM). One of the shafts is used as portals for starting platform tunnels.

Construction of tunnels by NATM requires proper design to ensure safety of overlying structures and a quick and economical construction.

Salient Features of NATM Design

a) Following are the salient features of NATM design:

- Development of 3-Dimensional geological model.
- Use of numerical modelling to arrive at outline design.
- Use of observational approach to refine and adjust the outline design during construction.

b) The 3D geological model is formulated based on geo-technical investigation done in various boreholes in open spaces available in and around construction area. The outline design is then done taking this geological model and using FLAC 3D numerical modelling.

Classification of Rock Mass type

Rock mass encountered during excavation cannot be said to be favourable or unfavourable only on the basis of the type of the rock.. Several other factors also play part in the rock mass behaviour. The excavation in the rock is depenent on the rock class based on several factors such as – compressive strength of rock, water condition, number of cleavages, condition of cleavages, dip and stike of the rock etc. There are various approaches of classification of the rock mass and most predominantly they are RQD, RMR and Q factor of the rock mass.

Rock Quality Designation Index (RQD)

The Rock Quality Designation Index (RQD) was developed by Deere (Deere et al 1967) to provide a quantitative estimate of rock mass quality from drill core logs. RQD is defined as the percentage of intact core pieces longer than 100 mm (4 inches) in the total length of core. The core should be at least NW size (54.7 mm or 2.15 inches in diameter) and should be drilled with a double-tube core barrel.

a) RMR Value:

RMR value depends upon the following factors:

1. Uniaxial compressive strength of rock material.
2. Rock Quality Designation (RQD).
3. Spacing of discontinuities.
4. Condition of discontinuities.
5. Groundwater conditions.
6. Orientation of discontinuities.

Based on this, the rock mass classification as per RMR is given in **Table 4.46**.

Table 4.46: Rock Mass Classification

RMR Value	100-81	80-61	60-41	41-20	<20
Rock Class	I	II	III	IV	V
Description	Very Good	Good	Fair	Poor	Very Poor

b) Q Factor:

It depends on the following:

i) Block size
ii) Inter block shear
iii) Active stress
iv) Reduction for joint water flow
v) Presence of weakness zones

Q factor varies from 0.01 to 1000 i.e. from exceptionally poor rock to exceptionally good rock

Rock Class Vis-à-vis Rock support system is based on Geotechnical studies. The rock support is provided for various rock classes and then monitoring of the deformations is done. The typical rock support system used in the construction of tunnel with TBM is given in **Table 4.47**.

Table 4.47: Rock Class

Rock Class	I	II	III	IV	V	VI	VII	VIII
Sealing Shotcrete	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Forepole	X	X	X	Yes	Yes	Yes	Yes	Yes
Wire Mesh	X	X	Yes	2 layer	2 layer	2 layer	2 layer	2 layer
Shotcrete (mm)	50	100	150	250	300	300	300	300
Lattice Girder	X	X	X	Yes	Yes	Yes	Yes	Yes
Rock Bolt	X	Yes	Yes	Yes	Yes	Yes	Yes	Yes

As most of the construction of tunnels for platform shall fall below covered area, the design is based on predicted geo-technical parameters of the adjoining borehole data. The initial design documents prepared based on available borehole data provide an outline design allowing for fast reaction and design adaptations on site in accordance with the encountered conditions on site, thus providing an economical and safe design. The observational approach is an integral part of NATM design. It has following advantages:

- Outline Design, providing the flexibility required on site.
- Organisational Structure on site allowing a fast decision making process.
- Extensive monitoring program both above and below ground providing the input information required for decisions.
- Experienced personnel on site capable of interpretation, evaluation and monitoring of results and provide guidance during the construction process.

- Acceptance and support of all involved parties for the requirements of daily monitoring activities.

Salient Features of NATM Construction

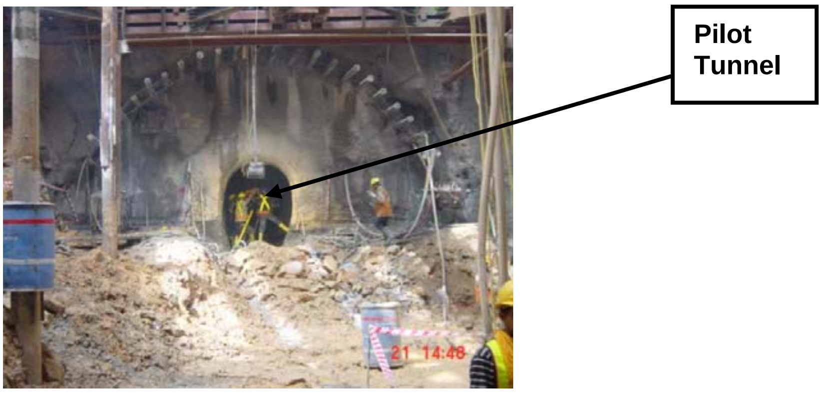
Provision of Pilot Tunnels

In an area where it is not possible to undertake detailed geotechnical investigation it is always helpful to excavate a pilot tunnel (area around 4-5 sqm) ahead of main large tunnels (areas more than 20 sqm).

The advantages of construction of pilot tunnel are many. Some of them are as follows:

- The pilot tunnel helps in dewatering of main tunnel area.
- It gives much more accurate idea of geological conditions along the alignment thereby assessing the requirements with regards to support measures.
- It helps in increase of excavation rate of main platform tunnel as it eases excavation by blasting in good rock conditions and thus increase in advance rate.

Figure 4.4: Actual Photograph showing the provision of Pilot Tunnel



Construction Sequence and Round Length

The general construction sequence for platform tunnels (area approximately 80-100 sqm) is top heading excavation followed by bench and invert excavation. In general, round lengths for excavation are limited by the governing ground conditions and by limitations due to blasting vibrations. Round length for top heading is generally 1.50 m in areas of good rock conditions and is reduced to 1.00 m in poor ground areas. Similarly the round length for benching and invert is 3 m and 6 m in areas of good rock conditions and is reduced to 2 m and 4 m in poor ground areas.

However, for cross passage tunnels (area approximately 20-25 sqm) the construction sequence is top heading followed by invert.

Figure 4.5: Construction Sequence

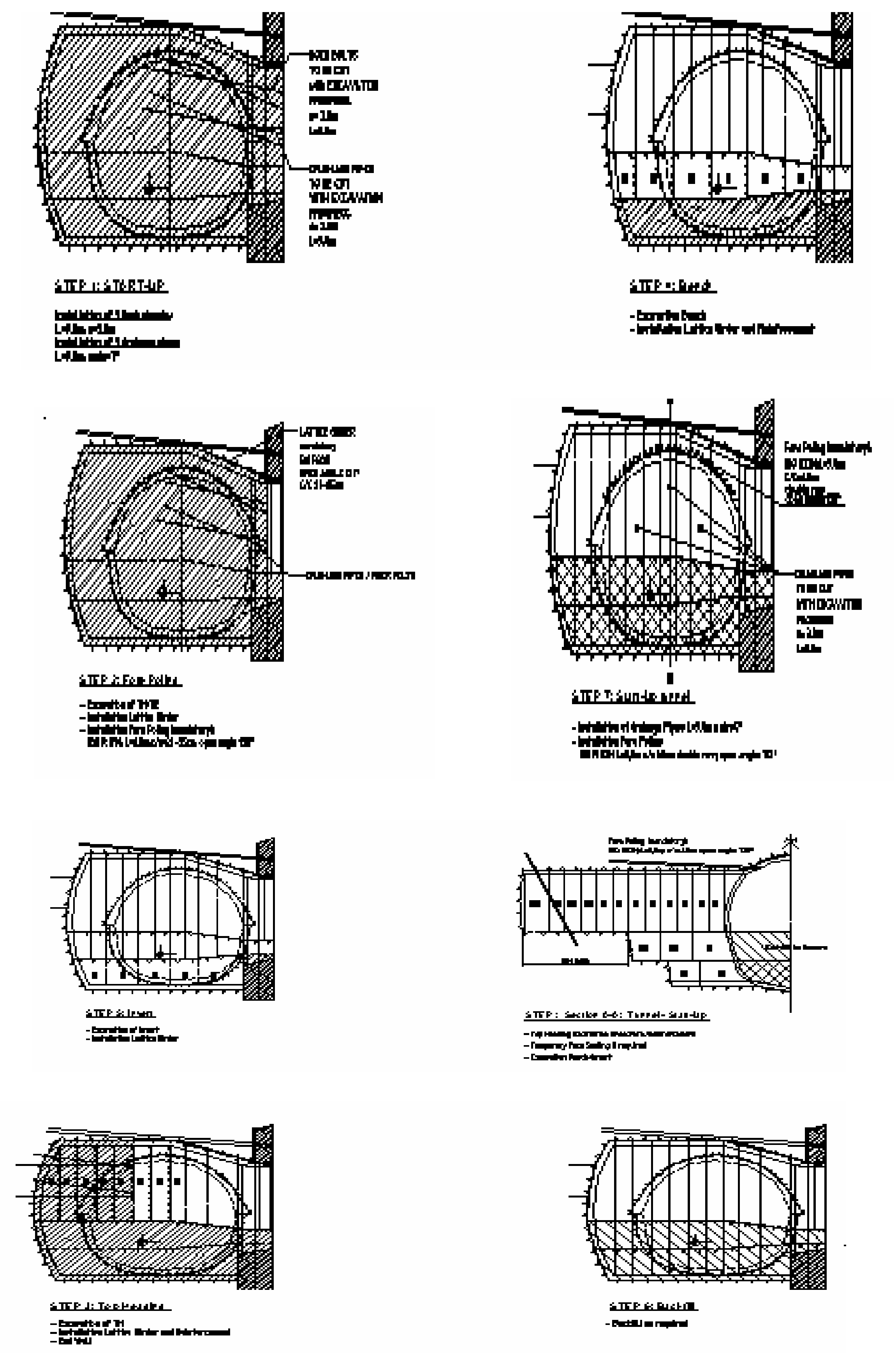
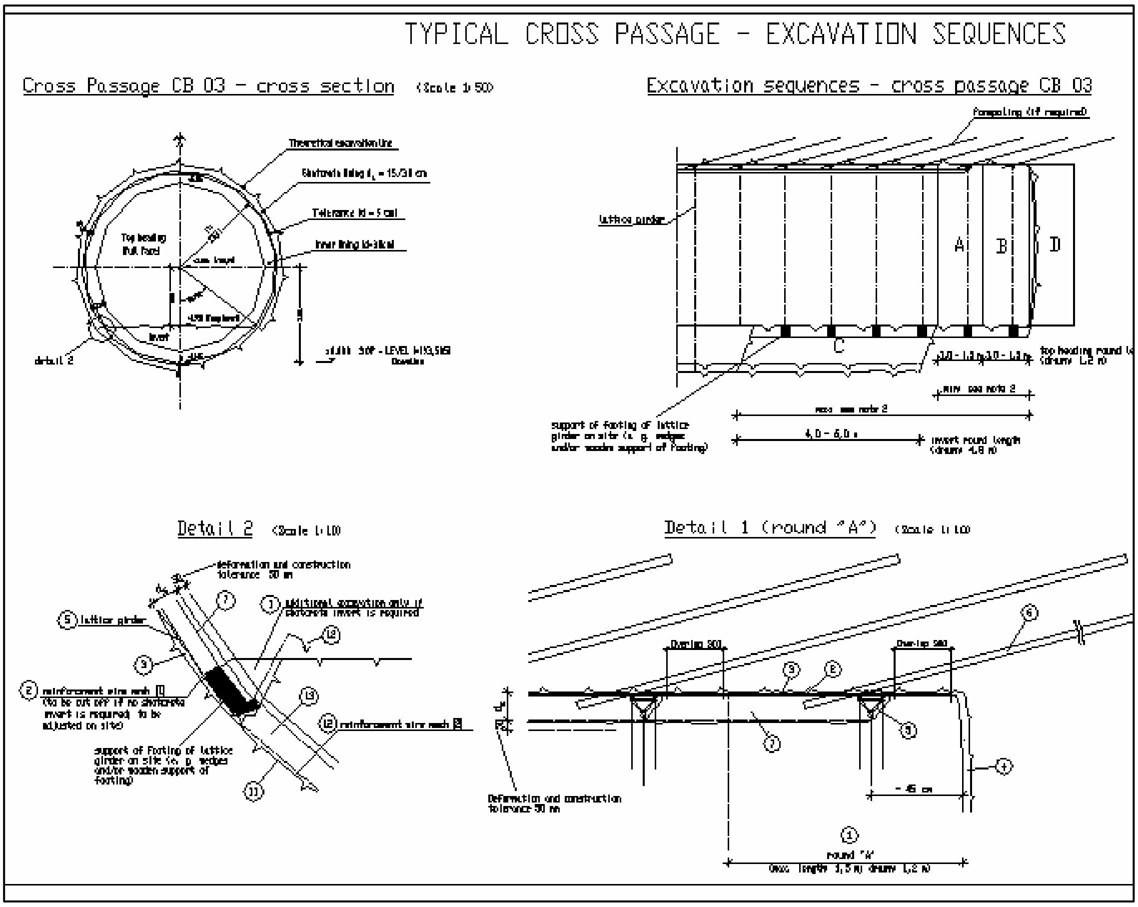


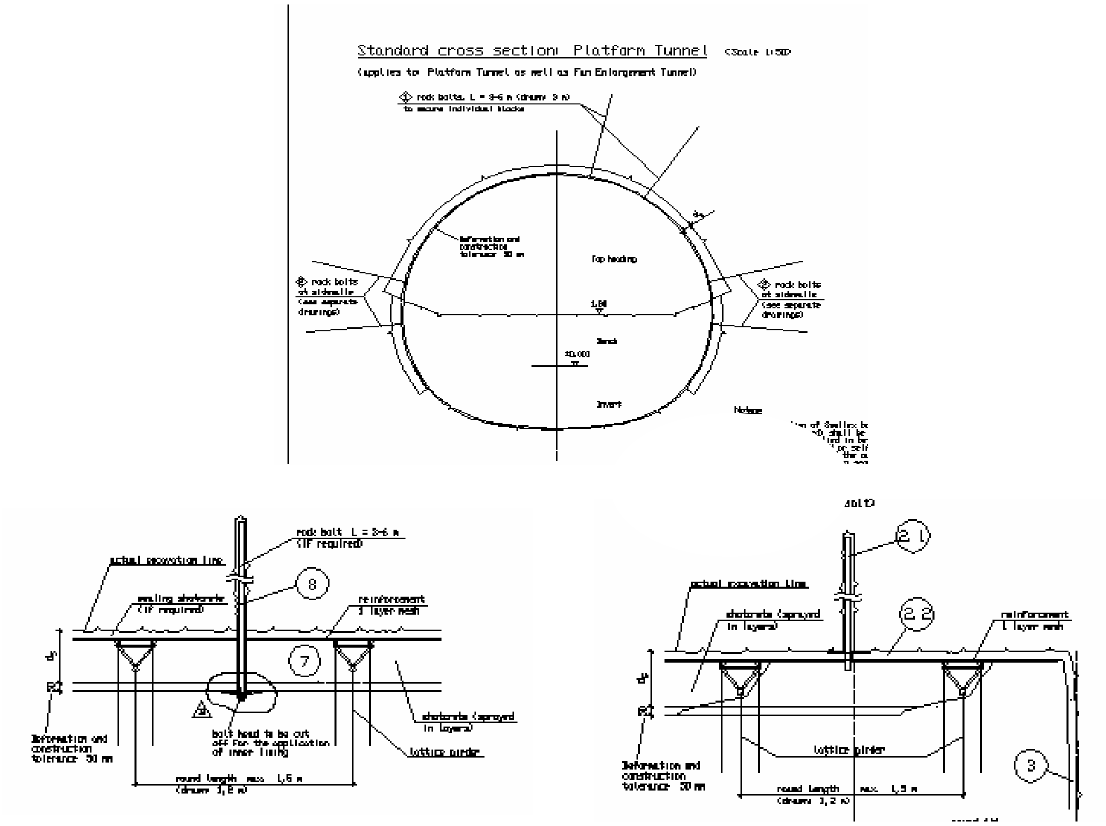
Figure 4.6: Typical Cross Passage – Excavation Sequences



Support Measures

Support measures prescribed for these NATM tunnels in general included shotcrete, wire mesh, lattice girders, forepiling etc. **Figure 4.7** shows typical support system. M25 grade of shotcrete is generally adopted for these tunnels. Standard shotcrete thickness is 20-30 cm for such sizes of platform tunnels, cross adits and service tunnels. However, in special areas such as intersections and transitions and areas of weak ground a higher shotcrete thickness of approximately 30-40 cm is applied. To avoid the buildup of water pressure on the shotcrete lining weep holes are drilled through the shotcrete lining. These weep holes are equipped with slotted PVC pipes wrapped in geo-textile.

Figure 4.7: Necessary Support Measures



For the tunnels wire mesh 150/150/6 mm are applied as standard. Wire mesh is applied after application of a shotcrete sealing layer. Proper overlap of 300 mm (2 mesh openings) is provided in both directions i.e. circumferential and in longitudinal direction.

Rock bolting for NATM tunnels is not proposed, as it is not considered as a systemic support measure in urban tunnelling with shallow overburden.

Lattice girders are installed to provide immediate support for the exposed rock mass during excavation and to serve as template for the excavation geometry. They also serve as guidance and support for forepiling and are considered as reinforcement of the shotcrete lining. Different types of lattice girders are installed depending on the applied shotcrete thickness.

In most of the areas forepling is installed in the crown area of the top heading to avoid development of loosening rock zones. Forepiling is installed after each round from the current top heading face to provide safety for the following top heading excavation round. It is installed from the top of the last lattice girder installed.

Table 4.48: Lattice Girder as per Shotcrete Lining Thickness

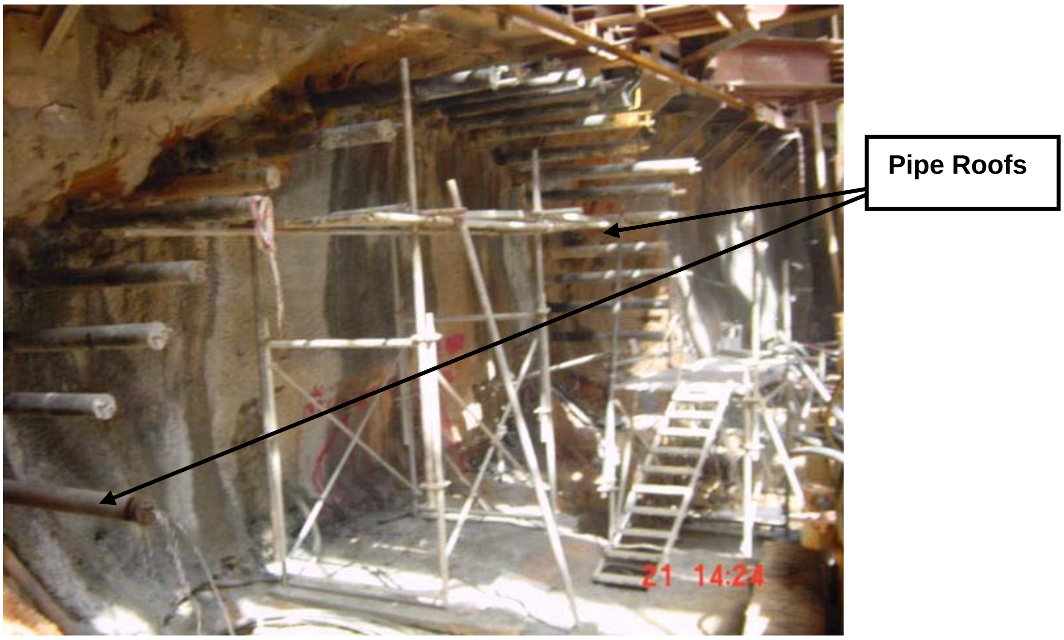
Shotcrete Thickness	Lattice Girder Type	Height of Girder
150 mm	70 / 18 / 26	114 mm
200 mm	95 / 22 / 32	149 mm
300 mm	130 / 26 / 34	190 mm

Machines for NATM

Following machines are generally used for NATM construction:

- Drilling Jumbo (boomer) for drilling holes for forepolling, weep holes, blast holes.
- Excavators {e.g. Liebherr 912 & 932, L&T 90 and EX 200 & 100} with rock breakers.
- Wheel loaders (e.g. HM 202).
- (Robojet) shotcrete mobile machine.
- Stationary shotcrete pump– for emergency.
- Jack Hammer with pusher legs for drilling where boomer could not be used.

Figure 4.8: Arrangement for Strengthening of Portals by Pipe Roof



Monitoring of Ground Movement & Surface Settlements

NATM works are always associated with displacements and surface settlements. It is, therefore, mandatory to have an extensive monitoring regime during NATM construction works. Mainly two types of monitoring, Standard Monitoring Sections and Enhanced Monitoring Sections are envisaged for excavation works.

Standard Monitoring Sections consist only of precision levelling points at the surface and targets for absolute displacement monitoring underground. They are installed at regular intervals (5-10 m spacing) in the tunnels.

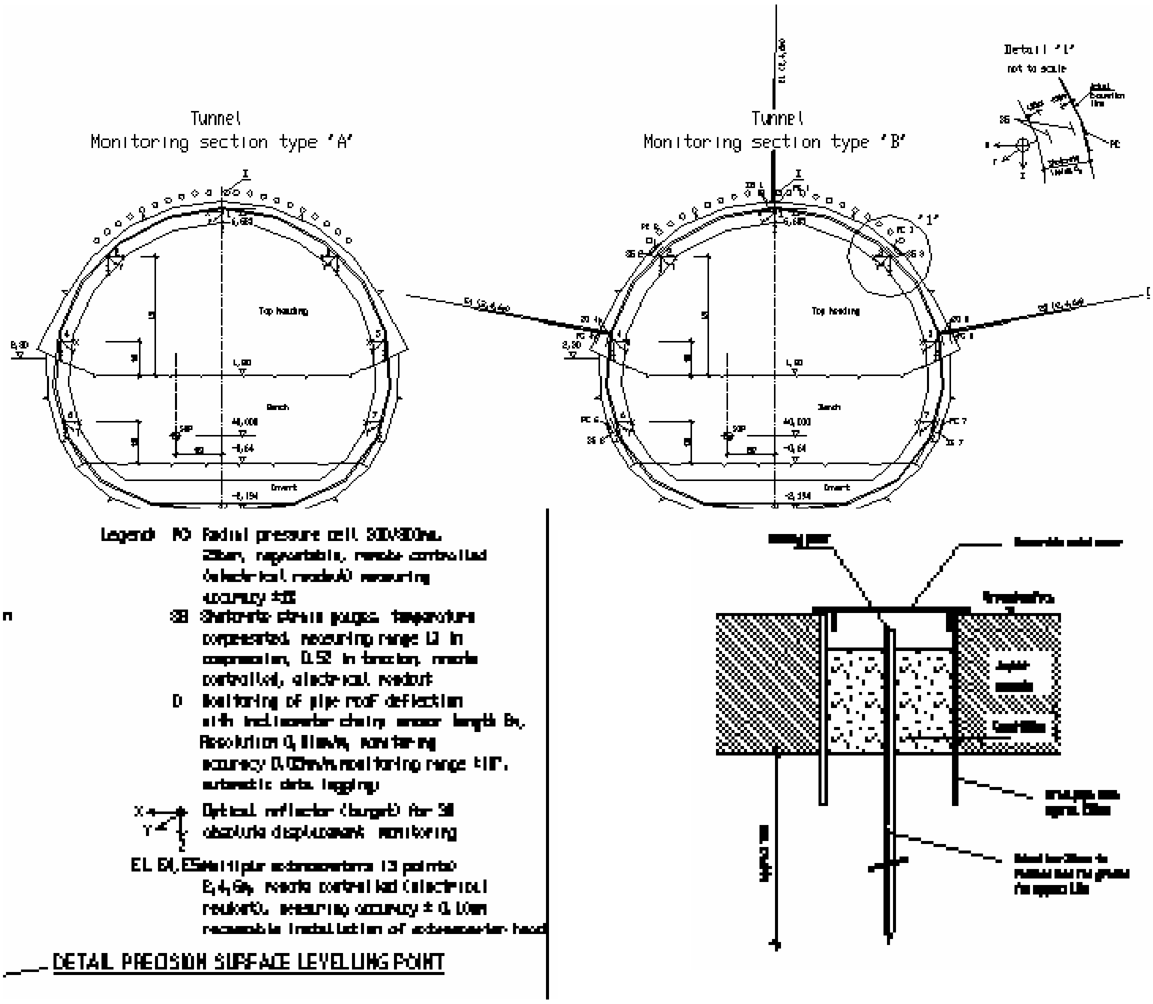
At certain locations called "Enhanced" Monitoring Sections monitoring devices such as extensometers, pressure cells, shotcrete strain meters are installed. They help in an assessment of the loading of the primary support and of ground movements outside the excavation for design verification purposes.

When NATM works are undertaken in densely populated area having buildings very sensitive to settlements, special provision for monitoring settlements of buildings are also planned. It is good to have a continuous monitoring of building settlements by installation of TCA 1800 automatic total stations. With this system, quick and instantaneous information (eliminating human errors) are obtained.

The frequency of monitoring except for online monitoring system is generally daily, however, it also is dependent on the instrumentation type and location, the stage of construction and the benefit of the data it provides.

Monitoring frequencies are reduced following completion of construction activities within the affected zone. The instrumentation itself is left in place until the completion of all construction.

Figure 4.9: Instrumentation Details



Expected Progress Rate

A progress of 1 m / day is expected in present case if planned properly. It is the experience that progress suffers due to the failure of equipments. It is suggested that proper maintenance facilities of equipments is ensured to achieve the desired progress. Also standby equipments are helpful.

Temporary Traffic Decking for busy streets

The proposed Cut and Cover –Top –Down methodology as described in Para above offers least disturbance during period of construction. It would, however, render the area unusable during period of construction which may extend from six months to one year. At some locations diverting traffic for even six months to one year may not be possible and traffic has to be continued during period of construction also. Traffic decking for smooth functioning is therefore a necessity in such a scenario.

King post is the vertical structural support member to prevent the sagging of cross-beams. The objective of construction of king post is to support traffic decking. The procedure of construction of King Post is as under

- For installing king post pile, bore hole of suitable dia and depth as per design to be done.
- The king post pile will be lowered and concreting shall be done up to bottom most slab and remaining portion will be filled with sand.
- The rig must be set up to maintain verticality of auger.

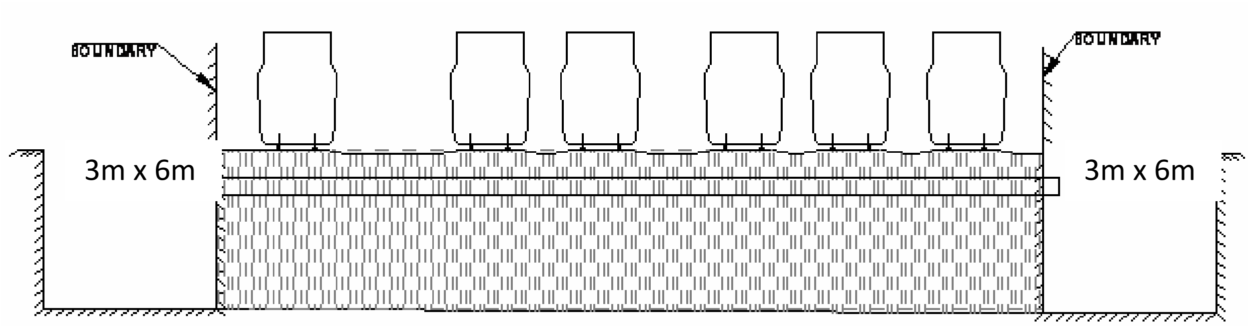
Construction of king post is a temporary arrangement for construction of underground station while the traffic is still moving above. The structural arrangement of such temporary works shall be proposed by the contractor and submitted to design consultant for review and approval.

4.10.6 Construction methodology for underground subways connecting stations to exits

There are some station locations which are required to be connected to suitable exits by construction of underground subways. The subways would have to be constructed in heavily built up urban areas without affecting ground features. The proposed subway shall be so planned that they do not infringe with any of the foundations of the existing structures Construction of these subways would be very challenging as they run under the busy streets/areas. One of the methodology of constructing these subways is pipe roof method, the brief of which is described below.

- Launching shafts (6m wide and 3m long) is prepared of both Ends at suitable locations.

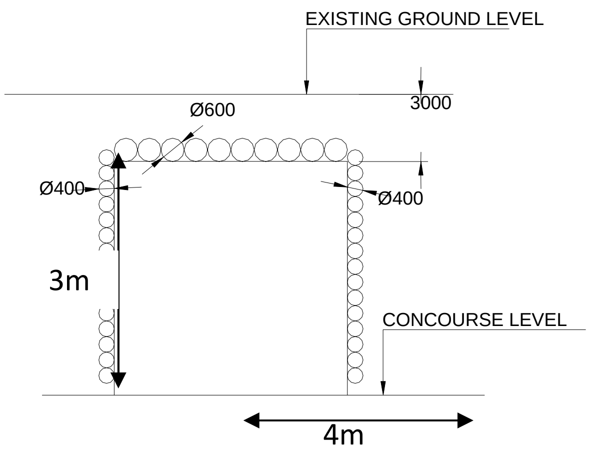
Figure 4.10: Launching Shaft on both Ends



- Number of longitudinal support members is inserted side by side through the ground beneath the existing street so that the support members extend continuously beneath from side to side thereof and overlie the roof of the subway to be formed. Number of longitudinal support members is also inserted along the height of the wall of the subway to be formed.

  These support members are pipes and the boring is accomplished by a boring machine having an auger extending through the pipe and a cutting head extending from the lead end of the pipe.

Figure 4.11: X-section of pipe supports



- After the pipes are in place, excavation is started in small longitudinal increment from one end to the other.

- The face of the excavation is reinforced with the help of fibre glass bolts and by spraying concrete.

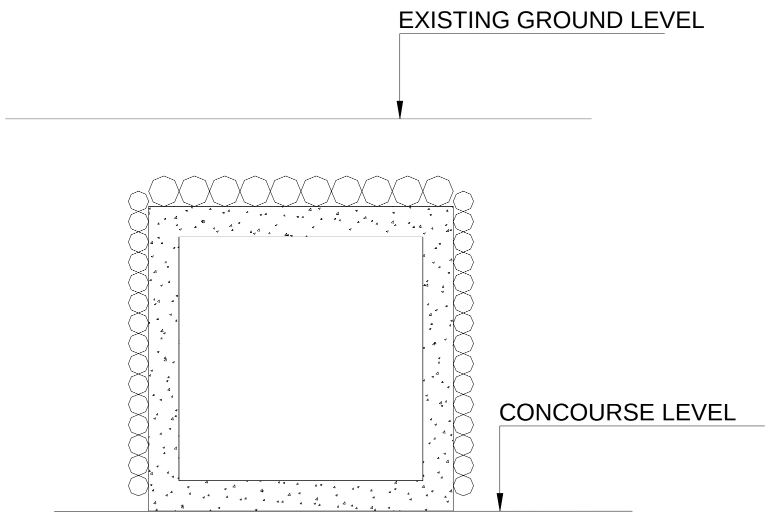
- Temporary tunnel forming supports are installed in the excavated part of the ground to support the longitudinal support members (pipes)

- Repeat steps 2 and 3 until earth has been excavated from beneath the pipes up to the entire length of the tunnel and the tunnel forming supports extend from one side of the structure to the other.

- At this stage the existing tracks are continually supported by the pipes which are in turn supported by the tunnel forming supports.

The tunnel is constructed without disturbing the normal movements on ground.

Figure 4.12: Completed *Tunnel* in X-section



However, this method is time consuming and expensive and may be used at locations not possible to be executed by normal Cut and Cover.

4.10.7 Underground construction in Mid-Section by TBM

- The Tunnel Boring Machine is a highly mechanised device, used as an alternative to drilling and blasting (D&B) method in rock and conventional hand mining in soil, to construct tunnels with a circular cross section virtually through every strata. The TBMs have so far been used for tunnels of 1 m diameter to 16 m diameter. TBMs have the advantage of limiting the disturbance to the surrounding ground and producing a comparatively smooth tunnel face. This significantly reduces the cost and makes them a preferred option for use in urbanized areas.

- Even though the TBMs are expensive to construct and difficult to transport, but in the case of long tunnels and in heavily urbanized areas, by implications and costs, this is a preferred alternative. Economy is also achieved as tunneling with TBMs is much more efficient and it reduces total project time affected by tunneling.

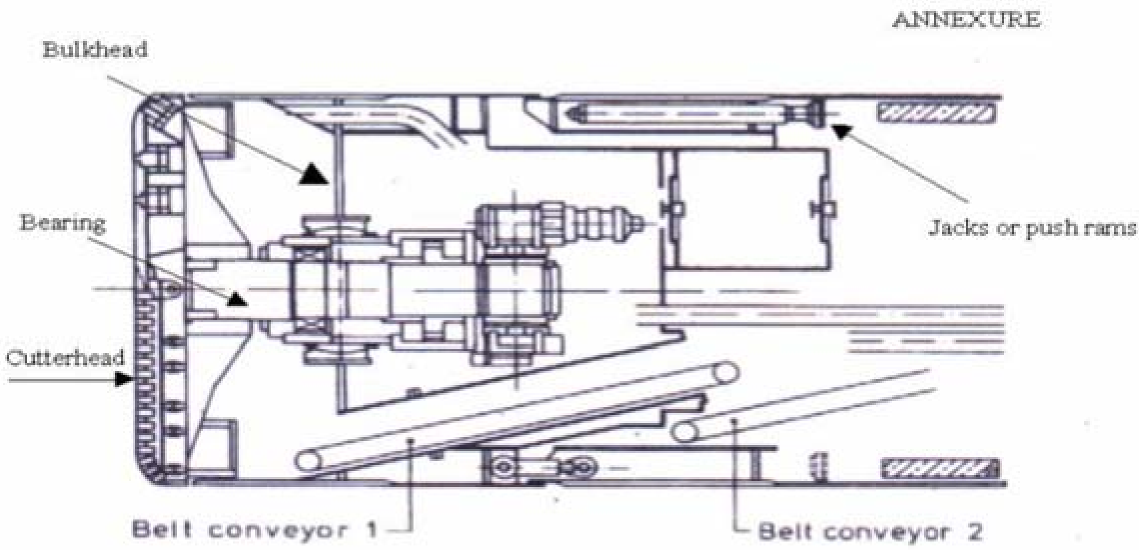
- Modern TBMs consist of a rotating cutting wheel (cutter head) with a specially designed mechanism for providing a thrust-system and trailing-support mechanism. The whole arrangement is designed based on rock characteristic and extent of ground water present etc.

- While the use of TBM obviates the need of large number of skilled workers required at high pressure locations, but sometimes a caisson system is required at the cutting head for slurry shield TBMs. Workers entering this zone for inspection, maintenance and repairs need to have experience to operate the locks and need to be medically examined for 'Fit to dive'.

4.10.8 TUNNELING IN URBANIZED ENVIRONMENT

Urban tunneling has the special requirement that the ground surface should remain undisturbed. This means that ground subsidence must be avoided. The normal method of doing this in soft ground is to maintain the soil pressures during and after the tunnel construction. There is some difficulty in doing this, particularly in varied strata (e.g., boring through a region where the upper portion of the tunnel face is wet sand and the lower portion is hard rock). TBMs with positive face control, such as EPB and SS, are used in such situations. Both types (EPB and SS) are capable of reducing the risk of surface subsidence and voids if operated properly and if the ground conditions are well documented.

Figure 4.13: Typical Assembly of Tunnel Boring machine



Another important aspect in use of TBMs in urban environment is that the location of other tunnels, existing utilities and deep foundations coming in alignment of TBM are accurately identified and appropriate measures taken in advance to shift them. A critical condition survey of all buildings close to alignment of the tunnel should be carried out jointly with the owner/occupants to identify existing cracks and distortions their location and extent. All existing cracks and distortions should be photographed and kept on record for future reference and comparison. System of classification of cracks is already indicate above. Otherwise during execution, occupants will attribute all pre-existing distortions and/or cracks in the building as the affect of vibrations caused by TBM. TBMs are deployed to excavate 'Lined' tunnels.

Figure 4.14: Earth Pressure Balance TBM

The salient features of their deployment are as under:

1) TBM can be designed and deployed both for Soil and Rock strata.
2) The depth of overburden required, in case of Tunneling by TBM (in case of Hard Rock) is usually equal to the diameter of the tunnel.*
3) A clear horizontal separation between two tunnels in hard rock (as in our case) should be usually about 1.5 D (where 'D' is the diameter of the tunnel).*
4) A Reaction frame and Cradle (a base for the assembly for TBM) is to be constructed for the assembly of TBM.
5) Average progress of TBM can be achieved as 15 m per day in round the clock working (or say 5 m per shift). With due regards to time required for the preparatory work, assembly and launching of TBM and unforeseen contingencies, for planning purpose a progress of app. 3.5 Km per month can be adopted.

6) TBM can be 'Dragged through' the station if station planning is done accordingly.

A FEW CONSTRAINTS ARE AS UNDER:

1) The dimension of the launching and Receiving Shaft are app.30x30m.
2) TBM is a chain of machinery and equipment totaling to an assembled length of about 80 m. The TBM is to be assembled in-situ.
3) TBM cannot be pulled back to 'Launching shaft' since the reaction for the movement of machine is taken from the 'Lining' of tunnel.
4) Measurements of 'Tilt' and/or 'Settlement' of the foundations/buildings are to be regularly monitored while working TBM under or very close to buildings and structures, specially when adequate clearance is not available between tunnel profile and the foundation of the existing buildings.

Thus, the construction involves providing twin tunnels of 6 meter diameter each. The two independent tunnels (one for each line) will have to be provided with interconnections at a distance not exceeding 244 meter apart, as laid down vide Cl. 6.2.2.3.2 (1) of Standards laid down in National Fire Prevention Association (NFPA-130-2007)[An International Codes and Standards Organization].

The following construction sequence is necessary before Assembly of TBM can be taken up:

1. **Construction of Head Wall & Installation of rubber seal ring**
   This is a concrete structure designed to hold the main frame of the Entrance ring of TBM and prevent water and slurry flowing into the shaft during the assembly and operation of the TBM. Rubber Seal (25 mm thick) and seal retainers keep full contact with the shield TBM. Three air ventilation tubes are installed near the tunnel crown and one at the invert, to release the air, when the void is being filled with grout while launching the TBM. These can also be used for grouting.

2. **Construction of Cradle**
   This is a Pre-fabricated steel structure over which the TBM is assembled in–situ. This also acts as guide to help TBM oriented in the required direction, while in operation. After the TBM becomes operational, the cradle will be carefully dismantled so that the same material can be used at different shaft.

3. **Construction of Reaction Frame**

   This is a steel Structure consisting of the Frame and supports which is fixed to the shaft floor and is designed to safely bear the thrust [a force of App. 1200 ton (30% of total thrust)] applied by the TBM during its working (force required by the cutting edge to cut the rock). The machine is to be assembled in- situ on a platform called Cradle, as stated above, and a Reaction frame is to be constructed in advance to bear the reaction of the force exerted by the main drive of the TBM for cutting the rock. Once the TBM becomes operational, the steel work in the Reaction Frame will be carefully dismantled as the same material is to be used repeatedly at subsequent assemblies at different sites.

Figure 4.15: Launching Chamber

Figure 4.16: Erector, Screw Conveyor & Backup System

After the Head Wall, Entrance ring, Cradle, Reaction Frames are constructed and other preparatory works are completed, the TBM can be assembled in- situ on the cradle and launched for tunneling.

Note:

1) It takes about three-four weeks each for completing the preparatory work and actual assembly of TBM in position, before it could be launched. The cradle and the Reaction Frames are specially designed for every situation depending upon the machine characteristics and the rock characteristics.
2) A 35 ton crane with a traveling gantry (or a suitable road mobile crane) is required for assembling the TBM. A 50 ton mobile crane will be required at the receiving end for dismantling TBM before shifting the same to another location.
3) Arrangements for competent staff and spares for TBM is an equally important task and that will need constant tie up with the machine manufacturers, to avoid stoppage of machine for want of the same.

Following steps are involved in the assembly of TBM-

1. Lowering of the shield,
2. Lowering of Cutter Head and fixing the same to the shield,
3. Fixing Segment erector and screw conveyor erection,
4. Lowering and Assembly of back up gantries.

The TBM will operate at all times in enclosed mode. The pressure being maintained by balancing excavated material and foam introduced against material removed via the screw. A belt weighing device will be included on conveyor belt .This will measure the weight of the excavated material as it is transported on the conveyor belt.

Figure 4.17: Excavation

4.10.9 Ring Erection

As the machine advances, the construction of the permanent lining takes place behind the excavation face of the machine and typically consists of 6 segments which make one ring.

Figure 18: Ring Segment

Figure 4.19: Segment Loaded on TBM

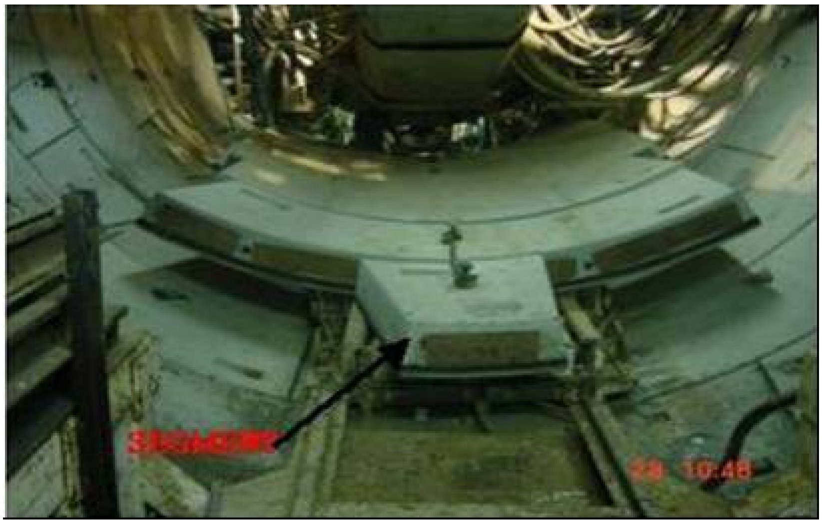


Figure 4.20: Operator Controlling the Movement of the Pre-cast Tunnel Segments

Grouting

After ring installation, theoretical void distance between the excavated radius and the external radius of the precast ring. Grouting fill the voids and it also controls the ground settlement. Grouting pressure is calculated on the basis of overburden pressure.

Settlement Control

Settlement is primary caused by over excavation by TBM and the failure to fill annular voids behind the segments.

- To prevent over excavation during the TBM drives the following actions will be carried out
- Surface monitoring scheme to be agreed and installed prior to TBM launch.
- Provision of belt weighing device to measure excavated material weight.
- Ground treatment of launch area & receiving area (if required)
- Display in TBM drivers cabin to show actual excavated volume vs. theoretical excavated volume in real time. Data to be recorded by TBM data logger.

The above actions should prevent over excavation during the TBM drive thereby controlling settlement. To ensure settlement do not occur due to the annulus ring not being filled by grout the following actions will be carried out.

- Selection of a grouting system based on pressure control.
- Recording of grout volumes & pressure by TBM data logger.
- Tabulation of grout volumes to be done weekly showing running 10 ring averages. Grout pressure will be adjusted as necessary.

The above actions should ensure all annular voids are filled during the initial drive thereby controlling settlement caused by poor grouting practices.

4.10.10 TBM in Station Area

Cradle will be installed to drag the TBM in station area and again drive to other end of station by cutting D-wall. One end of station is receiving chamber and other end is launching chamber.

Figure 4.21: TBM through the diaphragm wall

Figure 4.22: TBM pushed to the other end of the station

4.10.11 Construction sequencing of one typical station

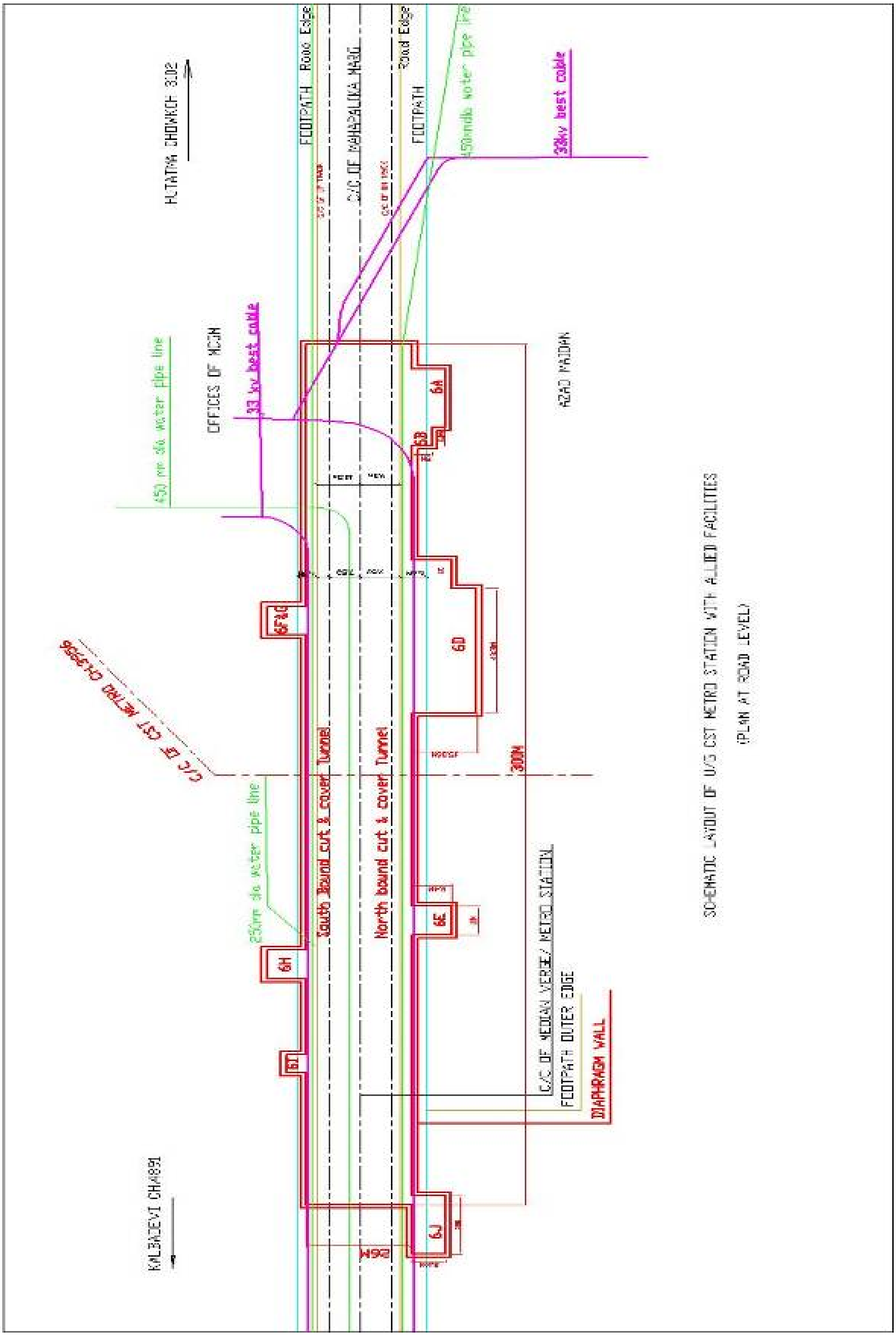
There are in all 27 underground stations along the corridor. Eleven of the stations along the proposed corridor would serve as interchange stations with other mode of public transport system of city. CST Metro station located on Mahapalika Marg is one of the busiest station providing intermodal interchange with Central Railway Suburban as well as Long distance trains. The broad construction methodology of CST Metro station is discussed in subsequent paragraphs.

4.10.11.1 Salient features of proposed CST Metro station

The typical details of CST Metro station are as under-

1. The station is located at Chainage 3956 and situated on Mahapalika Road having a carriageway of 10 m with footpath of about 5.50 m on either side.
2. Across the Mahapalika Road are the important Heritage buildings of MCGM.
3. Utilities such as Water Supply lines, Gas Supply lines, BEST cables and MTNL cables lie in the proposed station area
4. The total requirement of area for construction of station is 300 m X 26 m.
5. The station has Platforms at G-2 level and concourse divided into Paid and Unpaid area at G-1 level.
6. Eight Entry/ Exits are provided at the station. To optimise passenger dispersal and also to provide interchange with CST Station of Central Railway, connections are planned with existing subways located at South End of proposed Metro station.

   Schematic Layout of u/g CST Metro station showing allied structures is enclosed.



SCHEMATIC LAYOUT OF U/G CST METRO STATION WITH ALLIED FACILITIES

(PLAN AT ROAD LEVEL)

4.10.11.2 Construction planning of proposed CST Metro station

The station is proposed to be constructed with Cut and Cover –Top Down method. The planning of construction should be preceded by following detailed investigation and documentation.

1. Detailed Geotechnical investigation of area @ 30 m along the centre line of station
2. Detailed design of station structures
3. Preparation and approval of Method statements for various construction activities
4. Planning of utility diversions
5. Dewatering and drainage measures
6. Earmarking required area for material handling
7. Health and safety issues

4.10.11.2.1 Geotechnical Investigations

Detailed geotechnical investigations will be carried out with bore holes @ 30 m along the centre line of proposed CST Metro station. In all, 10 bole logs between chainage to will be taken and RQD values recorded. Also depth of water table will be accurately determined. The classification of rock will be the criterion for suitability of excavation/blasting technique to be adopted. The geotechnical data will also be used for detailed design of station structure and also the ancillary building.

4.10.11.2.2 Detailed design of station structures

For all the structures detailed design and 'GOOD FOR CONSTRUCTION' drawings to be issued for guidance of field staff. The design will include detailing for station box including Platforms, Concourse ,Entry/Exit , Staircase, Escalators, connections to Subway and also detailed drawing for Ancillary building to house Plant and Equipments such as Chillar Plant, Pump room, Ventilation Exhaust ,DG room, Water tank, Staff room , Refuse store etc.

4.10.11.2.3 Preparation and approval of individual Method statements

The construction activities at site have to be executed in accordance with approved Method Statement (MS). The MS will be prepared for individual activities such as Excavation, Diaphragm walls, Dewatering, Temporary support system, Traffic decking, Barricading etc. The MS should broadly include definitions, purpose, scope and applications, equipments, procedures, materials, quality assurances, health, safety and hazard analysis, environmental protection, responsibilities and authority.

4.10.11.2.4 Planning of utilities diversions

A detailed survey of existing utilities in affected area is to be carried out. As per available details from topographical survey, the available utilities in CST Metro station are water pipe lines, gas pipe lines, BEST cables and also the MTNL cables. The details are

Water Supply Lines:

S. No	Chainage	Affected Length (in m.)	Dia (mm)	Position w.r.t Alignment
1	CST Metro (3956) (6178-6363)	30	300	Along
		40	250	Along
		20	450	Along
		50	350	Along

Gas Pipe Lines (Mahan agar Gas) :

S. No	Chainage	Affected Length (in m.)	Approx. Depth	Dia (mm)	Position w.r.t Alignment
1	CST Metro (3843-4028)	70	1.0	150 Steel gas P/L	Along

Best Power Lines:

S. No	Station/Chainage	Affected Length (in m.)	Type	Position w.r.t Alignment
1	CST Metro (3956) (6178-6363)	2 x750	33KV	Along
		1x35	33KV	Across
		1x30	33KV	Skew

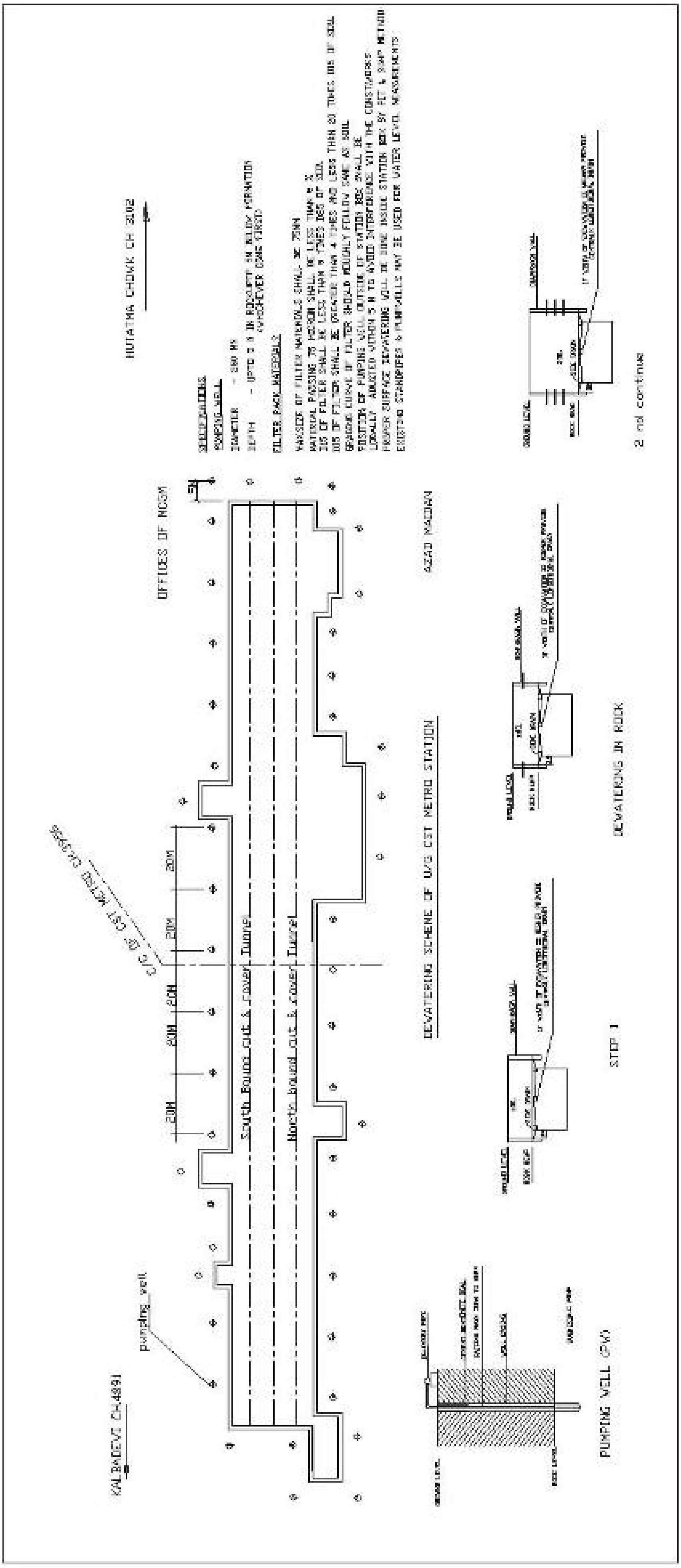
MTNL Cables:

S. No	Chainage	Affected Length (in m.)	Approx. Depth	Dia (mm)	Position w.r.t Alignment
1	CST Metro (3956) (3843-4028)	70	1.0	Cable duct	Along

These utilities of water supply lines, gas supply lines, BEST cables and MTNL cables would , therefore , need diversion before commencement of work at CST Metro station..

4.10.11.2.5 Dewatering and drainage measures

The excavation for underground station has to be preceded and accompanied by an effective dewatering and drainage management system. Detailed drawing for dewatering and drainage of site will be prepared and work progressed according to the plan. A sample typical dewatering and drainage plan of CST Metro station is enclosed.


HUTATMA CHOWK CH 3102
OFFICES OF MCGM
AZAD MAIDAN
KALBADEVI CH4891
pumping well
South bound cut & cover Tunnel
North bound cut & cover Tunnel
20M
DEWATERING SCHEME OF U/G CST METRO STATION
PUMPING WELL (PW)
STEP 1
DEWATERING IN ROCK
2 nd continue

4.10.11.2.6 Earmarking required area for material handling

During progress of construction of station, construction materials and equipments are required to be kept near the proposed CST Metro station. The temporary stacking ground may be developed in adjacent Azad Maidan area by barricading. The movement of construction material and equipments can be regulated thereupon.

4.10.11.2.7 Health and safety issues

A detailed health and safety MS to be ensured at site which will include planning for barricading, hoardings, sign boards, traffic diversions etc. Detailed traffic diversion plans for blocking the half road at the time of phased construction will be prepared and implemented in consultation with concerned authority. One lane of Mahapalika Marg will be blocked at a time for construction activities. After completion of one half of station and restoration of traffic, other half portion of Mahapalika Marg will be blocked for construction purpose.

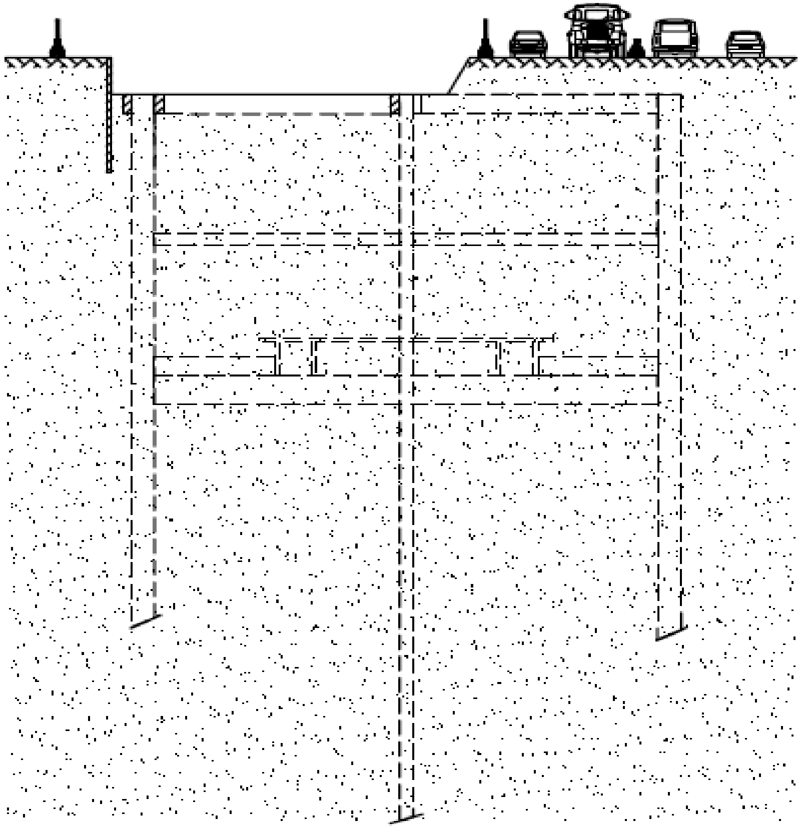
4.10.11.3 Construction methodology of CST Metro station

The CST Metro station is proposed to be constructed by Cut and Cover – Top Down method. The sequence of construction is as under

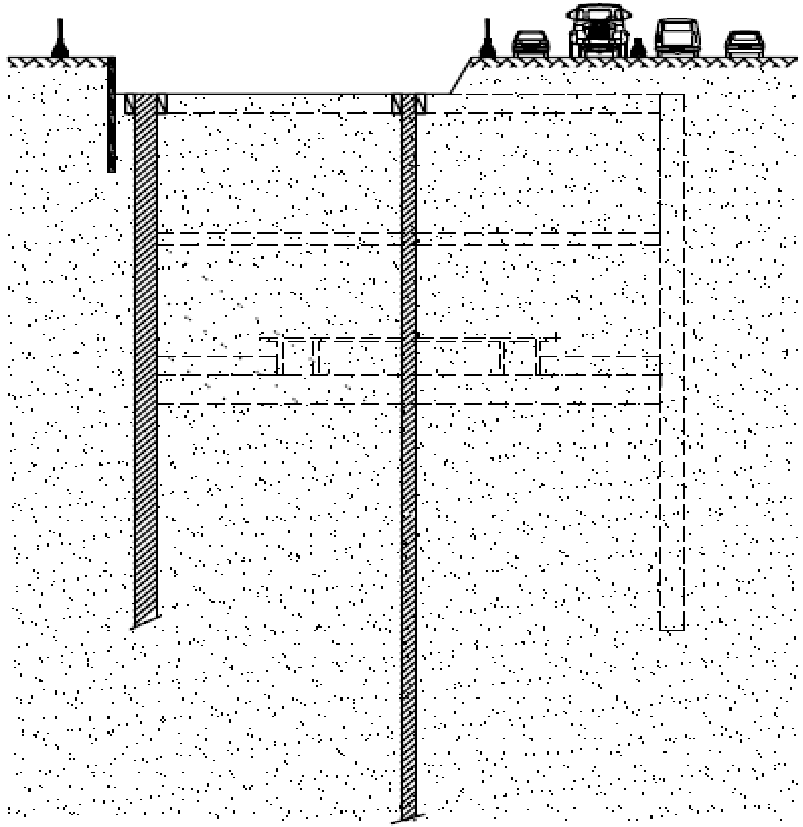
- *One half of the road is blocked while traffic continues on the other half*
- Traffic diversion for one half of the road width of Mahapalika Marg. Traffic on the other half will not be affected and can continue.
- Barricading along the median of Mahapalika road road for the length of the station.
- Diversion of utilities and site installation.
- Construction of diaphragm walls.
- Excavation upto desired level.
- Construction of temporary columns to support the top slab.
- Construction of top slab for the blocked width of the road.
- Backfilling on the blocked width and traffic restored.
- *Other half of the road is blocked and traffic restored on the first half*
- Traffic diversion for other half of the Mahapalika road. Traffic on the first half restored.
- Barricading along the median of the Mahapalika road for the length of the station.
- Construction of diaphragm walls.
- Excavation upto desired level.
- Construction of top slab for the blocked width of the road.
- Demolition of temporary columns.
- Backfilling on the blocked width and traffic restored.
- Excavation is to be continued upto the bottom level of the station.
- Construction of various station elements as per approved plan .

The sequence of construction is shown in schematic sketches below.

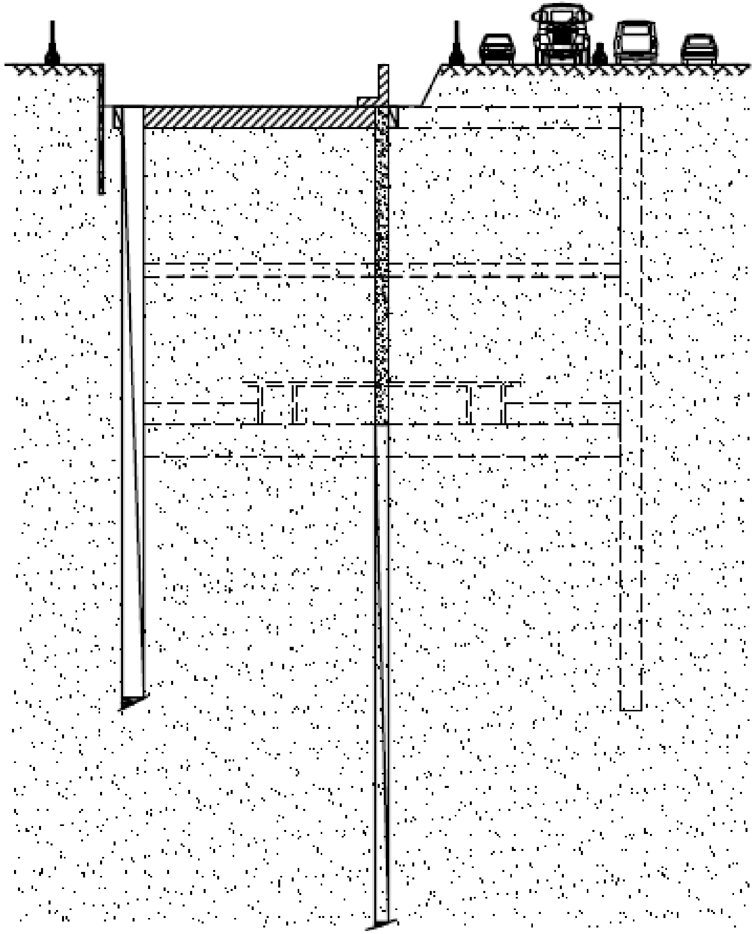
PHASE 1
Utilities diversion - Site installation
Soldier piles - Guide walls



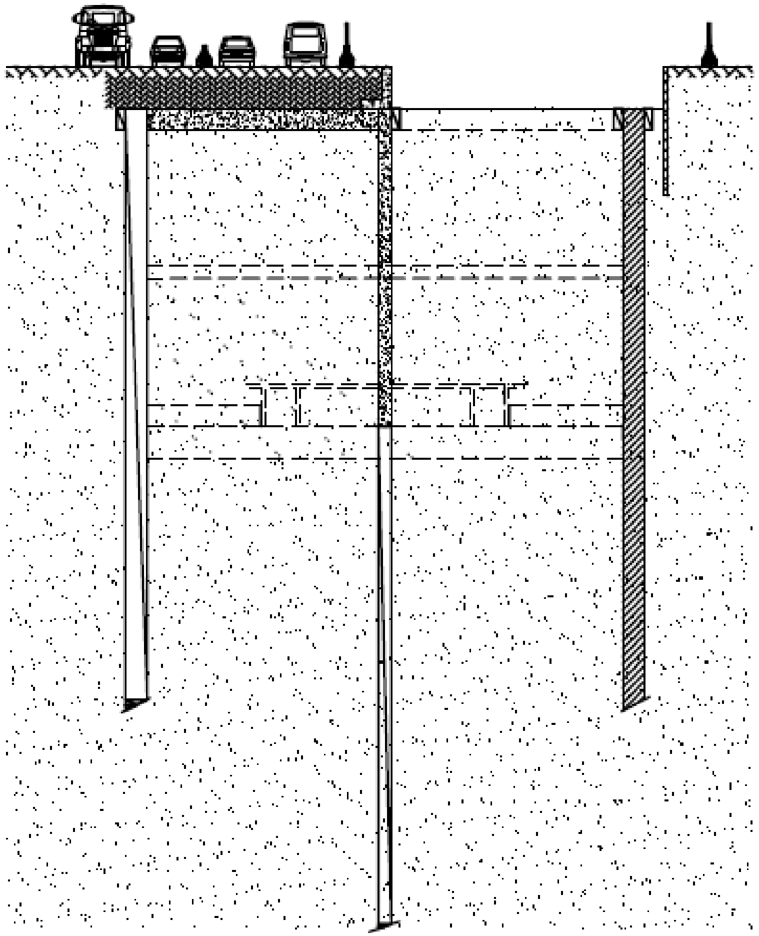
PHASE 2
Diaphragm wall
Prefounded columns



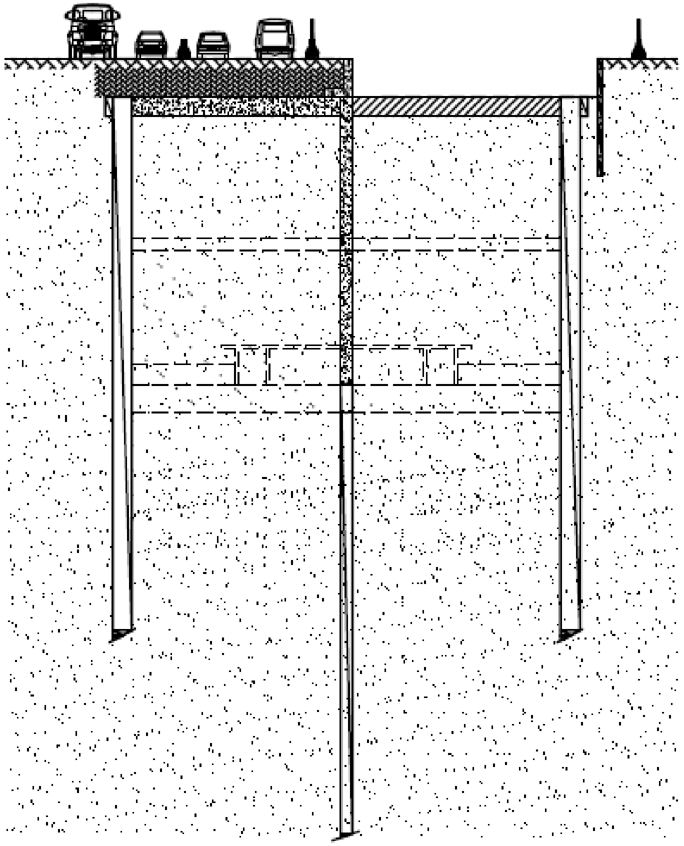
PHASE 3
Half roof slab construction
Waterproofing
Retaining wall



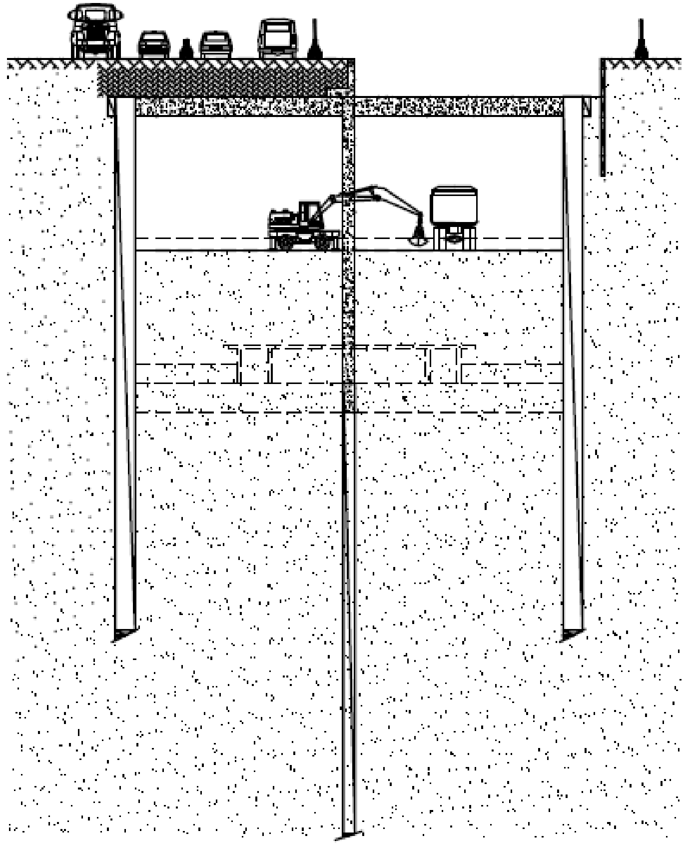
PHASE 4
Partial backfilling - Traffic diversion
Soldier piles - Excavation
Guide wall - Diaphragm wall



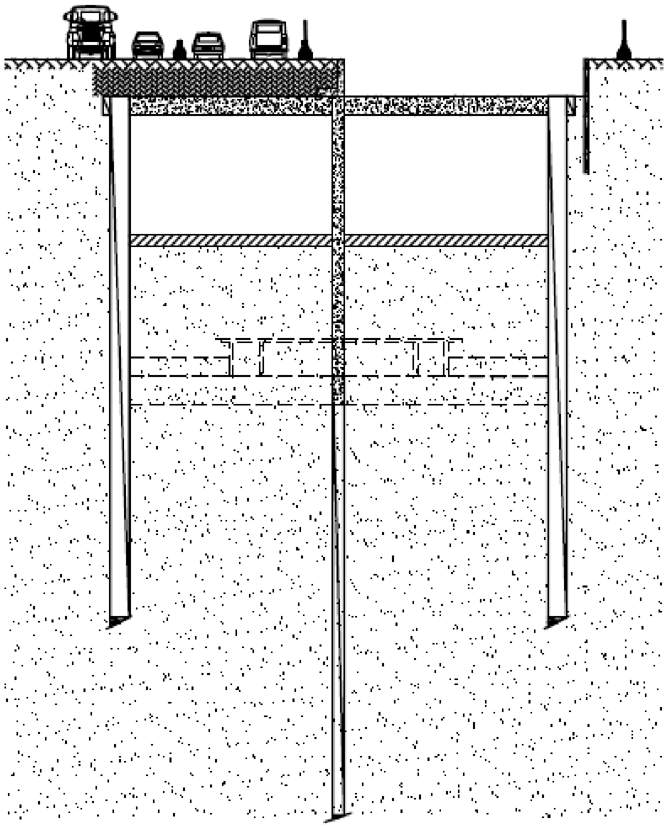
PHASE 5
Half roof slab construction
Waterproofing



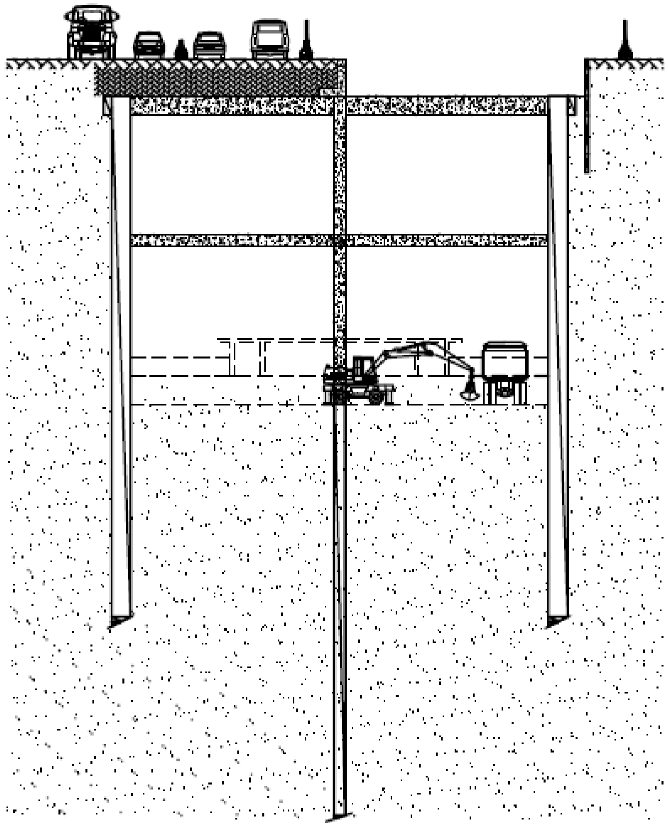
PHASE 6
Excavation stage - 1



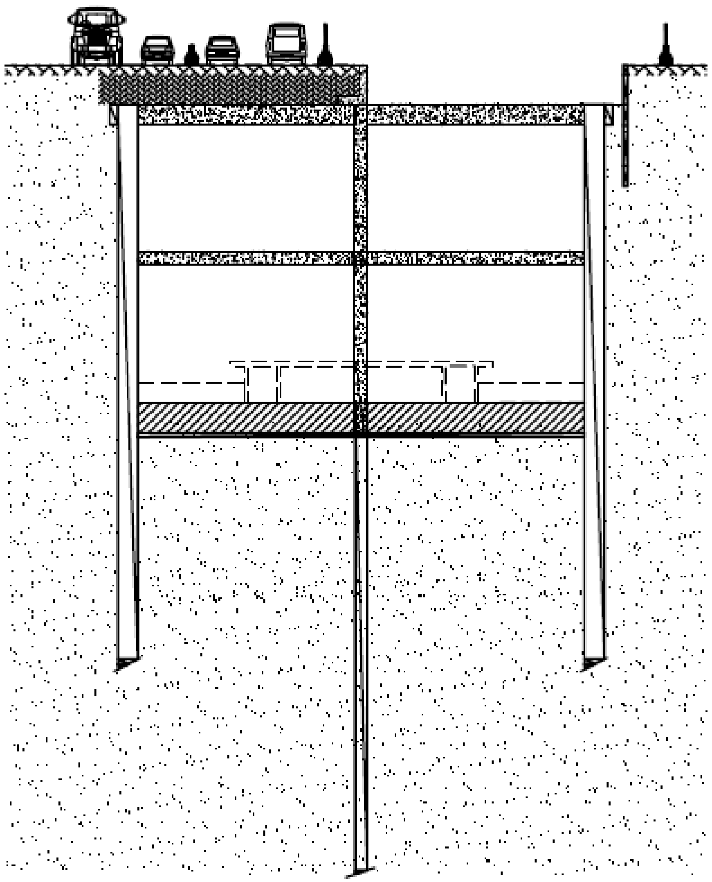
PHASE 7
Concourse slab construction



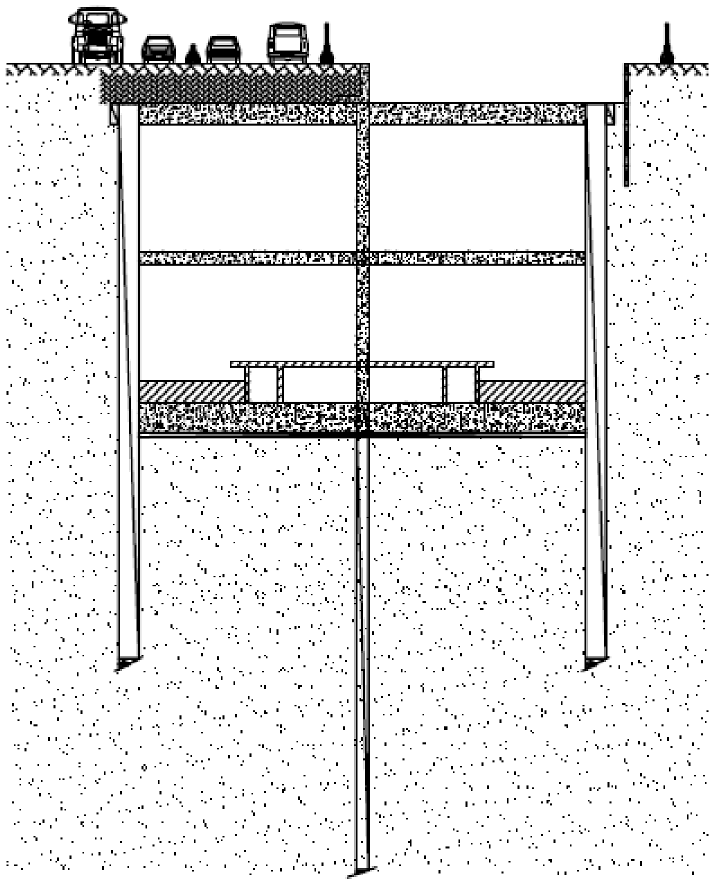
PHASE 8
Excavation stage - 2



PHASE 9
Raft waterproofing
Raft construction



PHASE 10
Platform construction
Prefounded column demolition



5. STATION PLANNING AND INTERMODAL INTEGRATION

5.1 STUDY CORRIDOR

The proposed Colaba – Bandra – SEEPZ Corridor is 33.5 km long and is planned to have 27 stations.

The corridor is planned to connect southern Mumbai with the major activity areas like Bandra Kurla Complex (BKC), Airport (Domestic and International), SEEPZ (Industrial Hub) and area along JVLR, which has got tremendous potential for new developments.

The alignment and the station locations (**Figure 5.1**) have been finalised after an extensive review of earlier DPRs, based on

- catchment areas
- integration with other mass transit corridors
- construction feasibility
- joint site visits & consultations with MMRDA

Stations have been located so as to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, interchange requirements with other modes of transport, station spacing, alignment, utilities, road and pedestrian requirements, etc. The typical size of the station would be nearly 27 m wide and 290 m long. The location and other characteristics of each station is indicated in **Table 5.1**, shown in **Figure 5.1** and explained briefly in the following paragraphs.

5.2 STATIONS

The salient characteristics of all stations areas are presented in Table 5.2

5.2.1 Colaba/ Cuffe Parade (Chainage 0.00 m)

Colaba/ Cuffe Parade Station is the starting point of the proposed metro corridor. The station is planned on the existing Cuffe Parade Road; located on the central verge along 20 m wide road. **(Figure 5.2).** Entry and exit stairs are provided along both sides of proposed station in 3m-7m wide configurations and planned in such a way that it gets integrated with the existing transport infrastructure.
Catchment area of the station comprises residential areas such as Dalmal Park Apartments, RBI officers quarters, etc. along with Public & Semi-Public areas such as World Trade Centre.

Table 5.1: Details of Proposed Stations

Sr No.	Station Name	Chainage (m)	Interstation Distance (m)	Road/Landmark
1	Colaba/ Cuffe Parade	0	-	Captain Prakash Pethe/ Foreshore Road/Woods Park
2	Badhwar Park	1000	1000	Jagannath Bhosle Road/ Badhwar Park, south of SB of Patiala
3	Vidhan Bhavan	1600	600	Madam Cama Road/Between Vidhan Bhavan and SBI
4	Churchgate Metro	2285	685	Jamshedji Tata Road/Near Eros Cinema
5	Hutatma Chowk	3102	817	DN Road /Near Flora Fountain
6	CSTM Metro	3956	854	Mahapalika Marg/near Azad Maidan
7	Kalbadevi	4891	935	Jagannath Shankar Road (JSS) Road/ Near Parsi Temple
8	Girgaon	5616	725	Jagannath Shankar Road (JSS) Road/ Near Zaveri Bazaar
9	Grant Road Metro	7156	1540	Dr. Lamington Road/ Near Municipal School
10	Mumbai Central Metro	8067	911	Dr.A. Nair Road/near Maratha Mandir
11	Mahalaxmi Metro	9216	1149	Sane Guruji Marg/ Near Jacob Circle
12	Science Museum	10316	1100	E. Moses Road/Near Mahalaxmi Racecourse
13	Acharya Atrey Chowk	11516	1200	E. Moses Road
14	Worli	12924	1408	Dr.Annie Besant Road/Near Akashvani
15	Siddhi Vinayak	14479	1555	Sane Guruji Garden/Behind Ravindra Natya Mandir
16	Dadar Metro	15756	1277	Gokhale Road/Ranade Road
17	SheetlaDevi Temple	17525	1769	Lady Jamshedji Marg / Miya Mohd. Chhotani Marg / SheetlaDevi Temple
18	Dharavi	19306	1781	Mahim – Sion Link Road
19	Bandra Metro	21225	1919	Sant Dnaneshwar Marg/ Near ITO
20	Mumbai University (Kalina)	22812	1587	University Road/In University Area
21	Santacruz Metro	24027	1215	East side service road of Western Express Highway
22	CSIA(Domestic)	26299	2272	In CSIA Area near Domestic Terminal
23	Sahar Road	27906	1607	In CSIA near Sahar Road
24	CSIA (International)	28958	1052	In CSIA Area near International Terminal
25	Marol Naka	29829	871	Chimatpada Slum Area, near Andheri Kurla Road
26	MIDC	31225	1396	Vikhroli Village Hutment Area
27	SEEPZ	32546	1321	Krantiveer Lakhuji Salve Marg/ Near SEEPZ Bus Depot

Figure 5.1: Corridor Alignment

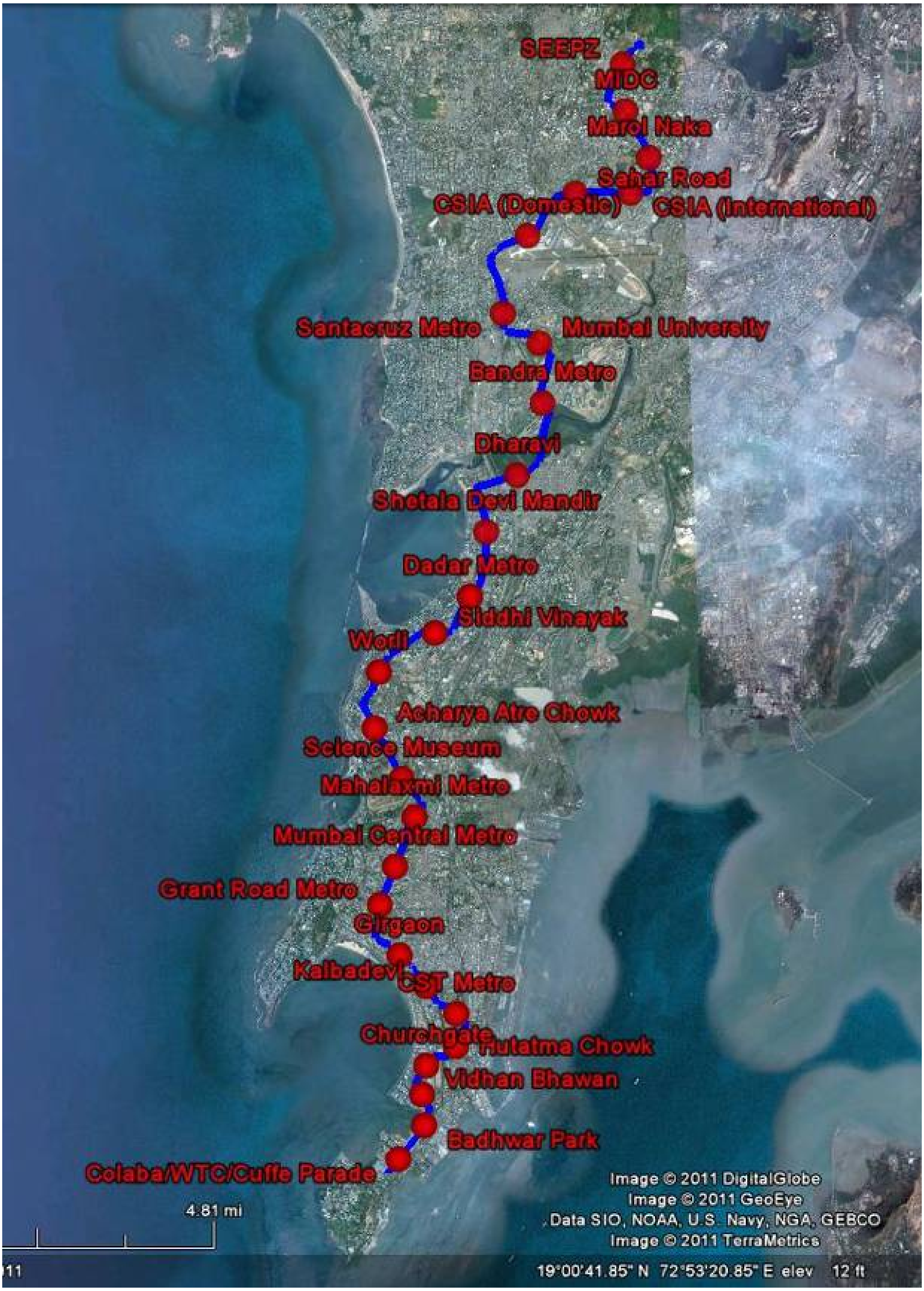


Table 5.2: Characteristics of Station Area

S. No.	Station	Predominant Landuse	Location of station	Activity area	Major Interchange	Major Catchment Area	No. of Entries/ Exits proposed to the station
1	Colaba/ Cuffe Parade	Residential	Near Woods Park	Residential cum Public & Semi-Public	Terminal station interchange with Colaba bus Depot/Terminal	World Trade Centre, Taj President Hotel, Dhobhi ghat and Navy Nagar	4
2	Badhwar Park	Public & Semi-Public	South of SB of Patiala	Public & Semi-Public		Western Railway officers flats, Colaba, Cusrow Bag colony, Gateway of India	4
3	Vidhan Bhavan	Public & Semi-Public	Between Vidhan Bhavan and SBI	Public & Semi-Public area along with residential areas		Public & Semi-Public buildings like Vidhan Bhavan, Mittal Tower and Nariman Point CBD area	5
4	Churchgate Metro	Recreational	Near Eros Cinema	Recreational areas	Interchange station with existing suburban / proposed elevated corridor	CBD area of Nariman Point, Marine Drive and Churchgate	4
5	Hutatma Chowk	Institutional/ Public & Semi-Public	Near Flora Fountain	Institutional area along with Public & Semi-Public area		Mumbai Stock Exchange, Gateway of India , Fort Area	4
6	CST Metro	Public & Semi-Public	Near Azad Maidan	Public & Semi-Public. / Transport Hub	Interchange station with existing suburban corridor	Chhatrapati Shivaji Terminus, Mumbai Municipal Corporation, Azad Maidan and Fort area	4
7	Kalbadevi Metro	Residential	Near Parsi Temple	Residential areas		Mixed landuse with commercial establishments of KalbaDevi, Dhobitalao, Marine Lines and Chandanwadi.	4
8	Girgaon Metro	Residential	Near Zaveri Bazaar	Residential areas	Charni road Suburban Railway Station about 400m away	Residential areas like Girgaon Ekta Housing Society, karel wadi, Vaidya Wadi, Ambewadi, Thakurdwar and Kranti Nagar on Jagannath Shankar Road .	4
9	Grant Road Metro	Mixed Landuse	Near Municipal School	Public & Semi-Public	Grant Road Suburban Railway Station about 600m away	Mixed landuse with commercial establishments comprising Bharat Nagar, Zoroastrian Colony, shapur Baug, etc.	4
10	Mumbai Central Metro	Public & Semi-Public/ Residential	near Maratha Mandir	Public & Semi-Public along with residential area.	Interchange station with existing suburban / proposed elevated corridor. Suburban Railway Station about	Mumbai Central Station, RBI Staff Colony, College of Arts & Commerce, Madanpura, Tardeo, etc.	4

S. No.	Station	Predominant Landuse	Location of station	Activity area	Major Interchange	Major Catchment Area	No. of Entries/ Exits proposed to the station
					600m away		
11	Mahalaxmi Metro	Commercial	Near Jacob Circle	Commercial , Entertainment, Media offices and small scale industries	Interchange station with existing suburban / proposed elevated corridor and upcoming monorail corridor. Mahalaxmi suburban Railway Station about 400m away	Mahalaxmi Temple, Haji Ali Dargah , Dhobi ghat,Mahalaxmi Racecourse, Jacob circle, Shanti Nagar, Adarsh Nagar	4
12	Science Museum	Public & Semi-Public/ Recreational	Near Mahalaxmi Racecourse	Public & Semi-Public area and recreational area		Science Museum, Racecourse, Famous Studio, Gandhi Nagar	4
13	Acharya Atrey Chowk	Commercial Cum Residential	Near MCGM school	Commercial along with residential area		Mixed and Residential areas like Sidharth Nagar, Bheem Nagar, Jeeja mat6a Nagar and Lower Parel	4
14	Worli	Residential/ Public And Semi-Public	Near Akashvani	Residential area along with public and semi-public area		Residential area like Worli Shivaji Nagar, Hanuman Nagar, Gopal Nagar, century Bazaar	4
15	Siddhi Vinayak	Residential	Behind Ravindra Natya Mandir	residential along with the institutional area	Interchange station with proposed MTHL corridor	Siddhi Vinayak temple , Ravindra Natya Mandir, Sane Guruji Garden, Adarsh Nagar, Kamgar Stadium	4
16	Dadar Metro	Commercial	Dr. Dalvie Maternity Hospital	Residential with commercial area	Interchange station with existing suburban / proposed elevated corridor Dadar Western Railway Station approximately at a distance of 1000 m	Mixed landuse with commercial establishments of Dadar West and Shivaji Park.	5
17	SheetlaDevi Temple	Residential	Near St. Michaels Church	Residential with commercial activity along the Lady Jamshed Ji Marg		Residential and Mixed Landuse areas of Mahim and Raja Wadi	4
18	Dharavi Metro	Mixed	In front of Dharavi Intersection	Dharavi Slum	Mahim Western Railway Station approximately at a distance of 600 m	Mixed Landuse areas of Dharavi	5

S. No.	Station	Predominant Landuse	Location of station	Activity area	Major Interchange	Major Catchment Area	No. of Entries/ Exits proposed to the station
19	Bandra Metro	Commercial	Along the Creek north of ITO intersection	Residential cum Institutional	Changeover terminal station of Metro Phase I Line II i.e. Charkop-Bandra-Mankhurd,	Bandra Kurla Complex, Residential areas along N Dharmadhikani Road and Madhusudan kalelkar Road, Chetna College, Kala Mandir Theatre, Government Colony Flats, 87/11/316 Bus Depot	3
20	Kalina University	Institutional	Near Gymnasium	Institutional	-	Kalina University	4
21	Santacruz Metro	Residential Cum Commercial	Near Santacruz junction along the western expressway	Residential cum Commercial	Suburban Railway Station about 700m away	Residential areas of Santacruz landuse with commercial establishments on road	4
22	Domestic Airport	Public/Semi Public	Near the existing parking of 1 B terminal	Transport Hub	Adjacent to Domestic Airport Terminal	Domestic Airport passengers and a belt of santacruz along the highway	4
23	Sahar Road	Public/Semi Public	Diagonal to the intersection of Sahar road and IA Project road, beneath the existing buildings	Residential cum Commercial	-	Residential and Mixed landuse areas along Sahar Road and Marol Pipeline Road	4
24	International Airport	Public/Semi Public	Parallel to the International Terminal, on the existing parking lot	Transport Hub	Adjacent to upcoming International Airport Terminal	International Passengers and Hotels like Hyatt, Grand Maratha etc.	4
25	Marol Naka	Commercial	Beneath the existing Chimatpada Hutment, perpendicular to Andheri Kurla Road	Residential cum Commercial	Upcoming Metro Line I (Versova – Andheri-Ghat Kopar Corridor)	Commercial establishments along Andheri Kurla Road and few Residential areas of Marol	3
26	MIDC	Mixed/ Industrial	Beneath the existing Vikhroli Village Hutment, along Road No. 7	Residential cum Commercial	-	Mixed and Industrial landuse establishments along Road no. 7 and Vikhroli Village Hutment area	4
27	SEEPZ Metro	Industrial/Commercial	Near the bus and taxi stand of SEEPZ	Industrial	Terminal Station, interchange with SEEPZ Bus Stand	SEEPZ and residential areas along Road 23, Sunder Nagar (slum), area further north along JVLR.	4

5.2.2 Badhwar Park (Chainage 1000 m)

Badhwar Park is the second station planned on the Capt. Prakash Pethe Marg; located on the central verge along 20 m wide road **(Figure 5.3)** . The station is about 1 km away from the Colaba Station. The entry and exit of the station will be provided on both the sides of the road.

Catchment area of the station would be prominent residential areas such as Badhwar Park including major other Public & Semi-Public areas on eastern and western side of the station.

5.2.3 Vidhan Bhavan (Chainage 1600 m)

Vidhan Bhavan is the third station planned on the Vidhan Chowk near Free Press Journal Road, Madam Cama road and Vidhan Bhawan Marg **(Figure 5.4)**. The station is about 0.6 km away from the Badhwar Park Station.

Catchment area of the station comprises major Public & Semi-Public areas including Vidhan Bhawan, Mantralaya along with residential areas like Madhuban Apartments, etc.

5.2.4 Churchgate Metro (Chainage 2285m)

Churchgate Metro station is the fourth station planned on the Jamshedji Tata Road ; located on the central verge along 21 m wide road **(Figure 5.5)**. The station is located on the southern side of the existing Churchgate suburban railway station. The station is about 0.69 km away from the Vidhan Bhavan Station. It would be an important interchange station, having passenger interchanges between existing Suburban station and proposed Metro station. Entry and exit stairs are planned in such a way that it gets integrated with the existing infrastructure like Subway and Bus Stops.

Catchment area of the station would includes the CBD of Nariman Point, Fort area, southern suburb of Colaba, sports stadiums as well as major tourist spots such as Gateway of India and Marine Drive.

5.2.5 Hutatma Chowk (Chainage 3102 m)

Hutatma Chowk is the fifth station planned on Dr. Dadabhai Naoroji Road; located on the central verge along 21 m wide wide road **(Figure 5.6).** The station is about 0.82 km away from the Churchgate Metro station. The major roads connecting the station are Sir Pherozeshah Mehta Road and Dr. Dadabhai Naoroji Road .The entry and exit of the station are planned on both sides of the road. Catchment of the station would be an institutional area along with Public & Semi-Public area includes Khadi Gram Udyog Bhawan and Jeevan Udyog.

5.2.6 CSTM Metro (Chainage 3956 m)

CST Metro station is the sixth station planned near the Chhatrapati Shivaji Terminus (Victoria Terminus) along the existing Mahapalika Marg; located on the central verge along 18.5 m wide road **(Figure 5.7).** The station is located on the west side of existing CST suburban railway station. It would be an important interchange station, with passenger interchanges between existing CST Suburban station and proposed Metro station. It is about 0.85 km away from the Hutatma Chowk station. Entry and exit stairs are planned in such a way that it gets integrated with the existing infrastructure like

Subway and Bus Stops. The major landmarks near the station are Chhatrapati Shivaji Terminus, Mumbai Municipal Corporation, Azad Maidan, J.J. College of Architecture. The major roads connecting the station are Mahanagar Palika road, Hornby road and Dadabhai Naoroji road.

Catchment area of the station comprises mainly Public & Semi-Public and mixed landuses.

5.2.7 Kalbadevi (Chainage 4891 m)

Kalbadevi is the seventh station planned on the Jagannath Shankar Seth Road (JSS) and partially along the footpath; located on the central verge along 12 m wide road **(Figure 5.8).** The station is about 0.94 km away from the CST Metro station.

Catchment area of the station comprises residential area along Shamaldas Gandhi road, Chandan Wadi road.

5.2.8 Girgaon (Chainage 5616 m)

Girgaon is the eighth station planned on the Jagannath Shankar Seth Road (JSS); located on the central verge along 12 m wide road **(Figure 5.9).** The station is about 0.73 km away from the Kalbadevi Metro station. The entry and exit of the station are planned on both sides of the road. The major roads connecting the station are Dr. Babasaheb Jaykar Marg and Jagannath Shankar Seth Road.

Catchment area of the station comprises residential area including Girgaon Ekta Housing Society, Karel Wadi, Vaidya Wadi and Kranti Nagar.

5.2.9 Grant Road Metro(Chainage 7156 m)

Grant Road Metro is the ninth station planned on Dr. Lamington Road; located on the central verge along 15 m wide road **(Figure 5.10).** The station is about 1.5 km away from the Girgaon Metro station. The station comes on the east side of Grant Road suburban railway station. The entry and exit of the station are planned on both sides of the road. The major roads connecting the station are Azim Premji Marg, Lamington Road, MS. Ali Road and Grant Road E.

Catchment area of the station has predominantly mixed landuse.

5.2.10 Mumbai Central Metro (Chainage 8067 m)

Mumbai Central Metro is the tenth station planned near the Mumbai Central Bus Depot on Dr. A. Nair Road; located on the central verge along 24 m wide road **(Figure 5.11).** The station is about 0.91 km away from the Grant Road Metro station. The station would be on the east side of Mumbai Central Railway Terminus. The entry and exit of the station are planned on both the sides of the road.

Catchment area of the station comprises Public & Semi-Public along with residential area.

5.2.11 Mahalaxmi Metro (Chainage 9216 m)

Mahalaxmi Metro station is the eleventh station planned on Sane Guruji Marg – one of the connecting arms of Jacob Circle Junction which is a multiple leg junction (7-Rasta Jn.) **(Figure 5.12).** The station comes on the east side of Mahalaxmi suburban railway station. The station is about 1.1 km away from the Mumbai Central Metro station. It would be an important interchange station, with passenger interchanges between existing Mahalaxmi Suburban station, proposed Metro and Monorail systems. The Major landmarks near the station are Mahalaxmi Temple, Haji Ali Dargah, Dhobi ghat and Mahalaxmi Racecourse.

Catchment area of the station comprises commercial Entertainment Media offices and small scale industries. This is a prominent station due to connectivity by seven roads at the junction.

5.2.12 Science Museum (Chainage 10316 m)

Science Museum is the twelveth station planned near Mahalaxmi Racecourse on the E. Moses Road; located on the central verge along 24 m wide road **(Figure 5.13).** The station is about 1.1 km away from Mahalaxmi Metro station.

Catchment area of the station comprises Public & Semi-Public area and recreational area along the E. Moses Road.

5.2.13 Acharya Aatrey Chowk (Chainage 11516 m)

Acharya Aatrey Chowk is the thirteenth station planned on the E. Moses Road; located on the central verge along 20 m wide road **(Figure 5.14)**. The station is about 1.2 km away from the Science Museum Metro station.

Catchment area of the station comprises commercial as well as residential areas such as Bheem Nagar along the E. Moses Road.

5.2.14 Worli (Chainage 12924 m)

Worli is the forteenth station planned on the Dr.Annie Besant Road; located on the central verge along 25 m wide road **(Figure 5.15)**. The station is about 1.41 km away from the Acharya Atrey Chowk Metro station. Catchment area of the station comprises residential area along with public and semi-public areas.

5.2.15 Siddhi Vinayak (Chainage 14479 m)

Siddhi Vinayak is the fifteenth station planned near the Kakasaheb Gadgil Marg on Nardulla Tank Maidan **(Figure 5.16).** The station is about 1.6 km away from the Worli Metro station.

Catchment area of the station comprises residential along with institutional areas around Sayani Marg, D.R. Marg and Appasaheb Marathe Marg.

5.2.16 Dadar Metro(Chainage 15756 m)

Dadar Metro station is sixteenth station planned on Gokhale Road; located on the central verge along 18 m wide road **(Figure 5.17).** The station is proposed on the west side of existing Dadar suburban railway station across Ranade Marg. S.K. Bole Road is the other major road connecting the station. The station is about 1.3 km away from the Siddhivinayak Metro station.

Catchment area of the station comprises residential, commercial establishments and mixed landuse. The prominent residential areas in the vicinity include Suprabhat Apartment, Louis Apartment, Suyash Society, etc. 'Our lady of Salvation Church', located on the east side of station, is one of the landmarks near the station

5.2.17 Sheetla Devi Temple(Chainage 17156 m)

Sheetla Devi is the seventeenth station planned on the Dharmaveer Sambhaji Raje Marg; located on the central verge along 22 m wide road **(Figure 5.18).** The station is about 1.8 km away from the Dadar Metro station. The station is proposed about 500 m west of existing Mahim suburban railway station.

Catchment area of the station comprises residential area along Dharmaveer Sambhaji Raje Marg. Sheetla Devi Temple is one of the landmarks near the station.

5.2.18 Dharavi (Chainage 19306 m)

Dharavi is the eighteenth station planned partially along the northern edge of Mahim-Sion Link Road **(Figure 5.19).** The station is 1.8 km away from Sheetla Devi station. The entry and exit of the station will be on footpaths on both the sides of the road.

Catchment area of the station would comprise the residential areas along Mahim – Sion Link Road, Dharavi and ONGC Colony and numerous small scale industrial units within Dharavi.

5.2.19 Bandra (Chainage 21225 m)

Bandra Metro station is the ninteenth underground station of the proposed alignment, located in Bandra Kurla Complex near Income Tax Office on the 28 m wide St. Dnyaneshwar Marg **(Figure 5.20).** The station is 1.9 km away from Dharavi station. It is planned as Mid Terminal station for the corridor.

Therefore, this station is planned to have one island and one side platform at 15.118 m below the ground level.

This station would be a major point of interchange between the Metro Line-II i.e. Charkop – Bandra – Mankhurd and proposed Colaba – Bandra - Seepz Metro corridor.

For the ease of interchange, one station entry/exit gate is planned on the main Bandra Kurla Complex Road adjacent to the Bus Stop which is proposed to be integrated with the gate of Metro Line II. The configuration for integration may be planned off at the time detailed design of BKC station, Metro Line II. The remaining two gates are proposed on either side of St. Dnyaneshwar Marg for serving the residential areas of northern side.

The catchment area of the station would comprise many Government Offices like MMRDA, Income Tax Office, Family Court, CMC House, Collector Office, Pay and Account Office, RBI, Stock Exchange etc. and Multinational Companies like IL&FS within Bandra Kurla Complex. It will also serve the residential areas along the Madhusudan Kalelkar Road, N. Dharmadhikari Road, Ramakrishna Paramahansa Road and the slums of St. Dnyaneshwar Nagar.

5.2.20 Kalina University (Chainage 22812m)

Kalina University station would be the twentieth underground station This station is planned for and will serve Kalina University. The station is planned near the back gate of Kalina opposite to Gymnasium Cum Security building **(Figure 5.21).** The station is 1.6 km away from the previous station with an island platform at 15.0 m (minimum) below the ground level. The entry and exit of the station will be on both the sides of the road.

5.2.21 Santacruz (Chainage 24027 m)

Santacruz station is an underground station planned to the east of Western Expressway flyover, partially on the service road and partially on the Expressway **(Figure 5.22)**. The station is 1.2 km away from the Kalina station.

Entry and exit stairs are planned in such a way that it gets integrated with the existing infrastructure like Subway, Skywalk and Bus Stops. The station would be a major point of interchange between the Mumbai Suburban Western Railway and proposed MRTS. To connect the both, one station entry/exit gate is proposed to be on the footpath near Hotel Regency near the Skywalk leg on the west of Expressway. Passengers can directly take the skywalk to reach Santacruz Suburban Railway Station. The other gate is proposed near the Hanuman Temple, integrating it with the existing BEST Bus Stop on the Western Side of the Expressway. For providing the access to the east of Western Expressway, one station entry/exit gate is proposed on the footpath near the Bus Stop and the fourth gate is proposed across the Jawaharlal Nehru Road near the Police Chowki and Subway entry/exit gate.

The catchment area of the station comprises residential and commercial establishments of Station Road and Jawaharlal Nehru Road, Vakola. The influence area of this station would extend upto Hotel Hyatt to the east and Suburban Railway to the west.

5.2.22 Domestic Airport (Chainage 26299 m)

Domestic Airport station is the twenty-second station in Mumbai Airport Authority's premises. The station is 2.3 km away from Santacruz Metro station. The underground Domestic Airport Station is planned for the passengers of Domestic Airport. It is located diagonal to the elevated road of Domestic Terminal 1 A below the existing Parking lot **(Figure 5.23).**

As per the decision of the MMRC, the design of the station along with the utility planning shall be done by the Airport Authority (MIAL) as per their Airport Master Plan.

5.2.23 Sahar Road (Chainage 27906 m)

Sahar Road Station is the twenty-third underground station primarily planned for the Airport Authority. The station is 1.6 km away from Domestic Airport Metro station. As per Airport Master Plan, Airport authority has envisaged huge industrial base within the Airport Authority Area connecting to Sahar Road and I. A. Project Road **(Figure 5.24).** Apart from this envisaged industrial hub, Sahar Road Station will be catering to the residential areas along the Sahar Road and Marol Pipeline Road.

5.2.24 International Airport (Chainage 28958 m)

International Airport Station is the twenty-fourth station also planned primarily for the passengers coming to the International Airport **(Figure 5.25).** The station is 1 km away from Sahar Road Metro station. It is located parallel to the I. A. Project Road near the existing parking lot . Airport Master Plan has proposed the international terminal to be extended upto the existing parking level. The MRTS station is planned to be parallel to the proposed terminal building approximately 100 metres in distance.

The station will also be accessible to the surrounding hotels like Hotel Hyatt, The Grand Maratha and The Lalit – Intercontinental.

5.2.25 Marol Naka (Chainage 29829 m)

Marol Naka is the twenty-fifth station which will have passenger interchange with the Metro Line-I i.e. Versova – Andheri – Ghatkopar. The station is proposed perpendicular to Metro Line-I beneath the existing slums of Chinmatpada **(Figure 5.26).** The interstation distance from previous International Terminal Station is 0.870 km with island platforms approximately 15.400 meter below the ground level and station box of 26 meter width and 300 meter length.

One station entry is planned on 46 meter wide Andheri-Kurla Road in integration with the entry/ exit gates of Metro Line-I near Kirpaney Associates Ltd. Remaining two gates are proposed in the centre of the station, considering the potential of area redevelopment. For integration with the Line I, a subway is proposed from the concourse level which will directly connect to the entry/exit gate.

The catchment area of this station comprise the commercial (Offices, Banks, hotels etc.) establishments on the Andheri-Kurla Road, Sahar Airport Marol Naka Road, Marol Maroshi Road and Makwana Road and the residential areas of Mapkhan Nagar and Chimatpada Hutment.

5.2.26 MIDC (Chainage 31225 m)

MIDC is the twenty-sixth station. The station is 1.4 km away from Marol Naka Metro station. The station is planned on Road no. 7 beneath the Vikhroli Village Hutment area **(Figure 5.27).** The major road connecting the station is Krantiveer Akhuji Salve Marg.

The catchment area of the station comprises residential areas such as Senior Police Colony, Sai Nagar Society along with many commercial establishments. It also includes Vikhroli Village Hutment area.

5.2.27 SEEPZ (Chainage 32546 m)

SEEPZ is the last station planned beneath the 26 m wide Krantiveer Lakhuji Salve Marg near WPRC building **(Figure 5.28).** It is planned to serve the large employment sector catered by the Special Economic Zone of Mumbai i.e. SEEPZ

(Santacruz Electronics Export Processing Zone). SEEPZ is a house of several Software Companies and Jewellery Exporters, expanded over 100 acres of land.

The station is planned near the SEEPZ Bus Stand and Taxi stand for better passenger interchange. The interstation distance from previous MIDC Station is 1.4 km with an island platform approximately 15.0 meter below the ground level. The entry and exit gates are proposed on either sides of the road.

The catchment area of this station comprises the Residential and Institutional areas along the Krantiveer Lakhuji Salve Marg, Road No. 23, Sunder Nagar (Slum) and Mahakali Caves.

Figure 5.2: Location of Colaba/ Cuffe Parade Station and its surroundings

Figure 5.3: Location of Badhwar Park Station and its surroundings

Figure 5.4: Location of Vidhan Bhavan Station and its surroundings

Figure 5.5: Location of Churchgate Metro Station and its surroundings

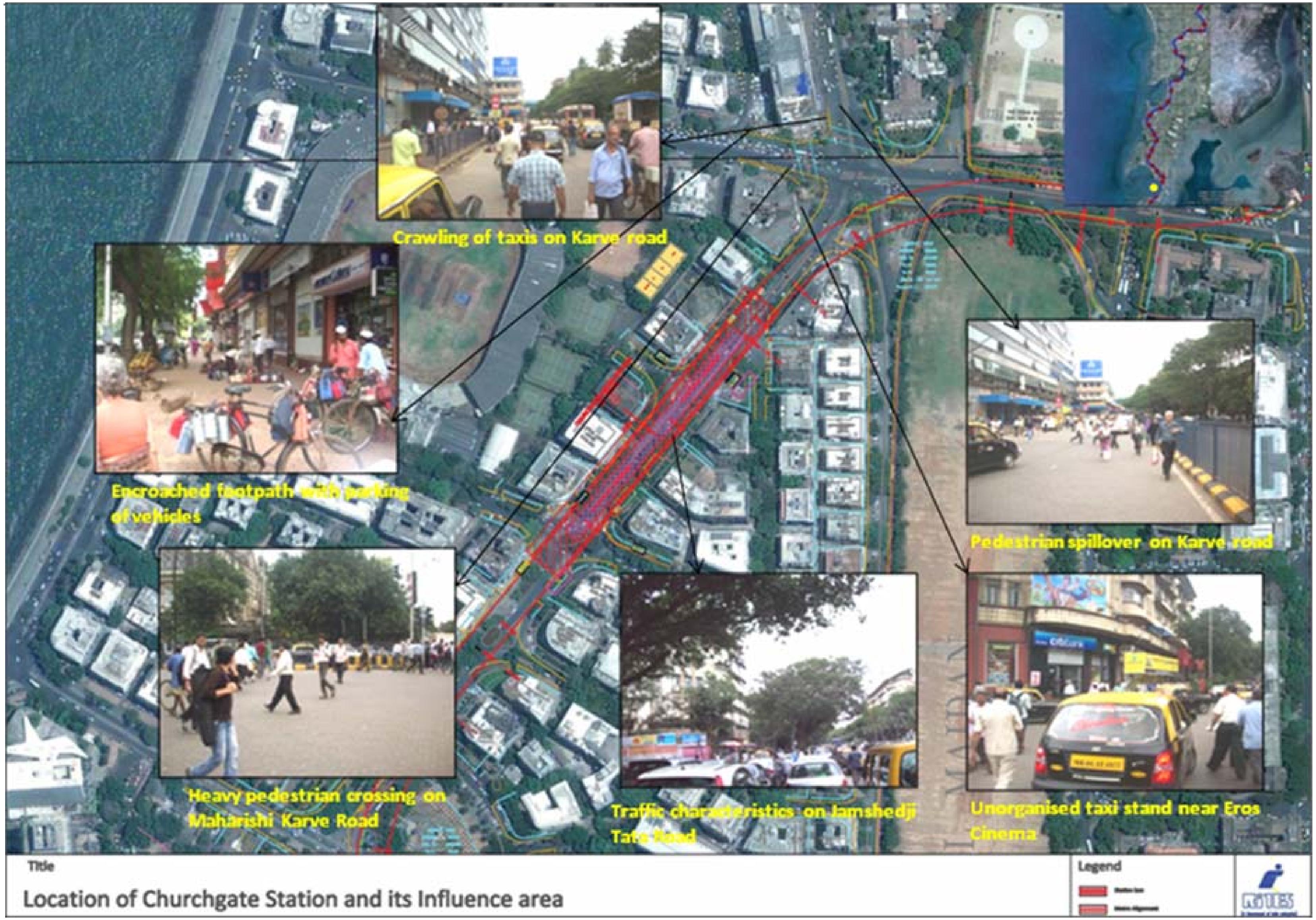


Figure 5.6: Location of Hutatma Chowk Station and its surroundings

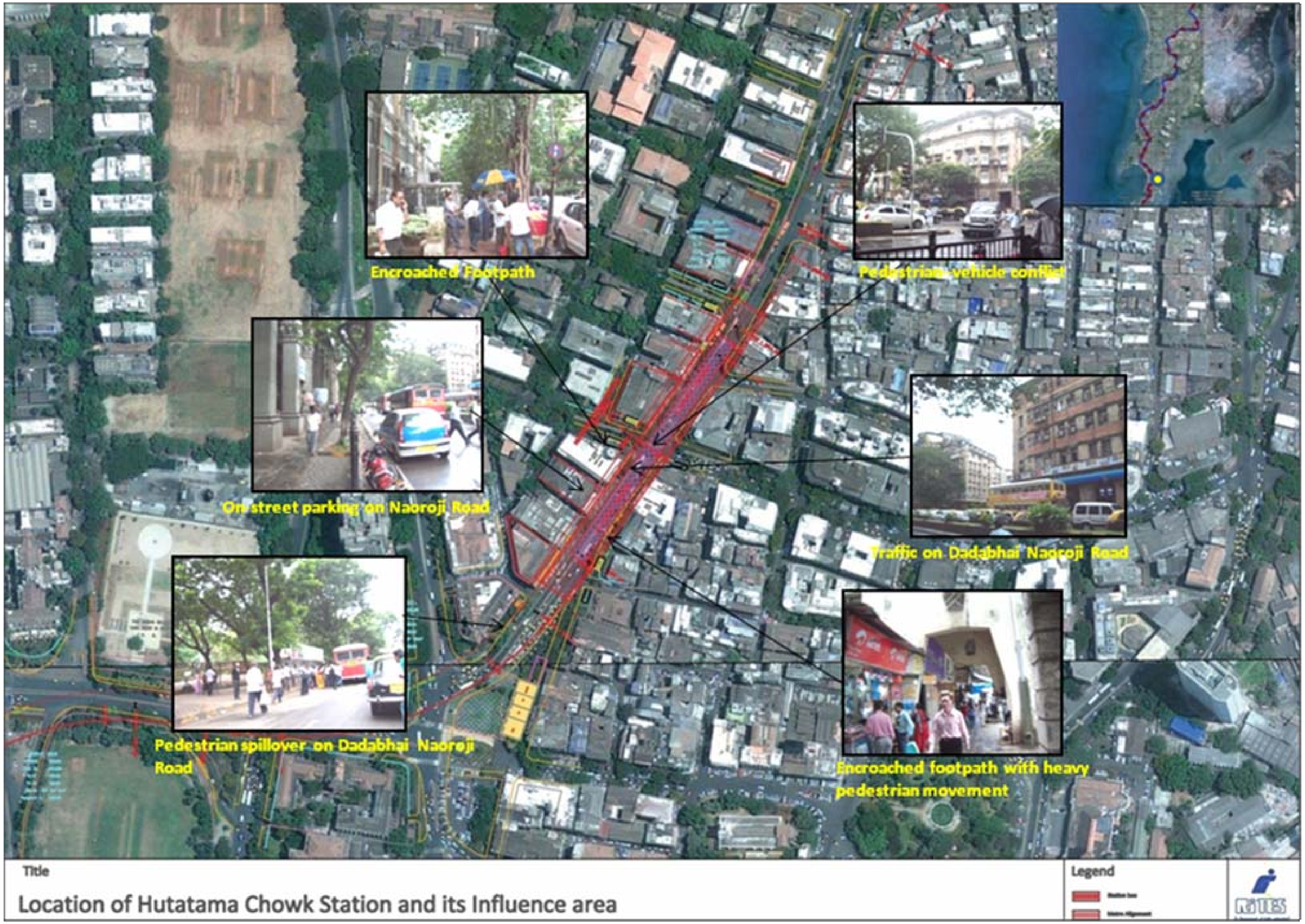


Figure 5.7: Location of CSTM Metro Station and its surroundings

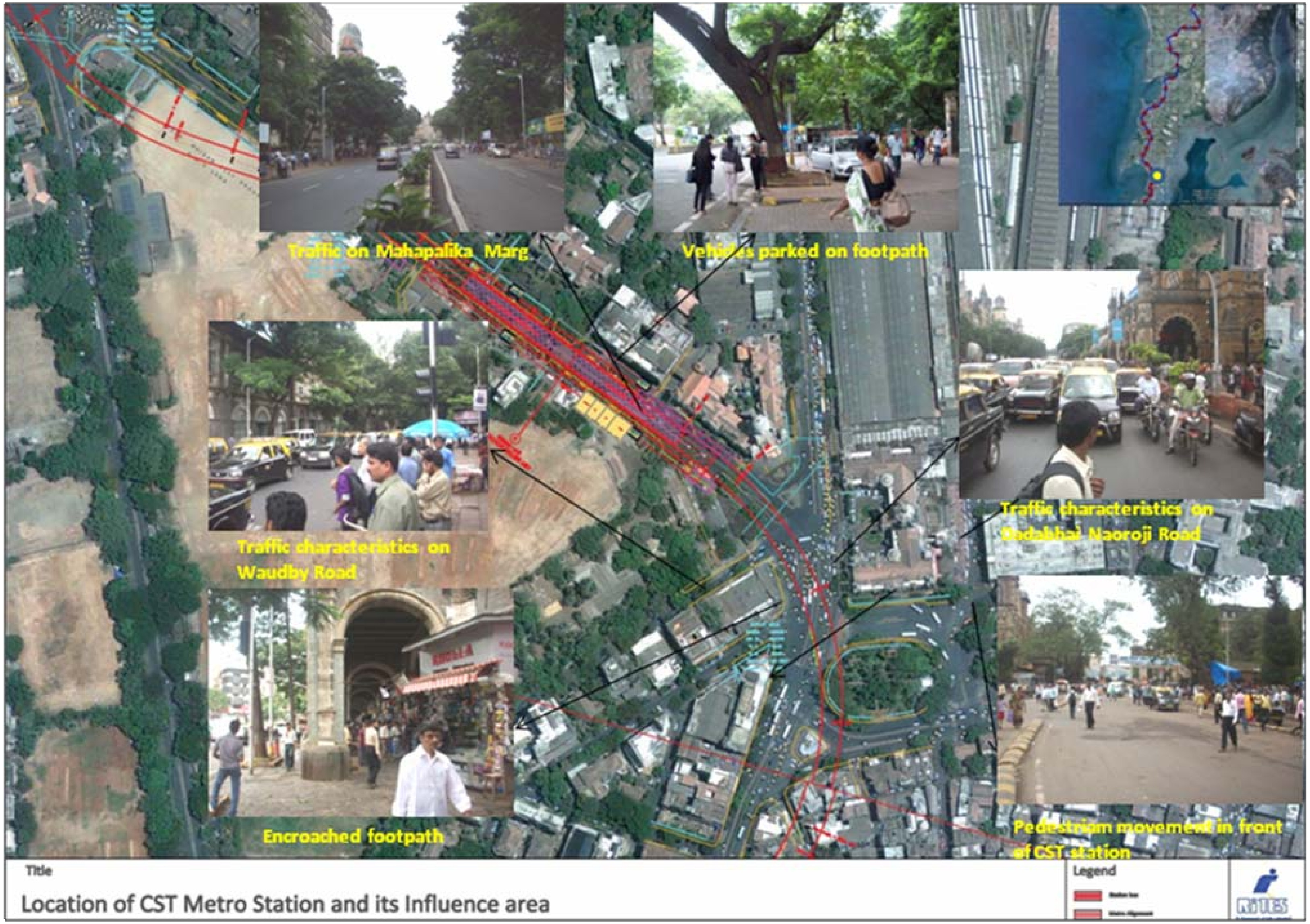


Figure 5.8: Location of Kalbadevi Station and its surroundings

Figure 5.9: Location of Girgaon Station and its surroundings

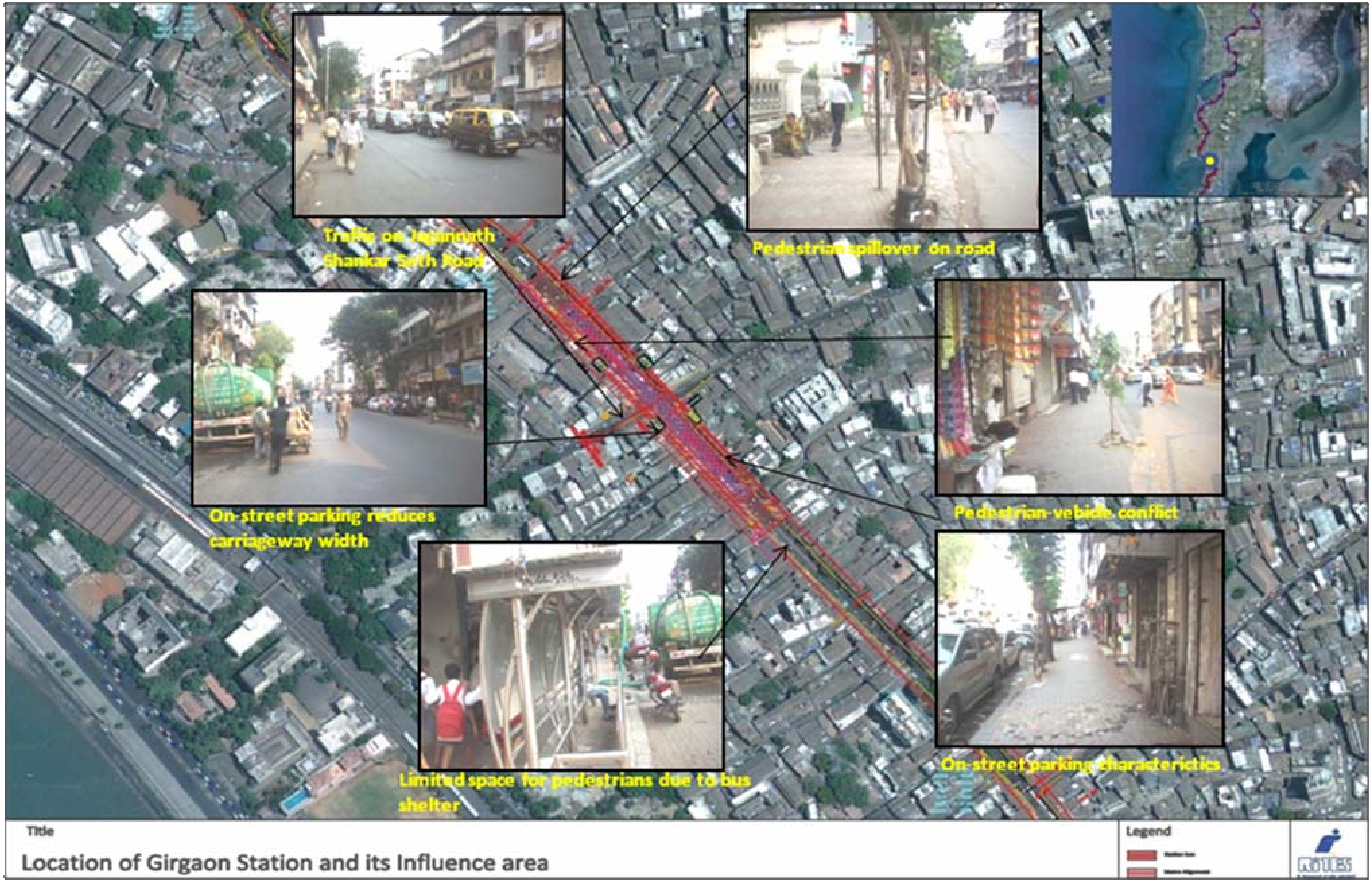


Figure 5.10: Location of Grant Road Metro Station and its surroundings

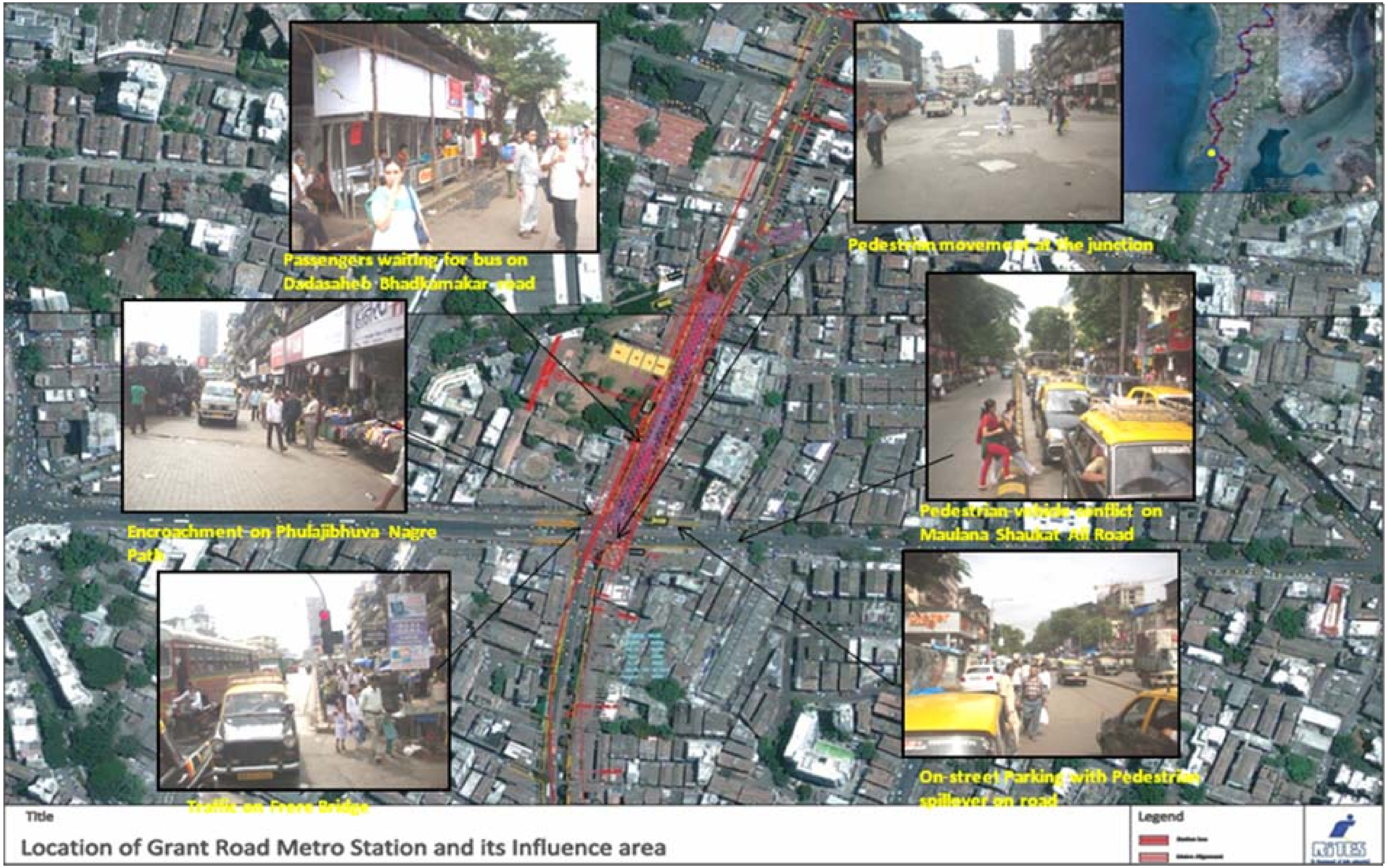


Figure 5.11: Location of Mumbai Central Metro Station and its surroundings

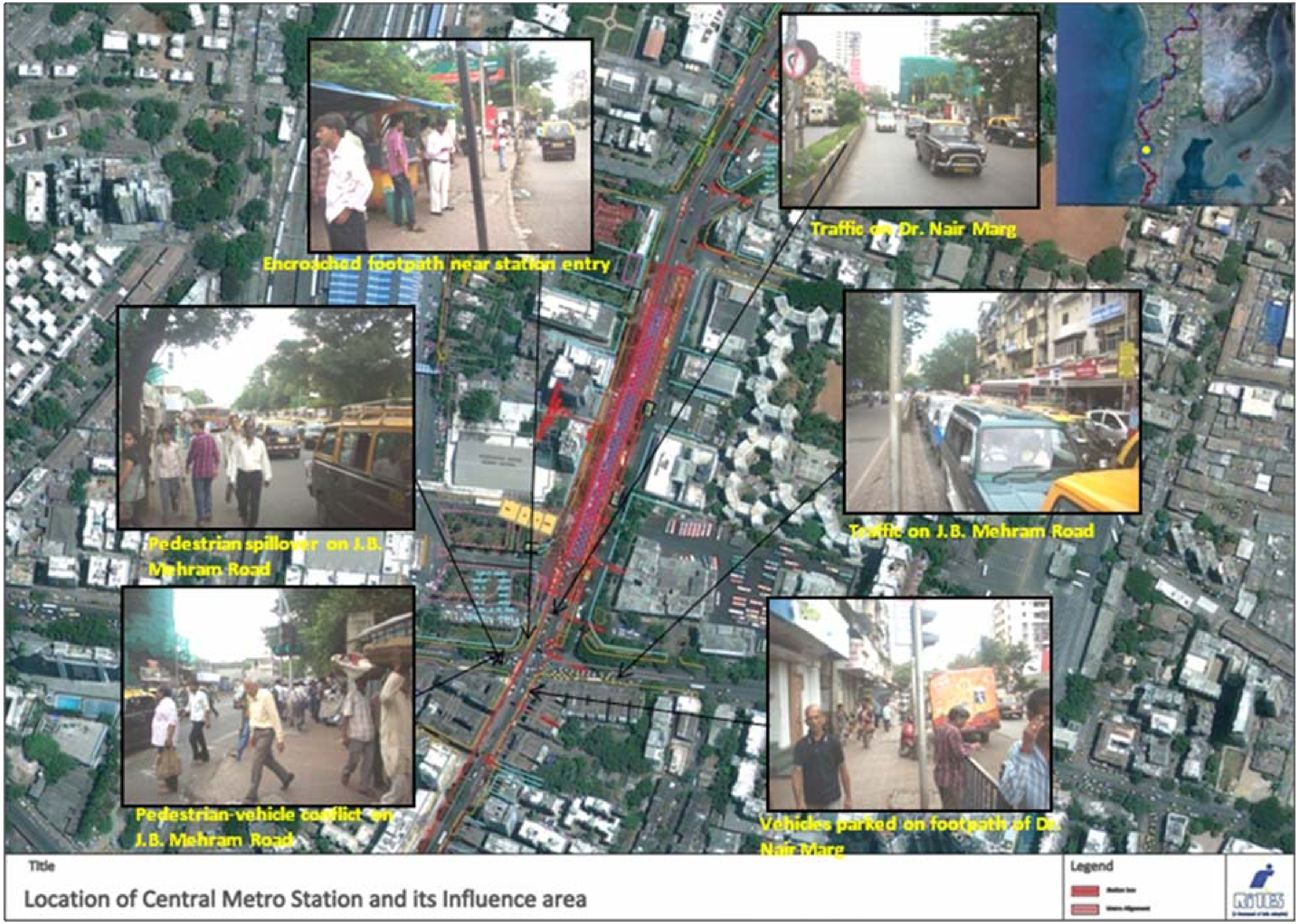


Figure 5.12: Location of Mahalaxmi Metro Station and its surroundings

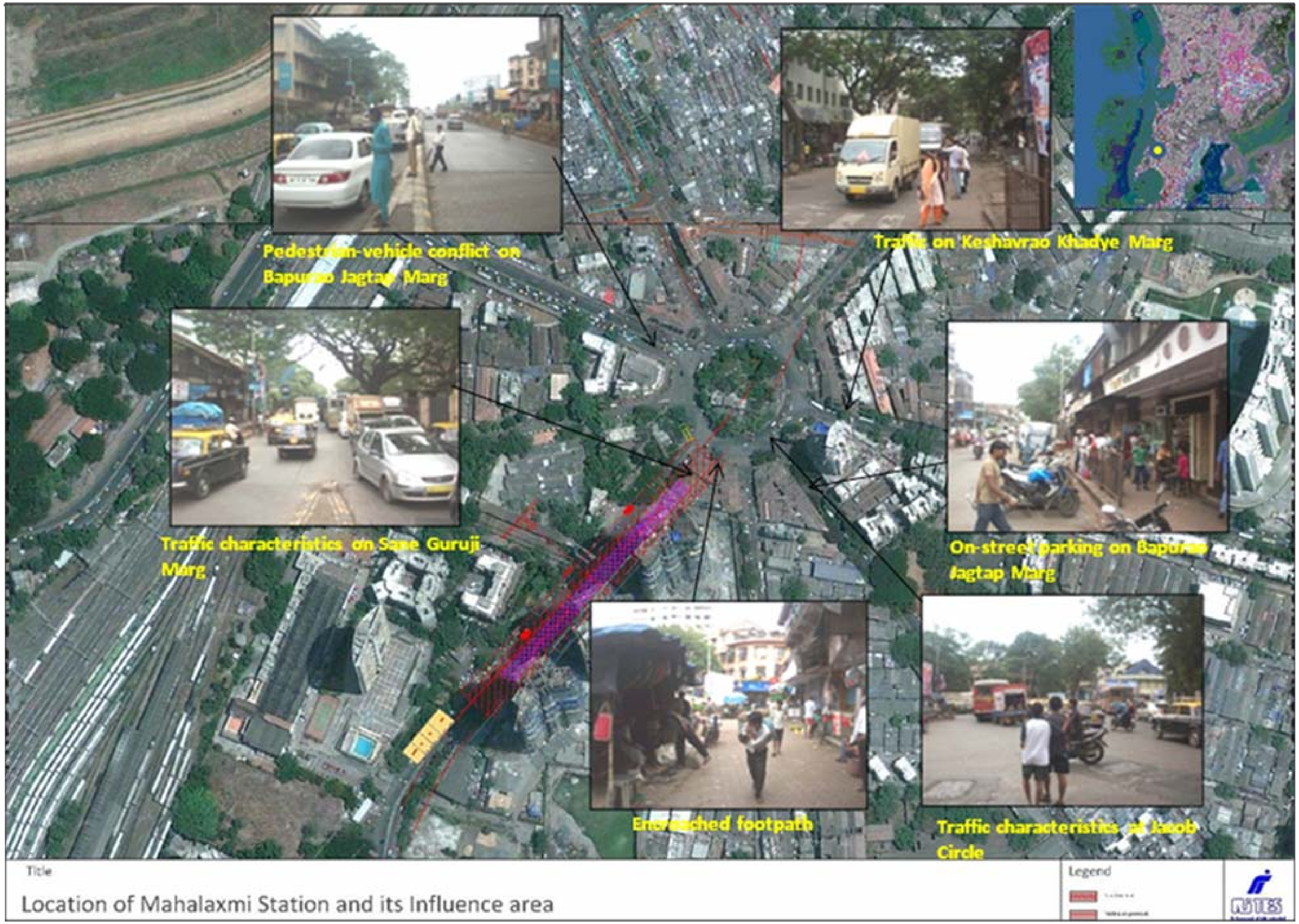


Figure 5.13: Location of Science Museum Station and its surroundings

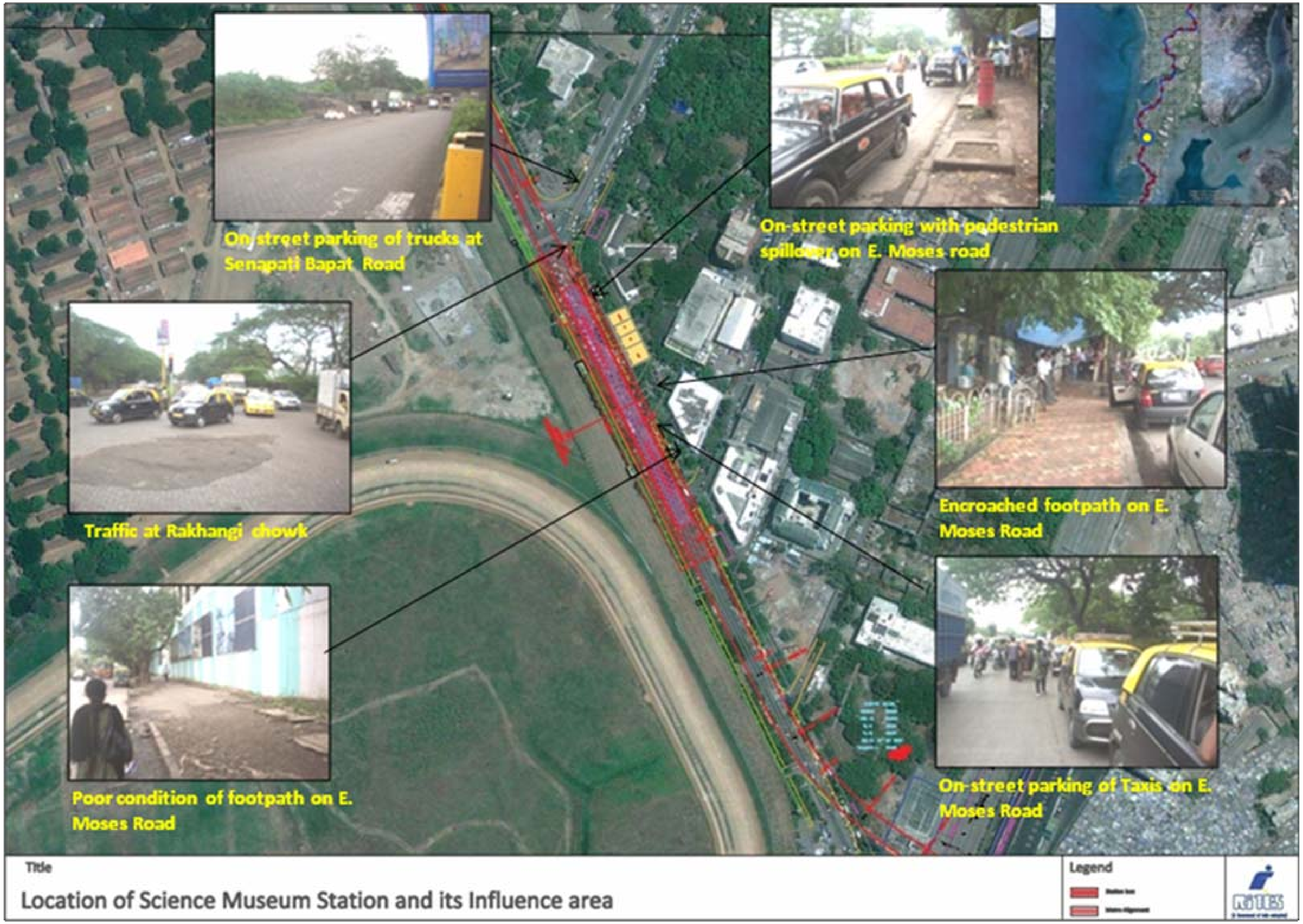


Figure 5.14: Location of Acharya Atrey ChowkStation and its surroundings

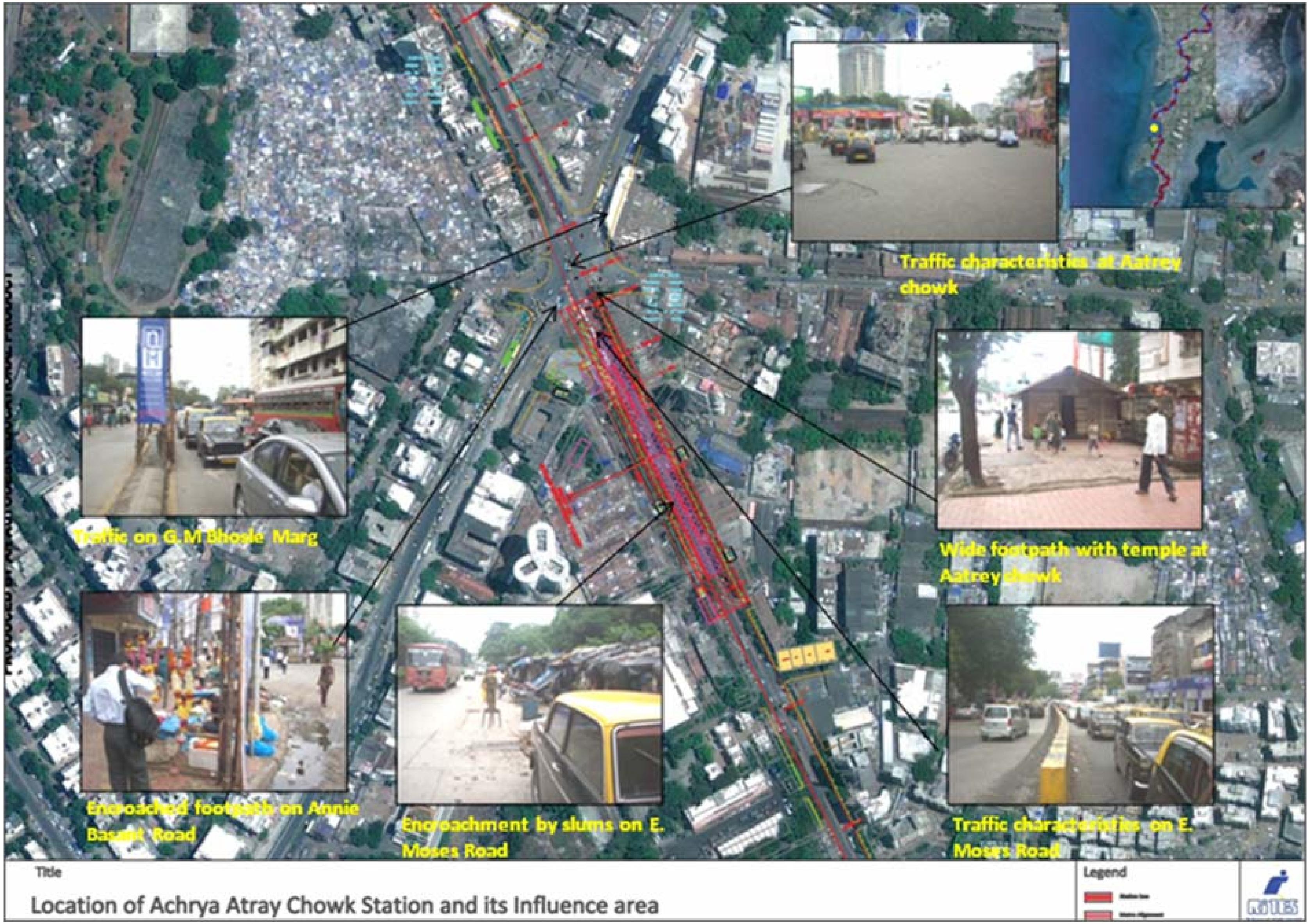


Figure 5.15: Location of Worli Station and its surroundings

Figure 5.16: Location of Siddhi Vinayak Station and its surroundings

Figure 5.17: Location of Dadar Metro Station and its surroundings

Figure 5.18: Location of Sheetla Devi Temple Station and its surroundings

Figure 5.19: Location of Dharavi Station and its surroundings

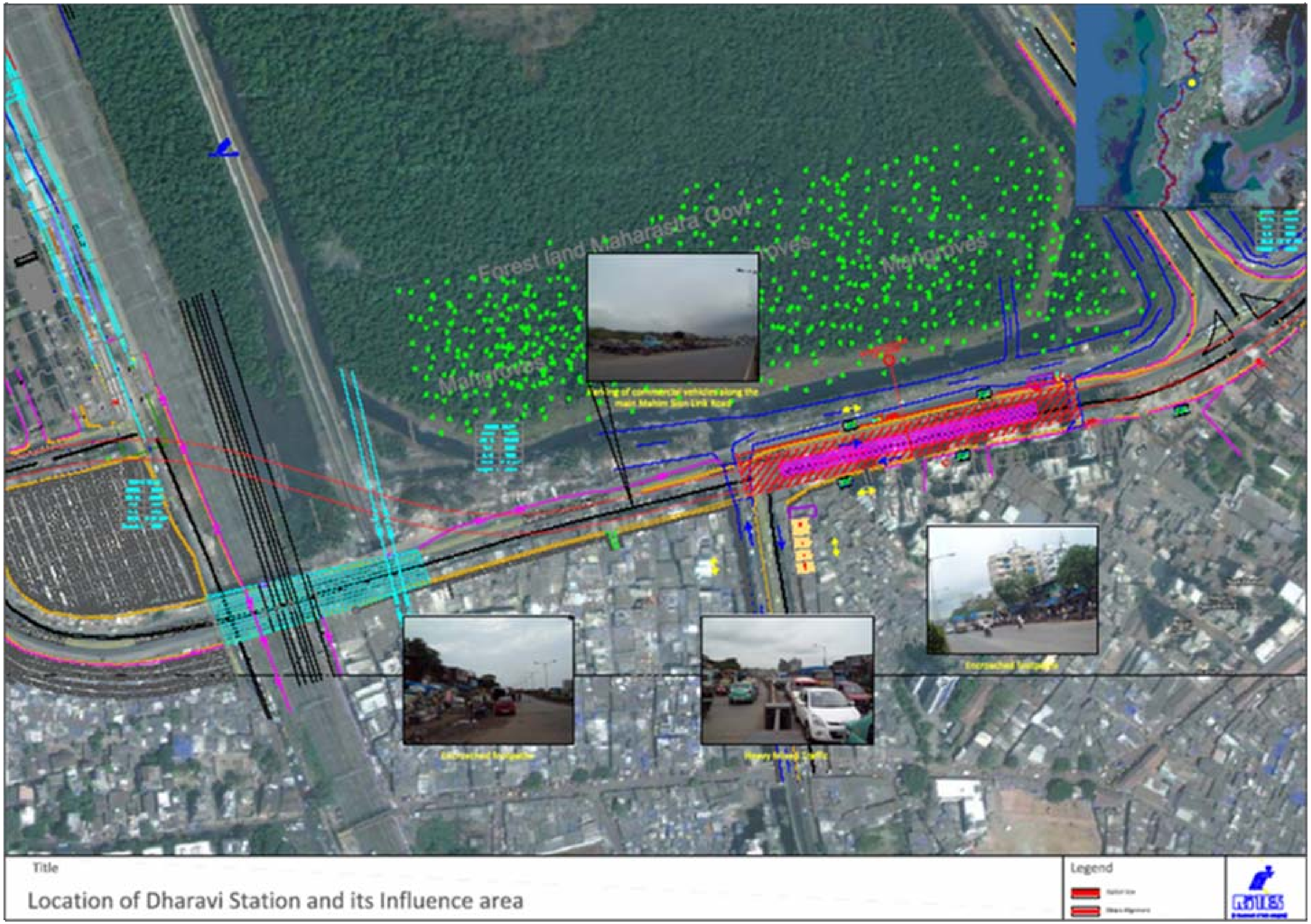


Figure 5.20: Location of Bandra Station and its surroundings

Figure 5.21: Location of Kalina Station and its surroundings

Figure 5.22: Location of Santacruz Station and its surroundings

Figure 5.23: Location of Domestic Airport Station and its surroundings

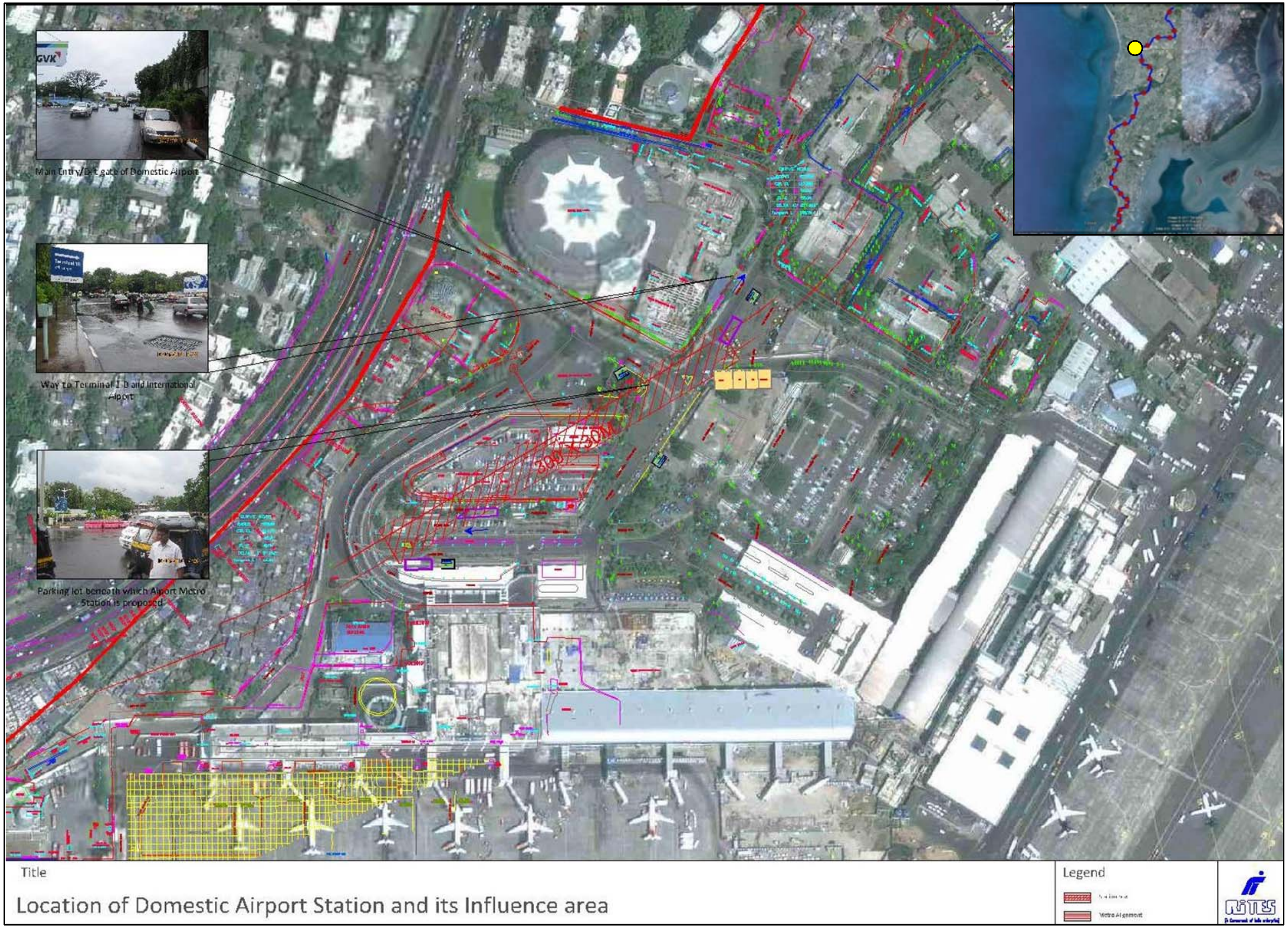


Figure 5.24: Location of Sahar Road Station and its surroundings

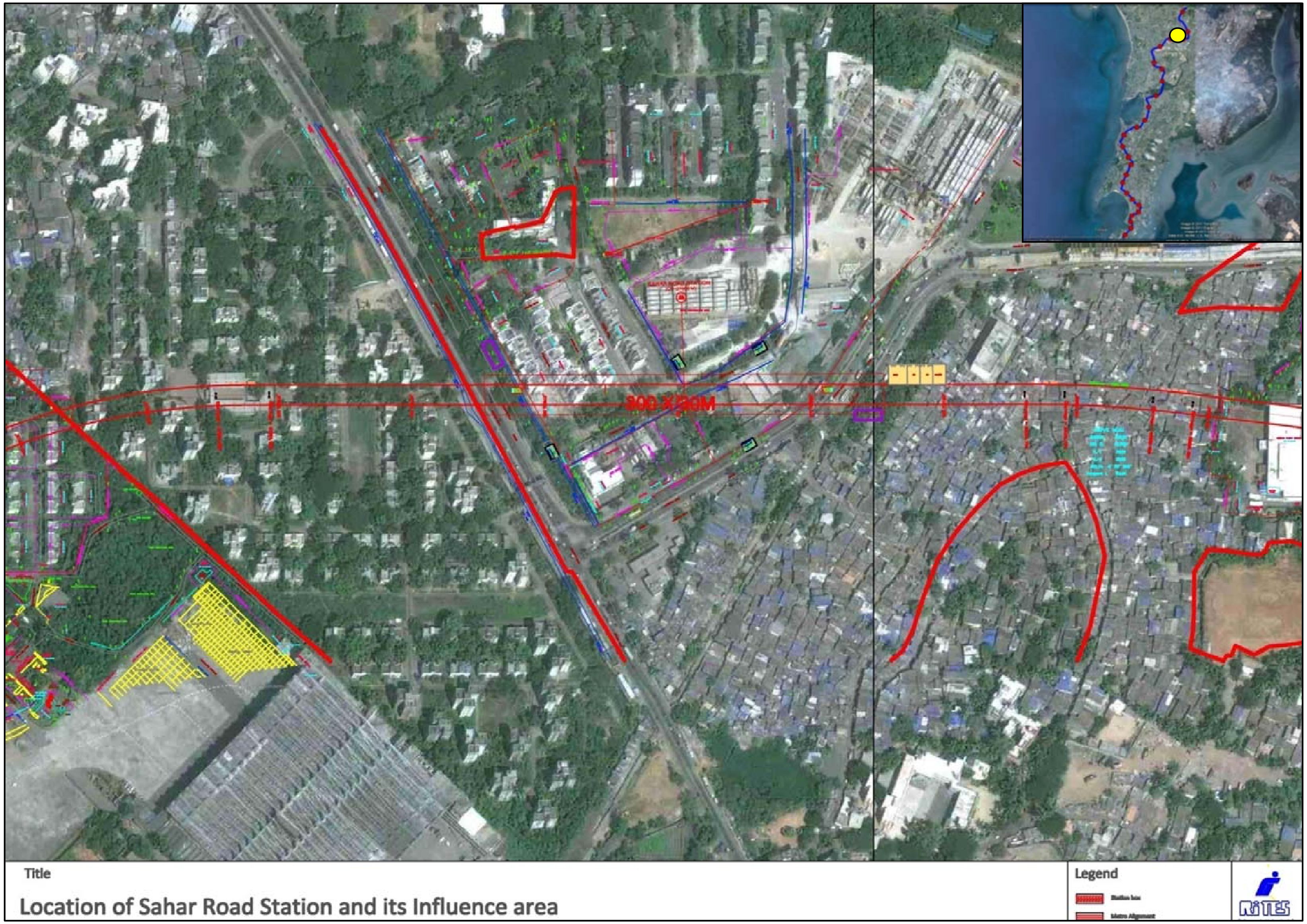


Figure 5.25: Location of International Airport Station and its surroundings

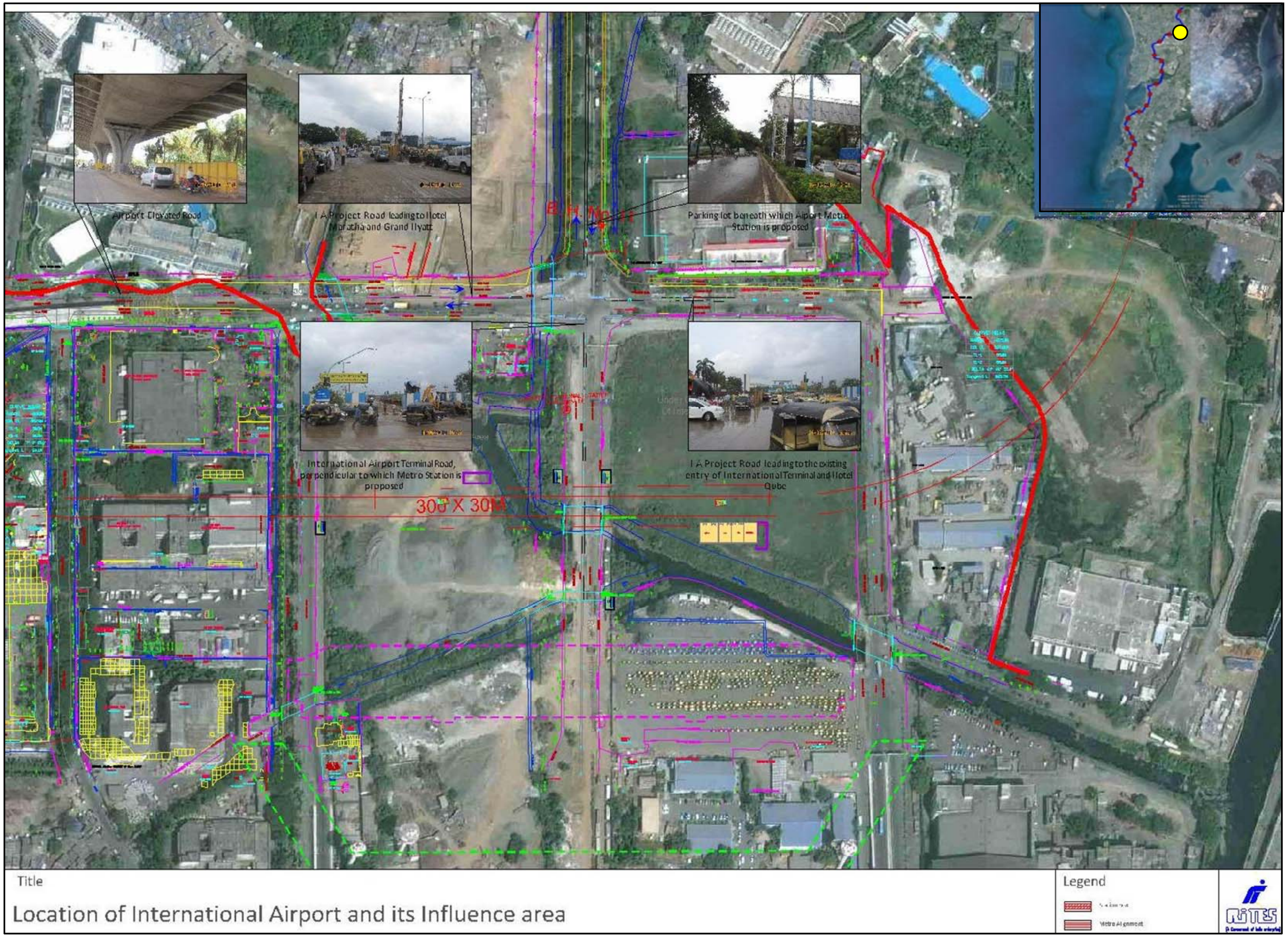


Figure 5.26: Location of Marol Naka Station and its surroundings

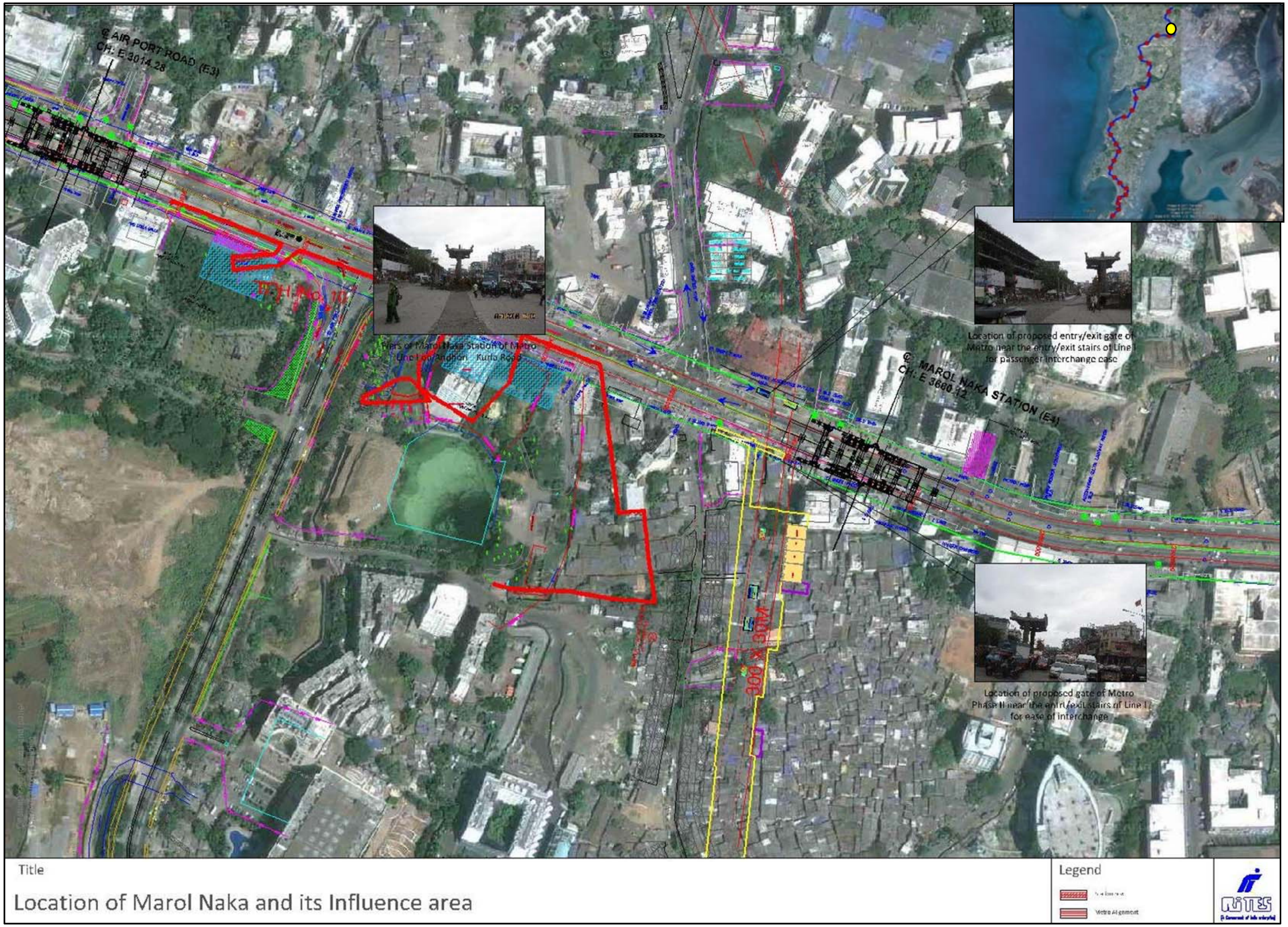


Figure 5.27: Location of MIDC Station and its surroundings

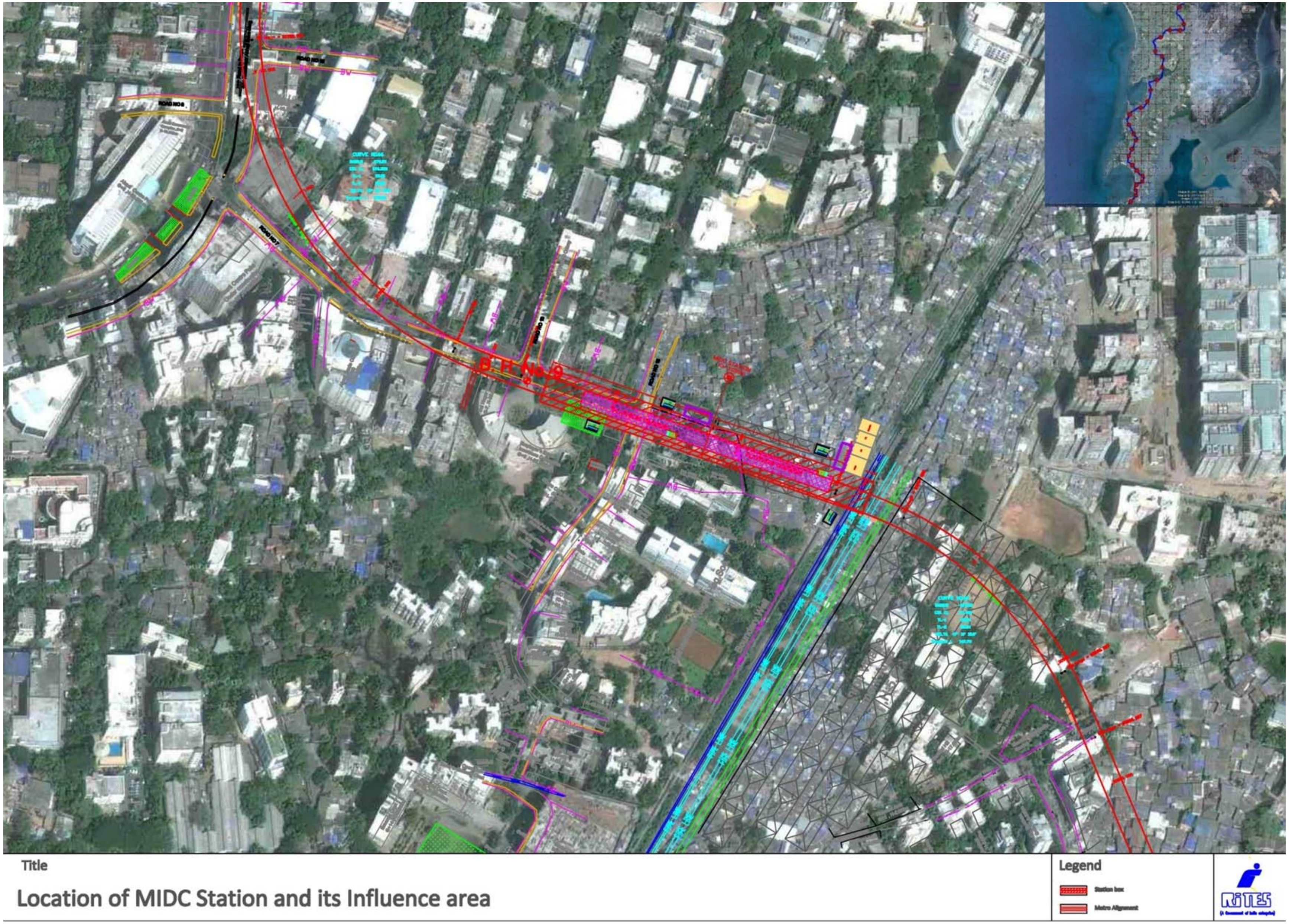


Figure 5.28: Location of SEEPZ Station and its surroundings

5.3 STATION PLANNING AND DESIGN

5.3.1 Introduction

The design of the Stations will respond to and be determined by the following factors:

- Operational requirements in the use of Centre and Side platforms: the Underground stations are planned around island platforms.
- Station Boarding/Alighting and the resulting entrance location requirements
- Utilities such as fire fighting systems, ventilation, water requirements etc
- Structural Requirements
- Flexibility in design to allow stations to respond to site specific requirements
- Future expansion

The essential quality in a satisfactory station layout is the provision of adequate space for efficient movement of passengers between ground level entrances on to the trains and vice versa in the most direct simple and logical way.

5.3.2 Salient Features of a Typical Station

a. Station entrances provide the link between the station concourse and the surrounding streets and their location must reflect the separate constraints of both. Station entrances are located with particular reference to passenger catchment points and also cater for inter modal interchange which may include bus transfer, taxi, motorcycle and bicycle transfer, drop off/pick up and park and ride facilities.

b. Important criteria that have been applied in the development of Station Planning and designs include:
    - Sizing of Station Passenger facilities
    - Stipulated Design standards
    - Emergency Evacuation
    - Passenger circulation, comfort, ease of use, safety and security
    - Operational accommodation (Back of House Areas)
    - Electrical and mechanical plant and Equipment space requirements

c. Concourse forms the interface between streets and the platform. This is where all the passenger amenities are provided.

d. Office accommodation, operational areas and plant room space is required in the non-public areas at each station.

e. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognised abnormal scenario (emergency).

f. The location of DG set, Bore Well pump houses, Ground tank/Overhead tank and Ground tank pump houses should preferably be located in one area on ground wherever possible.

5.3.3 Planning Norms & Standards

i. General

a. Station Design is dependent on the peak hour traffic load for each station on the corridor. The horizon year of the Study is taken as 2031, when a maximum PHPDT of about 42,000 is expected to be achieved, However, the system is being designed for a maximum PHPDT of 45,000 – considering the growth in traffic demand beyond 2031. Accordingly, a traffic correction coefficient of 1.2 is assumed in the Station Design calculations to cater to ultimate Peak Hour scenario. However, maximum capacity required at any station for emergency evacuation has been adopted.

b. Station Design is planned assuming a train operation frequency of 2 minutes 30 seconds in 2031. The station layout accommodates the worst case scenario at each station.

c. The maximum cars/train proposed by the year 2031 on the corridor is 6. However, the platform length is planned with the capacity of 8 cars/train.

d. The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the next level does not exceed 4.5 minutes (as per NFPA 130)

e. The Station Design is in compliance to the "Guidelines and space Standards for barrier Free Built Environment for Disabled and Elderly persons" published by the Ministry of Urban Affairs and Employment India in 1998. The principles outlined in this document are incorporated into the design of the stations.

ii. Entry/Exit

a. Entrances to stations have adequate capacity to satisfy predicted passenger flows and emergency evacuation requirement.

b. The position of entrances is determined by the juxtaposition of building location of roadways footpaths width, space availability and flow directions of passenger traffic.

c. The widths of entrances take into account the predicted passenger flows and available space.

d. All entrances extending to street level are protected against flooding. This protection is done by the provision of a minimum of 3 steps up to a landing (+450 mm minimum)

iii. Walkways/Ramps

a. Walkways/ramps are planned based on established principles of pedestrian flow and arranged to minimise unnecessary walking distances and cross-flows between incoming and outgoing passengers. Cross flows and changes in direction are minimized or eliminated.

b. Minimum Corridor width

- Unidirectional movement: 1.8 m
- Bi-directional movement: 2.0 m
- Where length of the corridor is more than 30 m: 3.0 m
- For staff: 1.2 m

c. Ramps

- Preferred gradient: 1:20
- Maximum gradient: 1:12
- Minimum width:
  - Unidirectional movement: 1.2 m
  - Bi-directional movement: 1.5 m
- For ramp exceeding 10 m, rest platform: 1.8m long

iv. Concourse Design Standards

a. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the AFCs.

b. Concourse consists of “Non Public Areas” and “Public Areas”. The “Non Public Areas” comprise of the Back of House (BOH) areas. The BOH areas consists of PST, System Rooms, Operations, Staff Facilities, Tunnel Ventilation System, Station ventilation System, Water Supply and Drainage System and Miscellaneous requirements. A list of BOH areas is given below in **Table 5.3**. The description of such areas is also detailed in the subsequent paragraphs.

c. The “Public Area” is further subdivided into “Paid” and “Unpaid Areas”. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the “paid area”, which includes access to the platforms.

d. Passenger handling facilities comprise of stairs/escalators, lifts, ticketing counters/automatic ticket vending machines and ticket gates required to process the peak traffic from street to platform and vice-versa. These facilities are provided in the concourse and they also act as a medium to transfer between Paid and Unpaid areas (these facilities also enable evacuation of the station under emergency conditions, within a set safe time limit).

e. Uniform number of these facilities has been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station based on the peak hour passenger load.

Table 5.3: Station Accommodation

PST (POWER SUPPLY & TRACTION)	**STAFF FACILITIES**
Auxillary substation	Staff toilets/ locker (male)
Track disconnection switch	Staff toilets/ locker (female)
Dg set	First aid
Fuel tank	Staff mess room
	Train crew room
SYSTEM ROOMS	**TUNNEL VENTILATION SYSTEM**
SIGNALLING	Tunnel ventilation plant room-1
Signalling Equipment Room (SER)	Tunnel ventilation plant room-2
Ups room (signalling)	ECS plant room-1
TELECOMMUNICATION	ECS plant room-2
TER	
Mobile phone equipment room	
Ups room (telecom)	
OPERATIONS	**STATION VENTILATION SYSTEM**
Station control room (SCR)	Chiller plant
Station manager	Cooling tower
Ticket office/ticketing	Staircase Pressurization
Ticket office supervisor	
Audit and cash storage	
TVM/ BOMS	
Security/ police room	
Excess fare office (EFO)	
MISCELLANEOUS	**WATER SUPPLY & DRAINAGE SYSTEM**
Emergency equipment room	Sewage pump room
Cleaners room-1	Seepage pump room-1
Cleaners room-2	Seepage pump room-2
Refuse store	Smoke extraction fan room
Permanent Way Store	

f. Operational rooms (BOH Areas)

<u>Operation Rooms for Public Use</u>

Ticketing Gates

a. The requirement of the number of gates is based on the peak hour passenger traffic at the station.
b. Ticketing gates' requirement has been calculated taking the gate capacity as 28 persons per minute per gate (80% of the Maximum Practical Capacity which is assumed as 35 persons per minute per gate). At least two ticketing gates will be provided at any station even if the design requirement is satisfied with only one gate. Uniform

space has been provided at all stations where gates can be installed as and when required.

c. The total number of gates also includes one more gate in case of breakdown.

d. The gate design will depend upon;
   - Check in and check out (distance fare): implying bi-directional gates
   - Fare media: smart card, magnetic or paper ticket.

e. The most popular gates are with sliding glass panels ("pavel" design): as shown in the photograph below

f. Special gates are designed for;
   - Disabled persons access,
   - Customers with luggage,
   - Customers with strollers

Elevated BTS AFC gates – Bangkok

Ticket Counters and Ticket Vending Machines (TVMs)

a. It is proposed to deploy manual ticket issuing counters in the beginning of the operation of the line. At a later stage, automatic TVMs would be used, for which space provision will be made at the concourse. At present, ticket counters would be provided, which would be replaced with TVMs in future. Capacity of manual ticket vending counters is assumed as 5 passengers per minute and it is assumed that only 20% of the commuters would purchase tickets at the stations while performing the journey. The rest are expected to buy prepaid tickets, prepaid card, smart card etc. About 10% of the Smart card users will use the Ticket window for renewal/recharging etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

b. The number of TVMs required is governed by the peak hour passenger traffic, the fare policy and the ticketing. Depending on the composition of monthly pass/smart card users and single ticket users, the number of TVMs could change. As a general thumb rule, it is proposed to provide 7 to 10 TVMs for stations with high traffic and 2 to 5 TVMs for other stations.

MTR Wall mounted TVM with maintenance corridor in the back – Hong Kong

Shinjuku Station Tokyo

Ticket Office

a. The number of Ticket Offices is determined by the passenger traffic and the operation policy.
b. It is recommended to plan for a minimum of 2 ticket office per station in the stations with high traffic, and a minimum of 1 ticket office per station in the stations with low traffic

First aid room

First aid room isn't a specific operation room but will be located in every station in accordance with the technical provisions of the project. This room could also be used as a detention room if it is needed.

Passenger amenities

Toilets for disabled are not specific operation rooms but will be provided at all stations in accordance with the technical provisions of the project.

<u>Operation Rooms for Staff Use Only</u>

Safe deposit
In each station, a safe deposit room located next to the main ticket office is provided.

This room has to be near the Ticket Office and TVM back-store, with restricted and monitored access, and shall be directly connected with it in the operation area, in order to avoid money transfer to be visible to the public. It should also be close to the station master's Control Room for management reasons.

Male and female locker and rest rooms
These rooms shall be close to the staff operation areas. Males & females shall have separate access, in the non public operation area. The area of these rooms will depend on the number of employees in each station.

Male and female staff toilet
It is recommended to fit the stations with specific toilets for the employees. Separate male and female toilets shall be provided in each station.

<u>Operation Rooms in Terminal Stations or Intermediate Terminal Station</u>

Train driver rooms
In case of start and shut down operation directly in terminals with stabled trains during the night, train driver rooms are required. These rooms are preferably located at the platform level and include:

- Train drivers dispatch office,
- Training room / emergency room,
- Operation storage room,
- Male and female locker rooms separated,
- Restrooms

The train drivers dispatch office is a specific room allowing conductors to sign on/sign off and to be informed of new instructions and special orders. The room should be located next to the Operation supervisor Office.

Lost and Found room
Management of Lost and Found items will be centralized in a specific station for the entire network. The lost and found room will be located into the public area at a Terminal/Mid Terminal Station (Mahim and BKC station in this case). The lost and found location will require a public zone and a restricted room dedicated to lost objects.

g. Passenger Handling Facilities
<u>Escalator Requirements</u>

Standards, Codes and Regulations

The following regulations and standards shall form the basis for the design of escalator system.

- American National Standard Institute (ANSI)
- American Society of testing Materials (ASTM)
- International Electro technical Commissions (IEC)
- Indian Standard (IS)
- European Norm (EN)
- National Electrical manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriter's Laboratories, Inc. (UL)

Design Criteria

The escalators will be heavy duty "public" service escalators capable of operating safely, smoothly and continuously in either direction, for a period of not less than 20 hours per day, seven days per week, (except special holiday which may be operated 24 hours a day) within the environmental conditions prevailing within the well way and at the location where the escalators are installed. The maximum allowable passenger load of each step should not be less than load equivalent of three 65 kg person per step.

The escalators will be equipped with energy saving system. Speed of escalators will be in the range of 0.6-0.75 m/s for normal operation. The energy saving system will reduce speed of escalators to standby speed mode of 0.20 m/s during low traffic hour.

The number of flat steps at the upper landing should be in proportion to the vertical rise of the escalator. For 6.1 m to 18.3 m rise, minimum four flat steps should be provided and for a rise up to 6.1 m manufacturers' standards should be used (2-3 flat steps)

The design of the escalators which act as emergency stairways should meet all the criteria requirements in NFPA 130.

The design of the escalators will be such that they can be used as fixed staircases under a condition of power failure, activation of stop button, or activation by safety/protection devices. When the escalators are stationed, no slipping, jerking, sliding and vibration should occur.

Escalators will be equipped with protective barriers, where necessary.

Interfacing requirements

The following escalators interface will be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault

- Emergency

Elevator Requirements

Standards, Codes and Regulations

The following regulations and standards will form the basis for the design of elevator system.

- American National Standard Institute (ANSI)
- American Society of testing Materials (ASTM)
- International Electro technical Commissions (IEC)
- Indian Standard (IS)
- European Norm (EN)
- National Electrical manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriter's Laboratories, Inc. (UL)

Design Criteria

Lifts will be of the goods/passenger public service type and rated at minimum 180 starts per hour. Lifts will be of proven technology and designed to have low energy consumption, low operational costs and will provide environment friendly passenger service. Lifts will be rope traction type capable of operating safely and smoothly without jerking under all loading conditions, for a period of not less than 20 hours per day (except special holiday which may be operated 24 hours a day), seven days per week within the environmental conditions prevailing within the hoist-way and at the location where the elevators are installed.

Lift will be capable of carrying minimum loading of 750 kg, and may be sized for comfortably taking an injured person on a stretcher with room for the stretcher bearers to place the stretcher in the lift without difficulty.

The design of the lift will take into consideration fire prevention, elimination of dust and dirt traps, and easy access for cleaning and routine maintenance.

Lift will have a minimum internal size of 1,400 mm x 2,300 mm wide, the door width will be minimum 1,100 mm clear and 2,200 mm high.

The drive machine, its associated machinery and all necessary control equipment of lifts at stations will be installed within the lift shaft without any lift machine room. Intercom will be provided inside the lift car to communicate with the Station Operation Room of the station where lifts are installed.

The leveling accuracy at the landing served, under no load and full load condition in either up and down direction, will be made within + 5 mm.

The speed of lift will be capable of reaching the uppermost discharge point in not more than one minute. The time will be calculated from the time the doors are fully closed at the lowest discharge point to the time that they begin to open at the uppermost discharge point. The minimum speed will be not less than 1.0 m/s irrespective of the travel distance.

Lifts will be equipped with facilities for physically challenged people, in accordance with the relevant standard.

Interfacing requirements

The following shall be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault
- Emergency Status.

Stairs Requirements

- A central handrail is provided where stair width is 4.5 m or more.
- Risers per flight: 3 minimum, 12 maximum
- All Steps in a flight of Stairs have the same dimensions
- Tread width of steps will be 300mm
- Riser will be 150mm
- Length of intermediate landing: lesser of 2m or width of stairs
- Handrail: 0.9m high, 50mm diameter, 45mm clearance to wall.
- Step noses will be rounded and colour contrasted
- Minimum Stair width for public use: 1500mm
- Minimum Stair width for emergency evacuation: 1100mm

v. Platform Design Standards

a. The length of the Platform will be 180 meter. This allows for the length of 8 car train and a stopping tolerance for the rail corridor Platforms.

b. The nominal platform width measured from the platform edge to any continuous (longer than 2000mm) fixed structure shall be a minimum of 3000 mm. The minimum distance from the platform edge to any isolated obstruction e.g. columns, shall be 250mm (an isolated obstruction shall not be longer than 2000 mm). This clearance shall be maintained for safety reasons, irrespective of passenger flows. The platform width greater than the minimum may be required at stations with large passenger flows. The platform edge shall have a safety margin of 60 mm wide with a non slip surface and a yellow warning strip of 100 mm wide of contrasting texture. The platform ends shall be provided with a 1200 mm wide security gate and be installed with a Pressure Mat Alarm system.

c. Platform widths shall be determined to cater to the following scenarios:

- Normal service: The platform width shall be determined by multiplying the peak minute flow by 0.5 sqm/person and headway, then dividing by the platform length.
- Delayed/Emergency service: The platform width shall be determined by the peak minute flow, allowing for two missed headways or passengers accumulated during 3 train intervals at 0.2 sqm/per person, including alighting passengers from a crush loaded train. The crush load is assumed as 2400 passengers/train for an 8 car train. For an island platform, the area between the boundaries of the two platforms can be included in the calculation.

d. Platform shall be laid to a fall at 1:100 from the inner face of platform screen doors for a distance of 3000mm towards the back of the platform. Where platform screen doors are not provided then platform shall be laid to a fall of 1:100 from the platform edge for a distance of 350mm towards the back of the platform.

e. Markings on the platform to assist and control the flow of passengers for boarding and alighting the trains shall be provided.

f. Space occupied by stairs, escalators, structure, seating, platform supervisor's accommodation etc. is not be included as part of the platform area.

vi. Emergency Evacuation Standards

a. The Requirement is to evaluate people from a station platform to another location, initially the next level below or above and then on to street level without hindrance.

b. The principles to be followed are :-
   - The maximum distance to an exit route on the platform shall be 50 meter.
   - The time required to walk from the farthest point on a platform to the escalator or stair landing must be considered. Walking speed is assumed to be 1 meter/sec.
   - A Check shall be made to ensure that sufficient capacity exists at the level to which passengers are evacuated as being a place of ultimate safety so that people can move freely away from stairs and escalators as they arrive.
   - The emergency is assumed to be occurring in one direction of travel only at any given point of time.

c. For ensuring adequacy of platform area, stair widths and requirement of additional emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising waiting passengers at the platform (including two missed headways) and section load (or full train load if the section load exceeds a full train load) expected to be evacuated at the station in case of an emergency.

d. The train will not move from the platform until passengers have begun clearing the platform and hence the 500 mm unoccupied zone adjacent to the platform edge for platform without platform screen doors is included in the calculations.

vii. Commercial Programs

<u>Advertising areas</u>

a. A high level of passenger traffic using the stations presents a great potential for high commercial value for advertising

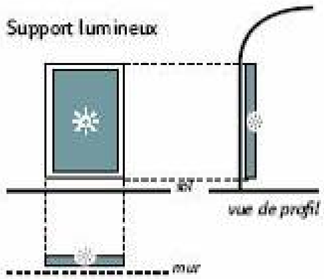
b. The conditions of success to attract announcers and advertising in transit systems include;
   - A high level of passenger traffic:
   - Maximum of space and maximum of repetitions: minimum space for posters is around 96 positions to be efficient on the entire network (that means a minimum of 6 positions per station)
   - Importance of light and the treatment of light to see the posters
   - Advertising sales agency to manage the advertising space.

c. The different possibilities of advertising spaces include;
   - On the platforms (20% of the spaces on the platform could be used for advertising).
   - On the walls beside the escalators

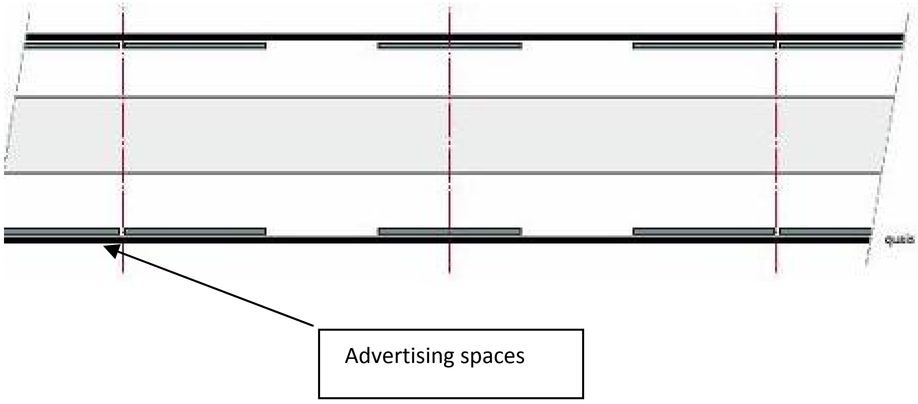
   - On the walls of the first level of the stations
   - Inside the rolling stock (specific dedicated areas)
   - On the rolling stocks: train wearing advertisement campaign (train is used as an advertising medium for one campaign)

- The entire station can be used as an advertising medium for one campaign
- New technologies can be used especially on the platforms: LCS screens (about 8m²) with projection. It implies cables have to be set up in the stations and on the platforms. The screens include sensors to calculate the number of passengers who pass and see the poster. The screen can also communicate with mobile phones.

d. General Principles about the advertising space:
   - Advertising spaces must be seen by the customers on the platforms, as illustrated below;



   - On the platforms, a symmetry position can be set up, as illustrated below;



<u>Commercial areas for retail shops</u>

a. Like Advertising, retail shops in the stations could provide additional financial income. The expected level of passenger traffic in the stations provides great potential for a high commercial value for the retail shops. An agency will preferably be appointed for management of these retail shops at all stations on the proposed Corridor.
b. The different area possibilities for location of retail shops;
   - Inside the stations (paid as well as unpaid areas)
   - Minimum space: 3.5 m of depth all the way across the station; 50m² (3.5 x 14 m) for the smallest stations
c. On the platforms
   - Space: 15 m² per platform for automatic vending machines (for drinks, eatables, etc.) or small convenience stores
d. Inside the stations (before the tool zone)

- Spaces for automatic vending machines could be dedicated (for example: for cash, photos)
- In the covered zone: space for a shopping mall could be created depending on the market potential.

e. Outside the stations (in front of the cars parks or the bus stops)

- Small corners or kiosks; licenses could be created and negotiated for such shops

- Commercial areas and designs will be guided by the market characteristics and local habits.

viii. Building Electrical and Mechanical Services (BEMS) Design Parameters

<u>Water Storage</u>
The Design of the Water tank is based upon the assumption of 35 litre/person for raw and treated water. The capacity of the Water Tank is provided as 100 cu.m approximately for each station.

<u>Electricity</u>
Two DG sets of 650 KVA each are provided at each station which does not include the power supply of the train. 33KV supply from Auxiliary Substation, break down to 430V and 230V is also provided at each station.

<u>HVAC</u>
To accommodate the requirement of air-conditioning approximately 800 Ton Refrigerant is proposed at each station assuming the design parameter as 150 sq ft/Ton.

5.3.4 Conceptual Planning of Selected typical Stations

The Conceptual Station Design is done for 3 selected typical stations namely:

- Bandra Metro (BKC) – Underground Mid Terminal & Interchange Station
- Santacruz – Underground typical Station
- Marol Naka – Underground Interchange Station

The Station Design is based on the Planning norms and guidelines detailed above in Paragraph 5.4.3. The Conceptual Design of other stations on the corridor will be taken up at the Implementation stage as such, the layouts are subject to revision based on the system wide contractors and their specific requirements.

Since land is at premium throughout the corridor, the process of reconciling the land that is actually required for the station development has had a major influence upon the design process and important elements of the stations such as entry/exits, concourse, platforms, ancillary buildings etc have been designed to overcome land acquisition problems.

The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation. The space planning requirement for each of the stations with respect to the number of AFC gates, ticket windows, stair width, number of escalators, platform width etc in normal and emergency conditions are based on peak hour passenger traffic which is detailed in **Table 5.4**. These calculations not only accommodate the normal and delayed operation but also satisfy NFPA 130.

The stations have been provided with an internal environment suitable for a world class metro railway system by incorporating the experience of international best practices to the design. The stations have been designed in such a way that they are easily operated, maintained and can be upgraded in future. Accommodation for staff and plant rooms is provided at both platform and concourse levels within areas that are entirely separate from the public access. The main plant systems accommodated within the station are the auxiliary sub-stations at the concourse level at each end, ECS plant rooms at concourse level at each end and adjacent to the station box and TVS plant rooms at platform level at each end, between the two tracks. The S&T equipment rooms are provided between the subway and ECS plant room.

The internal arrangement for the stations is evolved in such a way that Back of House accommodation is organized, so that the rooms of a similar operational use are placed along a common corridor and plant accommodation is clearly distinct from habitable rooms.

Due importance has been given to maintenance and access for maintenance during the process of designing of the station.

Table 5.4: Station Design Calculations based on peak hour passenger load

STATION DESIGN CALCULATIONS		Cuffe Parade	Badhwar Park	Vidhan Bhawan	Church gate	Hutatma Chowk	CST	Kalba devi	Girga on	Grant Rd.	Mumbai Central	Mahal axmi	Science Museum	Aatrey Chowk	Worli	Siddhi Vinayak	Dadar	Sheetla Devi	Dharavi	Bandra	Kalina	Santa cruz	Airport Domes tic	Sahar Road	Int Airpo rt	Moral Naka	MIDC	SEEP Z
Traffic Figures	Peak Hour Boarding (2031)	6192	4837	3253	5024	6561	6589	5397	6216	5861	7265	7808	3802	6784	5354	6701	13665	8286	8679	12899	2880	5179	3611	4172	2791	7061	5087	8036
	Peak Hour Alighting (2031)	7180	5484	6182	7055	8422	13491	7430	5397	3836	4797	4376	3230	6746	7447	6587	9120	6071	4543	10460	5389	3580	6689	4026	6900	5246	4774	5533
	Traffic correction coefficient (future for ultimate traffic load)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	Revised Peak Hour Boarding (future for ultimate traffic load)	7430	5804	3903	6029	7873	7907	6476	7459	7033	8718	9369	4563	8141	6425	8041	16398	9943	10415	15479	3456	6215	4333	5006	3349	8473	6104	9643
	Revised Peak Hour Alighting (future for ultimate traffic load)	8616	6580	7419	8466	10107	16189	8916	6476	4603	5756	5251	3876	8095	8936	7905	10944	7286	5452	12552	6467	4296	8027	4831	8280	6295	5729	6639
	Boarding/min	149	116	78	121	157	158	130	149	141	174	187	91	163	128	161	328	199	208	310	69	124	87	100	67	169	122	193
	Alighting/min	172	132	148	169	202	324	178	130	92	115	105	78	162	179	158	219	146	109	251	129	86	161	97	166	126	115	133
	Total Passengers/min	321	248	226	290	360	482	308	279	233	289	292	169	325	307	319	547	345	317	561	198	210	247	197	233	295	237	326
Ticket Windows	80% will hold smart cards	119	93	62	96	126	127	104	119	113	139	150	73	130	103	129	262	159	167	248	55	99	69	80	54	136	98	154
	20% will buy tickets	30	23	16	24	31	32	26	30	28	35	37	18	33	26	32	66	40	42	62	14	25	17	20	13	34	24	39
	Of the smart card holder 10% will use the window to renewal etc.	12	9	6	10	13	13	10	12	11	14	15	7	13	10	13	26	16	17	25	6	10	7	8	5	14	10	15
	Total Window users/minute	42	33	22	34	44	44	36	42	39	49	52	26	46	36	45	92	56	58	87	19	35	24	28	19	47	34	54
	No of windows required @ 5 pass/minute/wind ow	8	7	4	7	9	9	7	8	8	10	10	5	9	7	9	18	11	12	17	4	7	5	6	4	9	7	11
	No of Ticketing Windows @ 50% of the required	4	3	2	3	4	4	4	4	4	5	5	3	5	4	5	9	6	6	9	2	3	2	3	2	5	3	5
	No of Ticket Vending Machines	4	4	2	4	5	5	3	4	4	5	5	2	4	3	4	9	5	6	8	2	4	3	3	2	4	4	6
AFC Gates	AFC Gates In @ 28 pass/ min	5	4	3	4	6	6	5	5	5	6	7	3	6	5	6	12	7	7	11	2	4	3	4	2	6	4	7
	AFC Gates Out @ 28 pass/ min	6	5	5	6	7	12	6	5	3	4	4	3	6	6	6	8	5	4	9	5	3	6	3	6	4	4	5
	1 extra in case of emergency	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1 for disabled	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Total	13	11	10	12	15	19	13	12	10	12	12	8	14	13	13	22	14	13	22	9	10	11	9	10	13	10	14
Stairs and Escalators requirement in Normal Conditions from Platform to Concourse (Alighting Passengers)	Total passengers using vertical seperation/min	321	248	226	290	360	482	308	279	233	289	292	169	325	307	319	547	345	317	561	198	210	247	197	233	295	237	326
	No of Escalators required @ 135 pass/min (0.75m/sec) in case of Island Platform (underground station	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1
	Staircase Width @ 56 pass/m/min for upstairs (for underground station)	3	2	3	3	4	6	3	2	2	2	2	1	3	3	3	4	3	2	4	2	2	3	2	3	2	2	2
	Lift Requirement (capacity@8 passengers minimum)	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stairs and Escalators requirement	Total passengers using vertical seperation/min	321	248	226	290	360	482	308	279	233	289	292	169	325	307	319	547	345	317	561	198	210	247	197	233	295	237	326

STATION DESIGN CALCULATIONS		Cuffe Parade	Badhwar Park	Vidhan Bhawan	Church gate	Hutatma Chowk	CST	Kalba devi	Girga on	Grant Rd.	Mumbai Central	Mahal axmi	Science Museum	Aatrey Chowk	Worli	Siddhi Vinayak	Dadar	Sheetla Devi	Dharavi	Bandra	Kalina	Santa cruz	Airport Domes tic	Sahar Road	Int Airpo rt	Moral Naka	MIDC	SEEP Z
in Normal Conditions from Concourse to Platform (Boarding Passengers)	Staircase Width @ 63 pass/m/min for downstairs (for underground station)	2	2	1	2	2	3	2	2	2	3	3	1	3	2	3	5	3	3	5	1	2	1	2	1	3	2	3
	Lift Requirement (capacity@8 passengers minimum)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Total Staircase width	5	4	4	5	6	9	5	4	4	5	5	2	6	5	6	9	6	5	9	3	4	4	4	4	5	4	5
	No. of staircases	2	3	1	3	4	5	2	1	3	2	2	2	2	2	2	6	2	2	3	1	1	3	1	3	2	1	2
	Width of each staircase	3.0	1.3	3.0	1.7	1.5	1.8	3.0	3.0	1.3	3.0	3.0	1.0	3.0	3.0	3.0	1.5	3.0	3.0	3.0	3.0	3.0	1.3	3.0	1.3	3.0	3.0	3.0
	Width of Escalator	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Platform	width of island (including staricase, eslators, circulation,etc)	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**	**12.00**
Stairs and Escalators requirement in Emergency Evacuation from Platform to Concourse	Train Crush Load @300 passengers/coach (B)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
	Platform Fuly Loaded with Two Missed headways	1114	871	585	904	1181	1186	971	1119	1055	1308	1405	684	1221	964	1206	2460	1492	1562	2322	518	932	650	751	502	1271	916	1446
	Total number of passengers to be evacuated	7114	6871	6585	6904	7181	7186	6971	7119	7055	7308	7405	6684	7221	6964	7206	8460	7492	7562	8322	6518	6932	6650	6751	6502	7271	6916	7446
	Evacuation Time as per NFPA 130	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins	4.5 mins
	Passengers to be evacuated/min	1581	1527	1463	1534	1596	1597	1549	1582	1568	1624	1646	1485	1605	1547	1601	1880	1665	1680	1849	1449	1541	1478	1500	1445	1616	1537	1655
	Staircase Width @ 63 pass/m/min	25	24	23	24	25	25	25	25	25	26	26	24	25	25	25	30	26	27	29	23	24	23	24	23	26	24	26
Walkway	Walkway unidirectional @ 88 pass/m/min	18	17	17	17	18	18	18	18	18	18	19	17	18	18	18	21	19	19	21	16	18	17	17	16	18	17	19
	Walkway bidirectional @ 70 pass/m/min	23	22	21	22	23	23	22	23	22	23	24	21	23	22	23	27	24	24	26	21	22	21	21	21	23	22	24

i. Bandra Metro (BKC)

Bandra Metro (BKC) at Bandra Kurla Complex is proposed as a Mid Terminal Station. The BKC station is a major interchange station between the Metro Line II (CBM corridor) and the proposed Colaba – Bandra - SEEPZ corridor. To enable seamless transfer of passengers between one line and another, it is proposed to connect the paid area of the proposed mid terminal station with the paid area of the ITO station of the Charkhop - Bandra - Mankhurd Metro corridor.

The proposed station has a triple platform configuration with ticketing counters at the concourse level on both sides of the station. During the design process, a number of changes have been implemented to improve both the usability and character of the station. The size of the station box at Platform level is 256.00m x 33.8 m and sufficient space has been provided for the ECS plant room and ancillary building. The platforms are approximately 15.6 m below the ground level. Auxiliary substations for Power Supply and Traction facilities is placed at the platform level, where as the requirement of System Rooms, Staff facilities, Tunnel Ventilation System and Operations is contained at the Concourse Level. DG set, Fuel Tank, Water Tank and Chiller Plant is placed at the Ground Level.

Island platform is 180 m long and 11.6 m wide, whilst side platform is 180m long and 6.6 m wide. Vertical circulation, in the form of four sets of, adequately sized, stairs and escalators have been provided in the centre of the island platform, and side platform to cater to normal and emergency passenger movement for the projected year 2031.
The Metro Station is also accessible for the disabled with the provision of one lift to connect the ground level to the concourse level (unpaid public area) and another lift to connect the concourse level (paid public area) to the platform level. Separate firemen access stairs and passenger escape stairs have also been provided at each end of the station.

Retail space of about 240 sq mt is proposed at the Concourse level for small kiosks, automatic vending machines, retail shops etc. **Table 5.5** shows the Area Break up of the various facilities required at the station. **Figure 5.29** shows the Concourse Level and Platform Level Plan of the underground Bandra (BKC) Metro Station.

Table 5.5: Area Breakup of various facilities at Bandra (BK) Metro Station

ROOM NO.	DESCRIPTION	BKC	
		LEVEL	AREA (SQ.M)
PST (POWER SUPPLY & TRACTION)			
U36a	AUXILLARY SUBSTATION-1	PLATFORM	167
U36b	AUXILLARY SUBSTATION-2	PLATFORM	206
U47a	TRACK DISCONNECTION SWITCH-1	PLATFORM	17.12
U47b	TRACK DISCONNECTION SWITCH-2	PLATFORM	17.1
U48	DG SET	GROUND	208.50
U49	FUEL TANK	GROUND	

ROOM NO.	DESCRIPTION	BKC	
		LEVEL	AREA (SQ.M)
SYSTEM ROOMS			
	SIGNALLING		
U32	SIGNALLING EQUIPMENT ROOM (SER)	CONCOURSE	49.72
U33	UPS ROOM (SIGNALLING)	CONCOURSE	24.95
	TELECOMMUNICATION		
U34a	TER	CONCOURSE	30.54
U34b	MOBILE PHONE EQUIPMENT ROOM	CONCOURSE	10.861
U35	UPS ROOM (TELECOM)	CONCOURSE	30.65
OPERATIONS			
U03	STATION CONTROL ROOM (SCR)	CONCOURSE	72.24
U04	STATION MANAGER	CONCOURSE	24.20
U05a	TICKET OFFICE/TICKETING-1	CONCOURSE	18.90
U05b	TICKET OFFICE/TICKETING-2	CONCOURSE	17.80
U05c	TICKET OFFICE SUPERVISOR	CONCOURSE	23.85
U06	AUDIT AND CASH STORAGE	CONCOURSE	19.50
U07	TVM/ BOMS	CONCOURSE	15.45
U08	MISCELLANEOUS OPERATION ROOM	CONCOURSE	32.57
U12	SECURITY/ POLICE ROOM	CONCOURSE	12.79
U10a	EFO-1	CONCOURSE	10.70
U10b	EFO-2	CONCOURSE	10.70
STAFF FACILITIES			
U17	STAFF TOILETS/ LOCKER (MALE)	CONCOURSE	17.40
U18	STAFF TOILETS/ LOCKER (FEMALE)	CONCOURSE	17.40
U11	FIRST AID	CONCOURSE	10.26
U20	STAFF MESS ROOM	CONCOURSE	13.24
U29	TRAIN DRIVER'S LOCKER ROOM	CONCOURSE	33.00
U30	TRAIN DRIVER'S DISPATCH OFFICE	CONCOURSE	53.00
U46	TRAIN CREW ROOM	NA	NA
TUNNEL VENTILATION SYSTEM			
U19a	TUNNEL VENTILATION PLANT ROOM-1	CONCOURSE	363.54
U19b	TUNNEL VENTILATION PLANT ROOM-2	CONCOURSE	365.72
U23a	ECS PLANT ROOM-1	CONCOURSE	266.99
U23b	ECS PLANT ROOM-2	CONCOURSE	538.58
FIRE SYSTEM			
U21	WATER TANK & FS PUMP ROOM	GROUND	284.00
STATION VENTILATION SYSTEM			
U22	CHILLER PLANT	GROUND	141.00
U24	COOLING TOWER	GROUND	
U25	STAIRCASE PRESSURISATION-1	GROUND	
U26	STAIRCASE PRESSURISATION-2	GROUND	
U27	STAIRCASE PRESSURISATION-3	GROUND	
U28	STAIRCASE PRESSURISATION-4	GROUND	
MISCELLANEOUS			
U13	EMERGENCY EQUIPMENT ROOM	CONCOURSE	10.06
U14	DISABLED TOILET	CONCOURSE	7.24
U15a	CLEANERS ROOM-1	PLATFORM	4.68
U15b	CLEANERS ROOM-2	NA	NA
U16	REFUSE STORE	PLATFORM	6.13
U45	PERMANENT WAY STORE	PLATFORM	29.15
U50	UPS (STATION)	CONCOURSE	31.5
U66a	CABLE DUCT	CONCOURSE	67.7
U66b	CABLE DUCT	CONCOURSE	67.7
U53	LOST AND FOUND ROOM		
U52	TRAINING ROOM		

ROOM NO.	DESCRIPTION	BKC	
		LEVEL	AREA (SQ.M)
U37	UTILITY DUCT	CONCOURSE	91.5
RETAIL			
	RETAIL DEVELOPMENT	CONCOURSE	40
WATER SUPPLY & DRAINAGE SYSTEM			
U41	SEWAGE PUMP ROOM	PLATFORM	19.41
U42a	SEEPAGE PUMP ROOM-1	PLATFORM	29.16
U42b	SEEPAGE PUMP ROOM-2	PLATFORM	37.37
U44	SMOKE EXTRACTION FAN ROOM		

ii. Santa Cruz Metro

Santacruz station is proposed as a major station planned on the Western Expressway. The proposed station is underground and has an Island platform configuration. The platform level of the station is contained within a two storey cut and cover structural box of 280 m x 24.2 m. The platforms are approximately 15.6 m below the ground level. The size of the island platform is 180m x 12.5 m. Vertical circulation, in the form of four sets of, adequately sized, stairs and escalators have been provided in the centre of the island platform, to cater to normal and emergency passenger movement up till 2031.

In addition an elevator has been provided for the use of handicap people. Separate firemen access stairs and passenger escape stairs have also been provided at each end of the station.

Retail space of about 20 sq mt is proposed at the Concourse level for small kiosks and automatic vending machine. **Table 5.6** shows the Area Breakup of the various facilities required at the station. **Figure 5.30** shows the Concourse Level and Platform Level Plan of the underground Santacruz Metro Station.

Table 5.6: Area Breakup of various facilities at Santacruz Metro Station

ROOM NO.	DESCRIPTION	SANTACRUZ	
		LEVEL	AREA (SQ.M)
PST (POWER SUPPLY & TRACTION)			
U36a	AUXILLARY SUBSTATION-1	PLATFORM	303.73
U36b	AUXILLARY SUBSTATION-2	PLATFORM	303.73
U47a	TRACK DISCONNECTION SWITCH-1	PLATFORM	21.25
U47b	TRACK DISCONNECTION SWITCH-2	NA	NA
U48	DG SET	GROUND	208.50
U49	FUEL TANK	GROUND	
SYSTEM ROOMS			
	SIGNALLING		
U32	SIGNALLING EQUIPMENT ROOM (SER)	CONCOURSE	48.28
U33	UPS ROOM (SIGNALLING)	CONCOURSE	19.66
	TELECOMMUNICATION		
U34a	TER	CONCOURSE	44.53
U34b	MOBILE PHONE EQUIPMENT ROOM	CONCOURSE	49.66

U35	UPS ROOM (TELECOM)	CONCOURSE	19.66
OPERATIONS			
U03	STATION CONTROL ROOM (SCR)	CONCOURSE	48.13
U04	STATION MANAGER	CONCOURSE	17.07
U05a	TICKET OFFICE/TICKETING-1	CONCOURSE	46.80
U05b	TICKET OFFICE/TICKETING-2	CONCOURSE	15.56
U05c	TICKET OFFICE SUPERVISOR	CONCOURSE	22.09
U06	AUDIT AND CASH STORAGE	CONCOURSE	13.05
U07	TVM/ BOMS	CONCOURSE	19.49
U08	MISCELLANEOUS OPERATION ROOM	CONCOURSE	34.62
U12	SECURITY/ POLICE ROOM	CONCOURSE	15.67
U10a	EFO-1	CONCOURSE	12.18
U10b	EFO-2	CONCOURSE	12.18
STAFF FACILITIES			
U17	STAFF TOILETS/ LOCKER (MALE)	CONCOURSE	35.81
U18	STAFF TOILETS/ LOCKER (FEMALE)	CONCOURSE	16.78
U11	FIRST AID	CONCOURSE	12.47
U20	STAFF MESS ROOM	CONCOURSE	27.59
U29	TRAIN DRIVER'S LOCKER ROOM		
U30	TRAIN DRIVER'S DISPATCH OFFICE		
U46	TRAIN CREW ROOM	NA	NA
TUNNEL VENTILATION SYSTEM			
U19a	TUNNEL VENTILATION PLANT ROOM-1	CONCOURSE	376.38
U19b	TUNNEL VENTILATION PLANT ROOM-2	CONCOURSE	374.68
U23a	ECS PLANT ROOM-1	CONCOURSE	420.54
U23b	ECS PLANT ROOM-2	CONCOURSE	327.31
FIRE SYSTEM			
U21	WATER TANK & FS PUMP ROOM	GROUND	284.00
STATION VENTILATION SYSTEM			
U22	CHILLER PLANT	GROUND	141.00
U24	COOLING TOWER	GROUND	
U25	STAIRCASE PRESSURISATION-1	GROUND	
U26	STAIRCASE PRESSURISATION-2	GROUND	
U27	STAIRCASE PRESSURISATION-3	GROUND	
U28	STAIRCASE PRESSURISATION-4	GROUND	
MISCELLANEOUS			
U13	EMERGENCY EQUIPMENT ROOM	CONCOURSE	27.97
U14	DISABLED TOILET		
U15a	CLEANERS ROOM-1	CONCOURSE	6.42
U15b	CLEANERS ROOM-2	PLATFORM	11.56
U16	REFUSE STORE	CONCOURSE	4.30
U45	PERMANENT WAY STORE	PLATFORM	25.50
U50	UPS (STATION)		
U66a	CABLE DUCT		
U66b	CABLE DUCT		
U53	LOST AND FOUND ROOM		
U52	TRAINING ROOM		
U37	UTILITY DUCT		
RETAIL			

	RETAIL DEVELOPMENT	CONCOURSE	20
WATER SUPPLY & DRAINAGE SYSTEM			
U41	SEWAGE PUMP ROOM	PLATFORM	31.50
U42a	SEEPAGE PUMP ROOM-1	PLATFORM	34.67
U42b	SEEPAGE PUMP ROOM-2	PLATFORM	37.73
U44	SMOKE EXTRACTION FAN ROOM		

iii. Marol Naka

Marol Naka is also proposed as a major interchange station which will have passenger interchange with the proposed Colaba – Bandra - SEEPZ corridor and the proposed Metro Line-I (VAG corridor).

The proposed station is underground and has an Island platform configuration. The station is contained within a two storey cut and cover structural box of 256m x 24.2 size. The platforms are approximately 15.4 m below the ground level. The island platform is 180m long and 10.88 m wide. Vertical circulation, in the form of three sets of, adequately sized, stairs and escalators have been provided in the centre of the island platform, to cater to normal and emergency passenger movement up till 2031. The Metro Station is also accessible for the disabled with the provision of lifts to connect the various levels of the station. Separate firemen access stairs and passenger escape stairs have also been provided at each end of the station.

Retail space of about 163 sq mt is proposed at the Concourse level for small kiosks and automatic vending machine. **Table 5.7** shows the Area Breakup of the various facilities required at the station. **Figure 5.31** shows the Concourse Level Plan and Platform Level Plan of the underground Marol Naka Station. It is proposed to connect the paid area at the concourse level of the proposed underground metro station with the paid area of the proposed elevated station of the VAG corridor for the ease of interchange passengers as shown in **Figure 5.31**.

Table 5.7: Area Breakup of various facilities at Marol Naka Station

ROOM NO.	DESCRIPTION	MAROL NAKA	
		LEVEL	AREA (SQ.M)
PST (POWER SUPPLY & TRACTION)			
U36a	AUXILLARY SUBSTATION-1	PLATFORM	171.00
U36b	AUXILLARY SUBSTATION-2	PLATFORM	210.00
U47a	TRACK DISCONNECTION SWITCH-1	PLATFORM	17.12
U47b	TRACK DISCONNECTION SWITCH-2	PLATFORM	17.10
U48	DG SET	GROUND	208.50
U49	FUEL TANK	GROUND	
SYSTEM ROOMS			
	SIGNALLING		
U32	SIGNALLING EQUIPMENT ROOM (SER)	CONCOURSE	31.59
U33	UPS ROOM (SIGNALLING)	CONCOURSE	25.57
	TELECOMMUNICATION		
U34a	TER	CONCOURSE	26.98
U34b	MOBILE PHONE EQUIPMENT ROOM	CONCOURSE	39.74

ROOM NO.	DESCRIPTION	MAROL NAKA	
		LEVEL	AREA (SQ.M)
U35	UPS ROOM (TELECOM)	CONCOURSE	28.57
OPERATIONS			
U03	STATION CONTROL ROOM (SCR)	CONCOURSE	51.76
U04	STATION MANAGER	CONCOURSE	24.20
U05a	TICKET OFFICE/TICKETING-1	CONCOURSE	18.90
U05b	TICKET OFFICE/TICKETING-2	CONCOURSE	17.80
U05c	TICKET OFFICE SUPERVISOR	CONCOURSE	23.85
U06	AUDIT AND CASH STORAGE	CONCOURSE	19.50
U07	TVM/ BOMS	CONCOURSE	15.45
U08	MISCELLANEOUS OPERATION ROOM		
U12	SECURITY/ POLICE ROOM	CONCOURSE	12.79
U10a	EFO-1	CONCOURSE	10.70
U10b	EFO-2	CONCOURSE	10.70
STAFF FACILITIES			
U17	STAFF TOILETS/ LOCKER (MALE)	CONCOURSE	17.39
U18	STAFF TOILETS/ LOCKER (FEMALE)	CONCOURSE	17.39
U11	FIRST AID	CONCOURSE	10.25
U20	STAFF MESS ROOM	CONCOURSE	13.24
U29	TRAIN DRIVER'S LOCKER ROOM		
U30	TRAIN DRIVER'S DISPATCH OFFICE		
U46	TRAIN CREW ROOM	NA	NA
TUNNEL VENTILATION SYSTEM			
U19a	TUNNEL VENTILATION PLANT ROOM-1	CONCOURSE	363.54
U19b	TUNNEL VENTILATION PLANT ROOM-2	CONCOURSE	365.72
U23a	ECS PLANT ROOM-1	CONCOURSE	486.27
U23b	ECS PLANT ROOM-2	CONCOURSE	304.85
FIRE SYSTEM			
U21	WATER TANK & FS PUMP ROOM	GROUND	284.00
STATION VENTILATION SYSTEM			
U22	CHILLER PLANT	GROUND	141.00
U24	COOLING TOWER	GROUND	
U25	STAIRCASE PRESSURISATION-1	GROUND	
U26	STAIRCASE PRESSURISATION-2	GROUND	
U27	STAIRCASE PRESSURISATION-3	GROUND	
U28	STAIRCASE PRESSURISATION-4	GROUND	
MISCELLANEOUS			
U13	EMERGENCY EQUIPMENT ROOM	CONCOURSE	10.06
U14	DISABLED TOILET	CONCOURSE	7.24
U15a	CLEANERS ROOM-1	PLATFORM	4.68
U15b	CLEANERS ROOM-2	NA	NA
U16	REFUSE STORE	PLATFORM	6.13
U45	PERMANENT WAY STORE	PLATFORM	29.15
U50	UPS (STATION)	CONCOURSE	54.00
U66a	CABLE DUCT	CONCOURSE	68.00
U66b	CABLE DUCT	CONCOURSE	68.00
U53	LOST AND FOUND ROOM	CONCOURSE	91.50
U52	TRAINING ROOM		
U37	UTILITY DUCT		
RETAIL			
	RETAIL DEVELOPMENT	CONCOURSE	163.91
WATER SUPPLY & DRAINAGE SYSTEM			
U41	SEWAGE PUMP ROOM	PLATFORM	19.41
U42a	SEEPAGE PUMP ROOM-1	PLATFORM	29.16
U42b	SEEPAGE PUMP ROOM-2	PLATFORM	37.37
U44	SMOKE EXTRACTION FAN ROOM		

Figure 5.29: Concourse & Platform Level Plans – Bandra Metro (BKC)

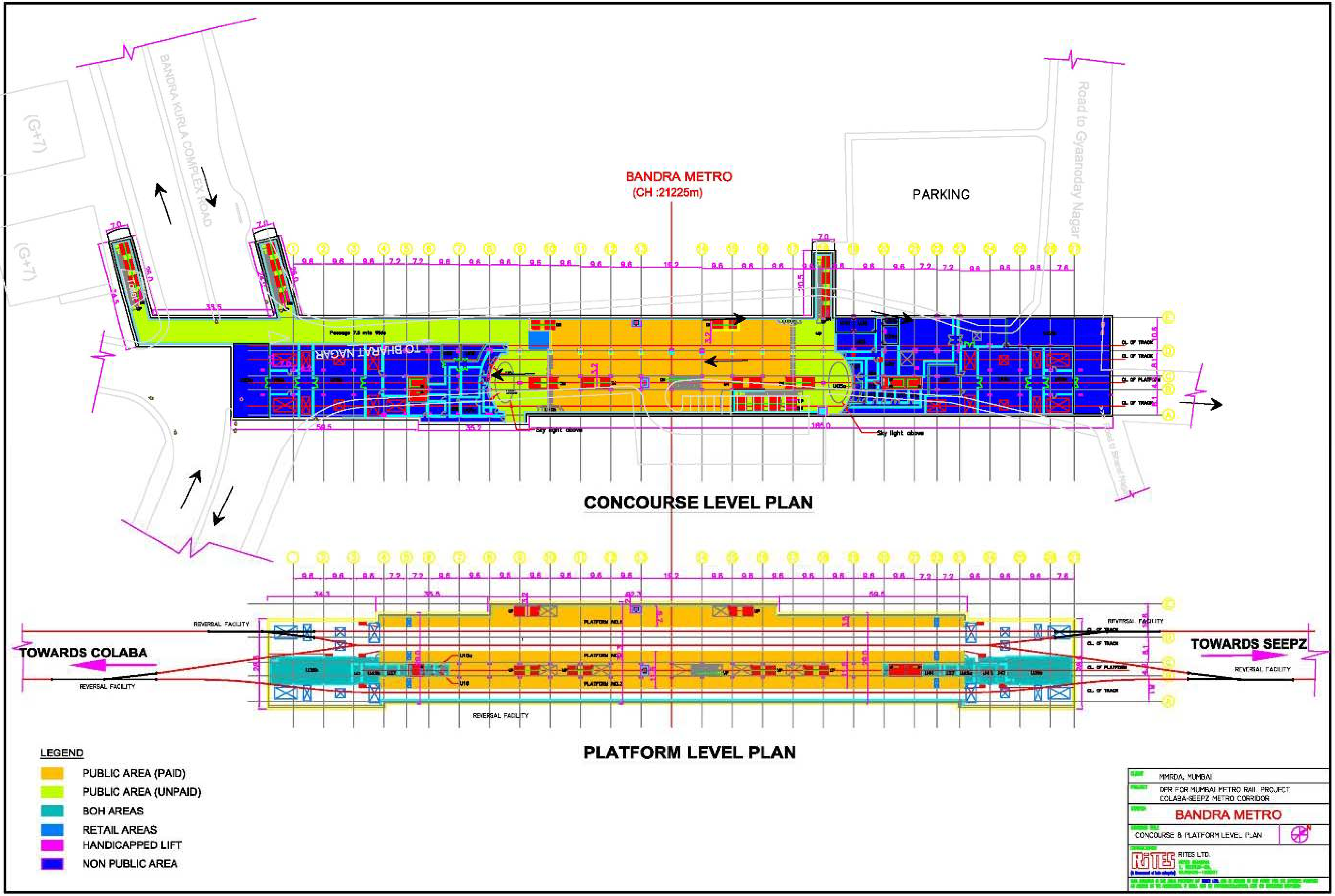


Figure 5.30: Concourse & Platform Level Plans – Santacruz Metro

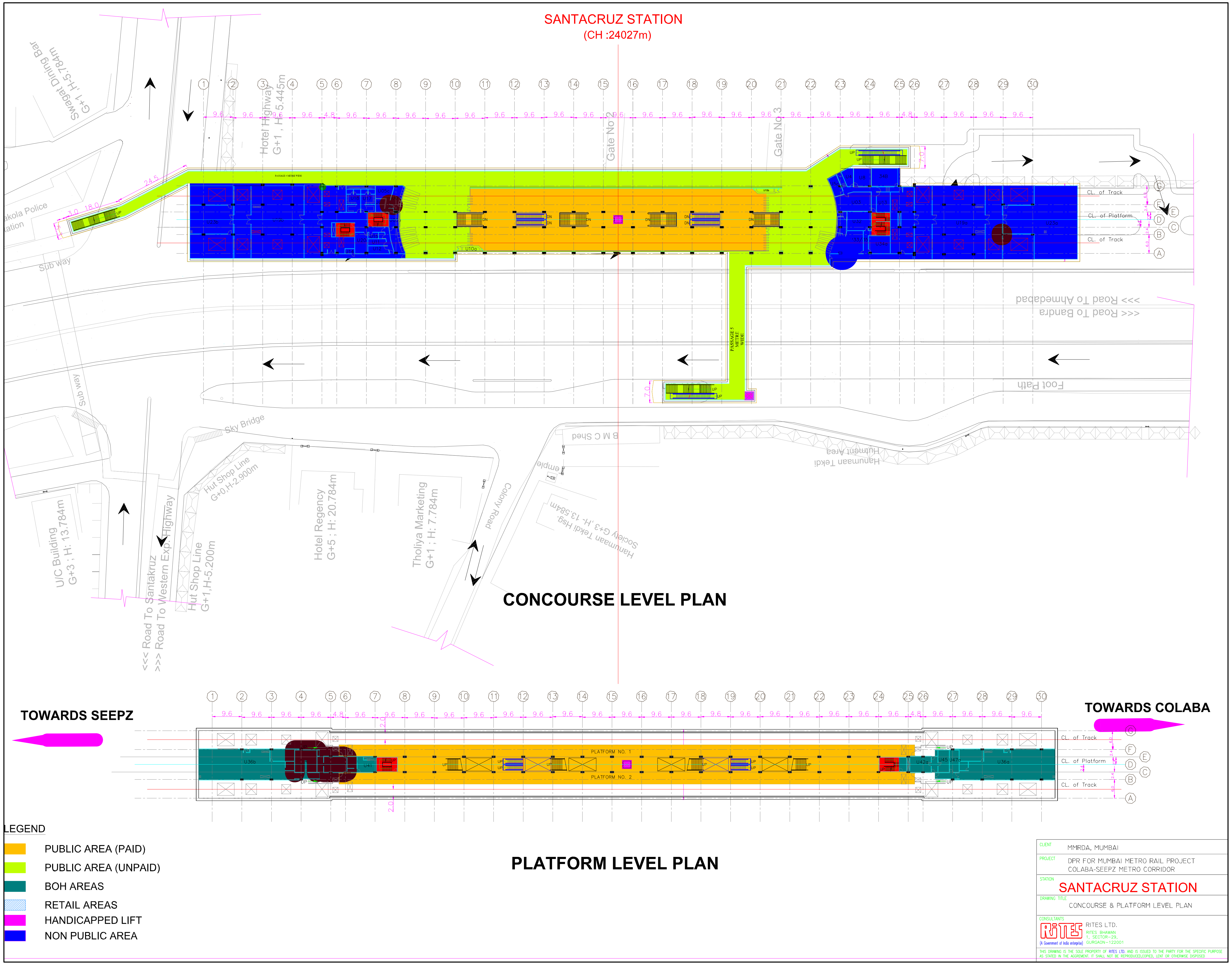
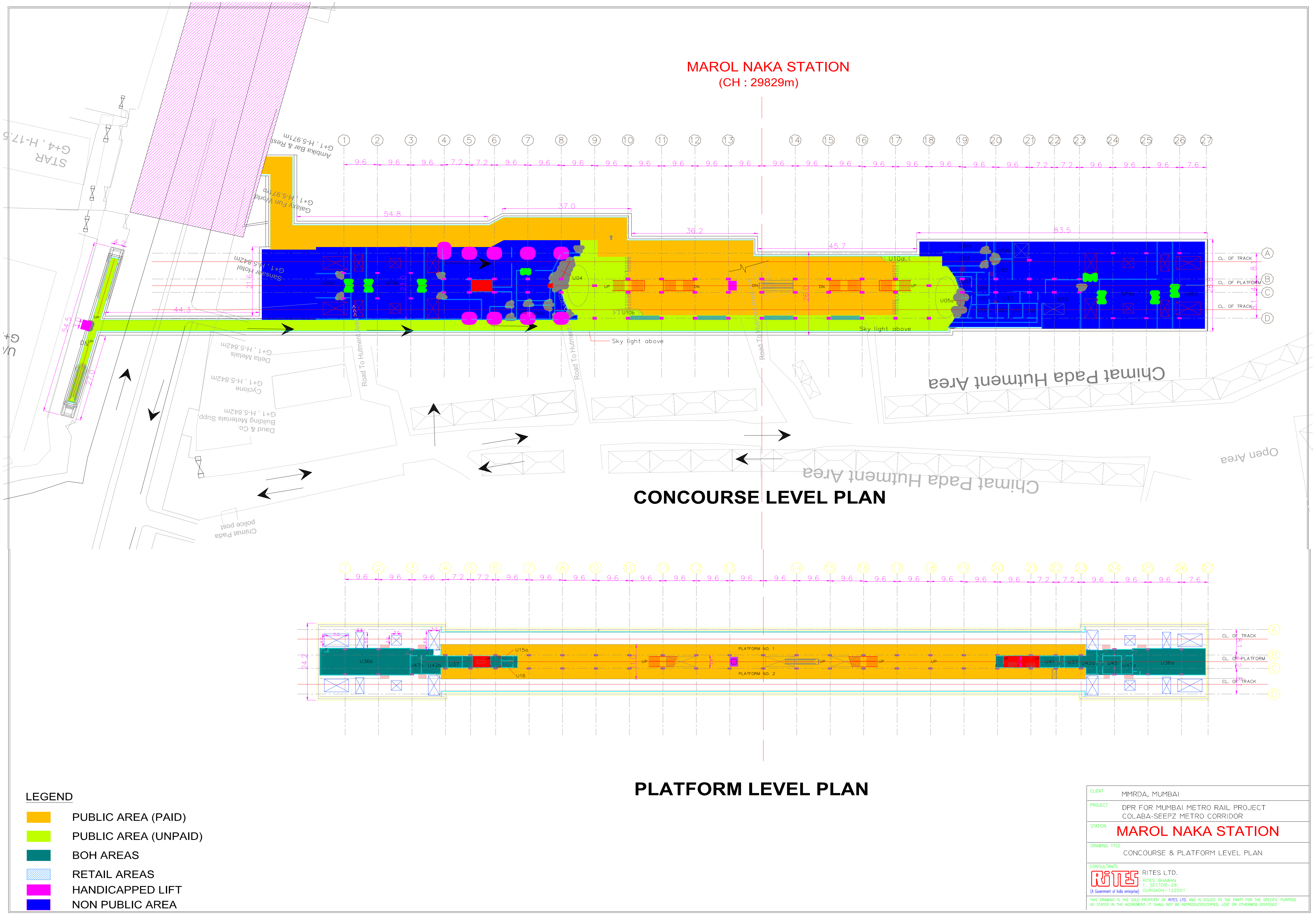


Figure 5.31: Concourse & Platform Level Plans – Marol Naka



5.4 STATION AREA PLANNING – INTERMODAL INTEGRATION AND DISPERSAL FACILITIES

With the increase in passenger traffic dispersing via the road network for the feeder trips, it is vital that adequate traffic dispersal facilities be planned accordingly in terms of overall horizon year traffic levels and and capacity of roads, footpaths/pedestrian facilities, bus stops, IPT stands, Pick / Drop areas to cater to the projected requirements for the proposed metro stations, considering the following objectives:

- To facilitate efficient transfer and dispersal of passengers from/ to the proposed system
- To provide for effective inter-modal interchange of the passengers with the feeder modes including walk, IPT and buses.
- To integrate the proposed system's entry/ exits with those of existing system and upcoming transport infrastructure

This issue becomes more important for stations involving major interchanges with other existing/proposed/upcoming mass transit modes. The approach followed to achieve these objectives involves the analysis of the present issues, concerns and the potentials in order to facilitate the future traffic demand levels.

The same for all proposed metro stations on the corridor are discussed in the **Section 5.4.1**. Further, the proposals for achieving the desired efficiency of inter-modal integration and passenger dispersal in view of the overall traffic volume in horizon year are presented in the **Section 5.4.2**.

5.4.1 Existing Situation and Concerns

Table 5.8: Issues, Concerns and Potentials of the Station Areas

S. No.	Station	Issues	Concerns	Potentials
1	Colaba/ Cuffe Parade	• Encroachment on footpaths by informal activities resulting in obstruction to pedestrian movement. • Absence of continuous footpath results in pedestrian traffic on road conflicting with vehicular traffic. • On-street parking can be observed on both sides of the road narrowing the effective carriageway width.	• On-street parking of vehicles is a major concern due to absence of adequate formal off-street parking. • Traffic jamming conditions at Jhulelal Mandir Chowk during peak hours.	• At-grade station structures can be accommodated on the vacant land near the station area, which can also be used for generating revenue through advertisements/ commercial developments. • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Adequate ROW to provide for station entry/ exits.
2	Badhwar Park	• Encroachment on footpath by informal activities results in obstruction to pedestrian movement. • Lack of defined Taxi stand/bays near the station results in haphazard on-street parking of taxis creating hindrance to the traffic • Pedestrian spillover on the road due to encroachment on footpath. • Due to absence of adequate formal off-street parking, on-street parking of vehicles on footpath also can be observed.	• On-street parking of vehicles and taxis is a major concern which create traffic chaos during peak hours. • Encroachment and parking of vehicles on footpath is also a concern.	• Scope of generating revenue through advertisements/ commercial development of surrounding station area • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange.
3	Vidhan Bhavan	• Encroached footpaths by informal activities near the station, bus-stop resulting in pedestrian movement on roadway and conflicting with the vehicular movement. • Narrow streets partially encroached by the parking and vendors combined with heavy pedestrian movement results in traffic congestion during peak hours. • Unorganised pedestrian and vehicular movement results in traffic congestion	• On-street parking of vehicles is a major concern due to absence of adequate formal off-street parking. • High incidence of on-street vendors & footpath encroachments are the major concern. •	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Wide footpaths can accommodate the passenger dispersal • Being located in the prominent area, it will generate ridership from surrounding areas. •

S. No.	Station	Issues	Concerns	Potentials
4	Churchgate Metro	• Subway provided at the Churchgate station does not connect all directions, especially Oval Ground – thus, forcing people to use at-grade crossing. • Chaotic traffic situation on eastern entry of the station due to conflicts between pedestrians, moving traffic and the bus stops & taxi stand. • Lack of defined Taxi stand/bays results in haphazard on-street parking of taxis creating hindrance to the traffic and reducing the capacity of the road. • Limited off street parking is available near Eros Cinema. Consequently heavy on-street parking is observed on IM Chambers Road and its by lanes thus reducing the capacity of the roads. • Encroachment on footpath by informal activities results in obstruction to pedestrian movement.	• Limited scope of new infrastructure due to heavily built area. For the provision of new public facilities, land would need to be acquired. • Churchgate station is located on the edge of the Ahilyabai Holkar Chowk, uncontrolled dispersal can lead to chaotic conditions on the main Veer Nariman road.	• Wide footpaths can accommodate the passenger dispersal. • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Proximity to Churchgate suburban station will aid in better integration with the suburban system. •
5	Hutatma Chowk	• Encroached footpaths by informal activities near the station, bus-stop resulting in pedestrian movement on roadway and conflicting with the vehicular movement. • Undefined and inadequate Bus stop area, resulting in passenger spillover on road. • Heavy pedestrian traffic along with encroachment on the street.	• Haphazard pedestrian crossings and high incidence of on-street vendors & encroachments are the major concerns of traffic. • On-street IPT, bus stands, absence of designated pick- drop result in undesirable pedestrian-vehicle conflicts and inefficient traffic circulation.	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Wide footpaths can accommodate the passenger dispersal • Scope of generating revenue through advertisements/ commercial development of surrounding station area
6	CST Metro	• Encroachment on footpaths by informal activities resulting in obstruction to pedestrian movement. • Pedestrian spillover on the road due to encroachment on footpath. • Due to absence of adequate formal off-street parking, on-street parking of vehicles on footpath also can be observed.	• Uncontrolled dispersal can lead to chaotic conditions on Dr. Dadabhai Naroji Road.	• Wide footpaths can accommodate the Passenger dispersal. • Proximity to CST suburban station will aid in better integration with the suburban system. • Bus Depot or Terminal & Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange.

S. No.	Station	Issues	Concerns	Potentials
		• Pedestrian – vehicle conflicts are created due to heavy pedestrian crossing at the junction		
7	Kalbadevi Metro	• Very limited Right Of Way. • Undefined and inadequate Bus stop area, resulting in passenger spillover on road. • Discontinuous and Encroached footpaths, result in pedestrian spillover on road. • Streets partially encroached by on-street parking and vendors combined with heavy pedestrian movement results in traffic congestion during peak hours.	• Land / property acquisition is indispensable for construction of entries / exist. • Discontinuous and Encroached footpaths, On-street parking of vehicles are the major concern of traffic circulation. • Undefined and inadequate Bus stop area. •	• Located in high density area which will generate significant ridership for the station. • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange.
8	Girgaon Metro	• Very limited Right Of Way. • Unorganized pick-drops of Buses on Bus stops and Bus terminal resulting in traffic chaos. • Lack of defined Auto stand/bays results in on-street parking of autos, creating hindrance to the pedestrian movement and vehicular traffic and reducing the road traffic capacity. • Discontinuous and Encroached footpaths result in pedestrian spillover on road.	• Land / property acquisition is indispensable for construction of entries / exist. • Encroached footpaths, on-street parking of vehicles are the major concern due to absence of adequate formal off-street parking. • Unorganized pick-drops of Buses on Bus stops and Bus terminal	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Located in high density area which will generate significant ridership for the station.
9	Grant Road Metro	• Very limited Right Of Way. • Discontinuous footpaths and Encroachment by informal activities near the bus-stop resulting in pedestrian movement on roadway and conflicting with the vehicular movement. • Absence of pedestrian crossing facilities results in traffic congestion and pedestrian – vehicle conflicts. • Parking of vehicles on footpath due to lack of adequate formal off-street parking facilities.	• Land / property acquisition is indispensable for construction of entries / exist. • Limited scope of new infrastructure due to heavily built area. For the provision of new public facilities land would be need to be acquired	• Proximity to Grant Road suburban station will aid in better integration with the suburban system. • Located in high density area which will generate significant ridership for the station.
10	Mumbai Central Metro	• Encroachment on footpaths by informal activities resulting in obstruction to pedestrian movement. • Closure of footpath at one side of junction	• Limited scope of new infrastructure due to heavily built area. Lan would need to be acquired to provide new public facilities. • Constrained road capacity with heavy	• Proximity to Mumbai Central suburban station will aid in better integration with the suburban system. • Located in high density area which will

S. No.	Station	Issues	Concerns	Potentials
		forces pedestrians to walk on carriageway further creating conflict with vehicular traffic • In absence of adequate formal off-street parking, on-street parking of vehicles on footpath also can be observed. • Due to limited capacity of taxi stand, on-street parking of taxis is observed • Pedestrian – vehicle conflicts are created at the junction due to heavy vehicular traffic.	vehicular traffic & on-street parking.	generate significant ridership for the station.
11	Mahalaxmi Metro	• Encroachment on footpaths by informal activities resulting in obstruction to pedestrian movement. • Absence of continuous footpath forces pedestrians to walk on carriageway. • Due to absence of adequate formal off-street parking, on-street parking of vehicles on footpath also can be observed. • Lack of defined Taxi stand/bays results in haphazard on-street parking of taxis creating hindrance to the traffic and reducing the capacity of the road. • Pedestrian – vehicle conflicts are created on Bapurao Jagtap Marg due to absence of pedestrian crossing facilities. • Constrained road capacity in comparison to the heavy vehicular traffic.	• During peak hours intersection on E. Moses road with station roads proves critical, resulting in traffic jams on all the arms of Jacob Circle. • Long taxi queues near petrol pump on Sane Guruji Marg add to traffic chaos	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Proximity to Mahalaxmi suburban station will aid in better integration with the suburban system. • Scope of generating revenue through advertisements/ commercial development of surrounding station area
12	Science Museum	• Absence of continuous footpath with on-street parking of trucks results in pedestrian spillover on road • Encroachment on footpaths by informal activities resulting in obstruction to pedestrian movement. • Closure of footpath at one side of junction forces pedestrians to walk on carriageway further creating conflict with vehicular traffic. • Unorganized Taxi stands and lack of pick/drop	• Discontinuous footpaths and Encroachment by informal activities and on-street parking of vehicles are the major concern. • Unorganized Taxi stands and lack of pick/drop areas.	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Scope of going high rise & earning benefits from commercial development of surrounding station area.

S. No.	Station	Issues	Concerns	Potentials
		areas results in traffic congestion and pedestrian – vehicle conflicts		
13	Acharya Atrey Chowk	• Unorganized Taxi stands and lack of pick/drop areas results in traffic congestion and pedestrian – vehicle conflicts • Encroached footpaths by informal activities, bus-stop resulting in pedestrian movement on roadway and conflicting with the vehicular movement. • Unorganised pedestrian and vehicular movement near the intersections results in traffic congestion.	• Traffic congestion due to on-street parking and encroachment and lack of pedestrian facilities increase the conflict of pedestrian – vehicular traffic. • Unorganized Taxi stands and lack of pick/drop areas, discontinuous and encroached footpaths are the major concern.	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Wide footpaths can accommodate the passenger dispersal. Located in high density area which will generate significant ridership for the station.
14	Worli	• Heavy pedestrian traffic on road conflicting with vehicular traffic due to unutilization of footpath on some road stretches. • Undefined Taxi/Auto stands and lack of pick/drop areas results in traffic congestion and pedestrian – vehicle conflicts. • Encroached footpaths by informal activities near the station, bus-stop resulting in pedestrian movement on roadway and conflicting with the vehicular movement.	• Lack of designated Pick-Drop and parking areas are the major concern Encroachment on footpaths and streets by vendors and shopkeepers	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Scope of generating revenue through advertisements/ commercial development of surrounding station area
15	Siddhi Vinayak	• Absence of proper bus bays forcing people to encroach the carriageway as well as available footpath behind the bus shelter. • Unavailability of specific taxi stand area resulting in on-street parking of taxis, thus reducing the capacity of carriageway near the station area. • Discontinuous and encroached footpath resulting in pedestrian spillover on road. • Encroachment of road by parking of vehicles reduces its capacity but also forces pedestrians to walk on carriageway.	• Petrol Pump near Siddhi Vinayak crossing results in chaotic traffic conditions. • Boundary wall of Siddhi Vinayak temple reduces road width from five lane to three lane carriageway on a certain stretch of road near proposed metro station.	• At-grade station structures can be accommodated on the vacant land near the station area, which can be used for generating revenue through advertisements/ commercial developments. • Will cater to the potentially high ridership from the famous Siddhi Vinayak temple and surrounding dense areas.

S. No.	Station	Issues	Concerns	Potentials
16	Dadar Metro	• Wide footpaths are encroached upon by the informal activities, thus reducing the walkable area. • High incidence of on-street vendors and encroachments. • On-street parking of vehicles reduces the existing carriageway capacity. • Heavy traffic jam due to nearby Dadar Market area.	• Heavy traffic jam on Ranade Road during peak hours due to traffic from Dadar market area. • If dispersal locations are not planned and controlled properly, results in chaotic traffic conditions on Gopal Krishna Gokhale road. • Limited scope of new infrastructure due to heavily built area for the provision of new public facilities land would need to be acquired	• Wide footpaths can accommodate the passenger dispersal. • Proximity to Dadar suburban station will aid in better integration with the suburban system. • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange.
17	SheetlaDevi Temple	• Streets partially encroached by the parking and vendors combined with heavy pedestrian movement results in traffic congestion during peak hours. • Encroached footpaths by informal activities resulting in pedestrian movement on roadway and conflicting with the vehicular movement. • Undefined Taxi/ Auto stand conflicts the vehicular and pedestrian movement. • On-street parking of vehicles on footpath creating hindrance to the pedestrian movement and vehicular traffic and reducing the capacity of the road.	• On-street IPT, absence of designated pick-drop result in undesirable pedestrian-vehicle conflicts and inefficient traffic circulation. • Footpaths encroached by informal activities result in pedestrian movement on carriageways.	• Wide footpaths can accommodate the passenger dispersal. • Located in high density area which will generate significant ridership for the station.
18	Dharavi Metro	• Encroachment on footpath by informal activities results in obstruction to pedestrian movement. • Parking of vehicles on footpath leaves no space for pedestrians resulting in pedestrian spillover on the road • Haphazard on-street parking of autos and taxis can be observed at the junction due to lack of defined taxi. Auto bays/ stand	• Encroachment on footpath by informal activities and limited width of footpath are the major concerns. • Parking of vehicles on footpath is also a matter of concern.	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange.

S. No.	Station	Issues	Concerns	Potentials
19	Bandra Metro	• Interchange with Charkop-Bandra –Mankhurd Metro Line needs to be suitably addressed	• The immediate surroundings have marshy land wherein the facilities like parking cannot be planned because of Environment concerns and clearances	• Large employment base in the catchment area • Wide footpaths which can accommodate the passenger dispersal • Will cater to the ridership from the proposed Metro Line II i.e. Charkop – Bandra – Mankhurd • Future possibilities of high density as large chunk of land is still vacant which will add to the metro ridership
20	Kalina University	• Standard road Cross-section needs to be developed	• Entry/ Exits should be integrated with University Developments.	• Adequate Road widths available to accommodate station entries/ exits and station infrastructure on ground • Ample open space for development of Depot
21	Santacruz Metro	• The presence of main highway – heavy traffic flows and suburban railway station – heavy pedestrian flows, make the location of station critical • Lack of defined auto bays near the suburban station which results in haphazard street parking creating hindrance to traffic and reducing capacity of Road • Crawling auto rickshaws which hinders the traffic flow • Underutilized pedestrian facilities i.e. Skywalk and Subway - at grade crossing is practiced by the pedestrian due to lack of enforcement	• Limited scope of new infrastructure due to heavily built area. For the provision of new public facilities land would be need to be acquired • Located on the main Western Expressway which can lead to chaotic conditions if dispersal locations are not planned and controlled properly due to weaving of slow traffic with the fast traffic on Expressway	• Scope of going high rise and earning benefits from commercial development of station area (by increased FSI) • Located in high density area which will generate significant ridership for the station. • Proximity to Santacruz suburban station will aid in better integration with the suburban system. • Wide footpaths which can accommodate the expected passenger dispersal • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Presence of pedestrian facilities like Skywalk and subway which can be utilized for safe and convenient interchange
22	CSIA Domestic Airport	• Integration with Domestic Airport Terminal for efficient passenger dispersal	• Traffic Circulation needs to be integrated with the proposed airport development plans	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • The proposed station will serve the Domestic Airport Terminalpassengers and employees
23	Sahar Road	• Encroachment on footpath by slum areas of Sahar Village create hindrance to pedestrian	• Encroachment on footpath by informal activities and haphazard on-street parking	• Bus stop location adjacent to the proposed station will aid in accessible and more efficient

S. No.	Station	Issues	Concerns	Potentials
		movement. • Haphazard on-street parking of autos and taxis can be observed due to lack of defined taxi /Auto bays • Pedestrian – vehicle conflicts can be seen at the junction.	of autos/ taxis are the main concerns.	passenger interchange.
24	CSIA International Airport	• Existing construction at the site of proposed station creates hindrance in the smooth flow of traffic • Haphazard on-street parking of autos and taxis in absence of organized auto/ taxi stan	• On-street parking of autos and taxis is a major concern because of lack of proper taxi stand	• Proposed station will serve the passengers and employees at the upcoming International Airport Terminal • Bus stop location adjacent to the proposed station will aid in accessible and more efficient passenger interchange.
25	Marol Naka	• Main linking road with heavy traffic flows, face traffic jams during peak hours • Intense pedestrian – vehicle conflicts, Haphazard pedestrian crossing, especially at Marol Naka Intersection • Undefined and haphazard auto stands and pick/drop operations compound the traffic chaos on Andheri Kurla Road • Encroached footpaths by informal activities and projections by shopkeepers results in pedestrian movement on roadway • Discontinuous and encroached footpaths resulting in pedestrian spillover on road	• Limited scope of new infrastructure due to heavily built area. For the provision of new public facilities land would be need to be acquired • Both the station i.e. of Line I and present corridor are located on the edge of the main Marol Naka Intersection, uncontrolled dispersal can lead to chaotic conditions on the main Andheri – Kurla Road	• Located in high density area which will generate significant ridership for the station. • Will cater to the ridership from the proposed Metro Line I i.e. Versova – Andheri – Ghatkopar • Scope of redeveloping the Chimatpada hutment area and new large commercial development which can bring the authority monetary benefits
26	MIDC	• Encroachment of road by parking of vehicles reduces the effective width of carriageway. • Discontinuous and encroached footpath	• Land would need to be acquired for at-grade station infrastructure	• Will cater to the ridership from MIDC area and surrounding dense areas.
27	SEEPZ	• Encroachment of road by parking of vehicles reduces the effective width of carriageway. • Discontinuous and encroached footpath by unauthorized shops resulting in pedestrian movement on carriageway. • Undefined and haphazard auto stand and pick/ drop operation near entrance to SEEPZ add to the traffic chaos.	• Land would need to be acquired for at-grade station infrastructure	• SEEPZ Bus Depot and Taxi stand location adjacent to the proposed station will aid in accessible and more efficient passenger interchange. • Will cater to the ridership from SEEPZ area and surrounding dense areas.

i. Colaba/ Cuffe Parade Station

1. Traffic characteristics on Cuffe Parade road with on-street parking

2. Encroachment on footpath along with parking on footpath

3. Encroachment on footpath by informal activities along with on-street parking

4. Unutilisation of footpath with pedestrian movement on road

5. Absence of footpath results in pedestrian traffic conflicting with vehicular traffic

6. Encroachment on footpath by shopkeepers

ii. Badhwar Park

1. Encroachment on footpath obstructs the pedestrian movement

2. On-street parking of taxis in absence of defined taxi bay/ stand

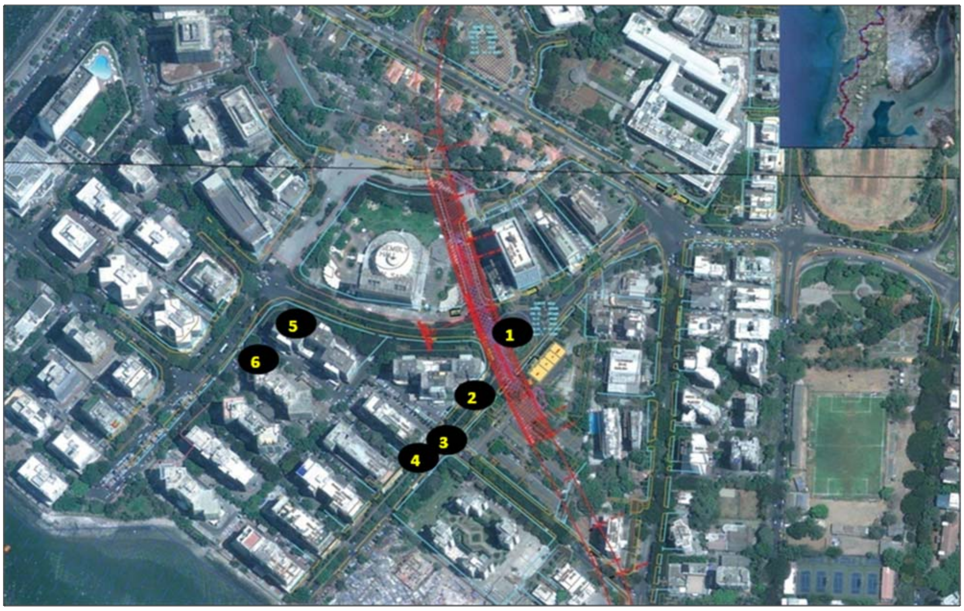
3. Encroachment on footpath by informal activities

4. Parking of vehicles on footpath blocks the passage

5. Traffic characteristics at the station area

6. Pedestrian spillover on the road due to encroachment on footpath

iii. Vidhan Bhavan



1. Traffic characteristics with major share of taxis

2. Pedestrian spillover on the road

3. Encroachment on footpath hinders the pedestrian movement

4. Pedestrian conflicting with vehicular traffic

5. Encroachment on footpath along with on-street parking of vehicles

6. Encroachment on footpath by informal activities

iv. Churchgate Station

1. Passengers cross M. Karve road at-grade - conflicting with vehicular traffic.

2. Lack of defined taxi stand and bus bays - resulting in congestion.

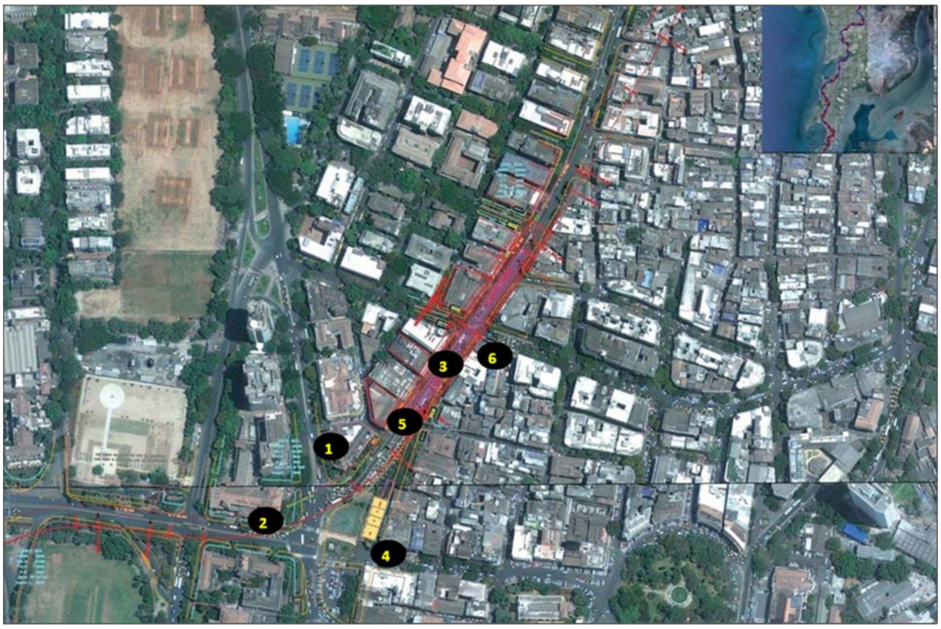
3. Chaotic scenario due to pedestrian-

4. On-street parking and Encroachment on

5. Traffic chaos due to on-street parking and encroachment on Jamshedji Tata Road

6. Heavy at-grade pedestrian crossing conflict with vehicular traffic

v. Hutatma Chowk



1. Encroachment on footpath by street

2. Encroachment on footpath by

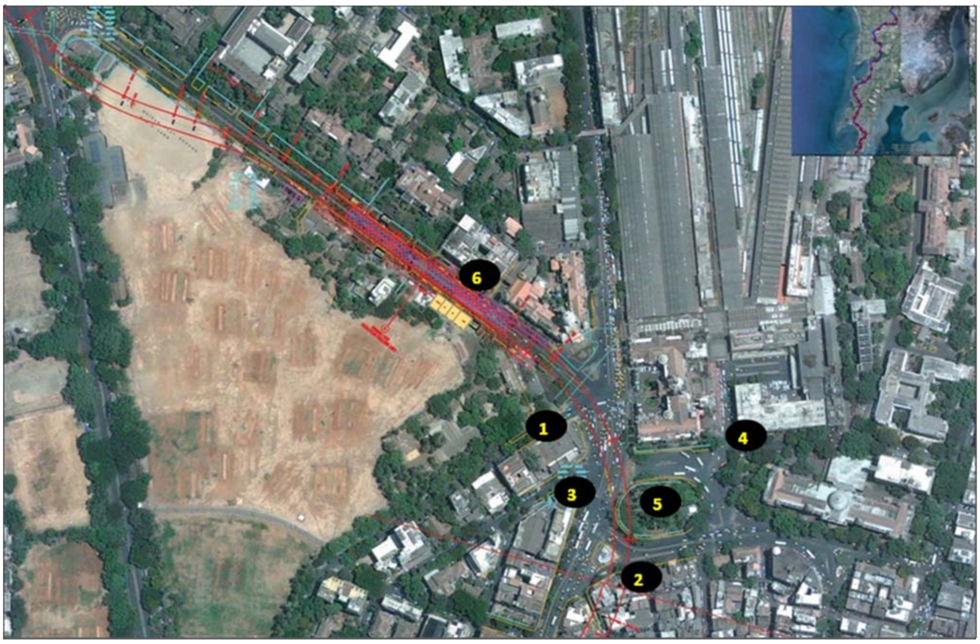
3. Traffic characteristics on Dadabhai Naoroji

4. Heavy pedestrian traffic along with

5. Pedestrian – vehicle conflict

6. Encroachment on footpath along with on-street parking of vehicles

vi. CST Metro Station



1. Pedestrians conflicting with heavy vehicular traffic

2. Encroachment on footpath by informal activities

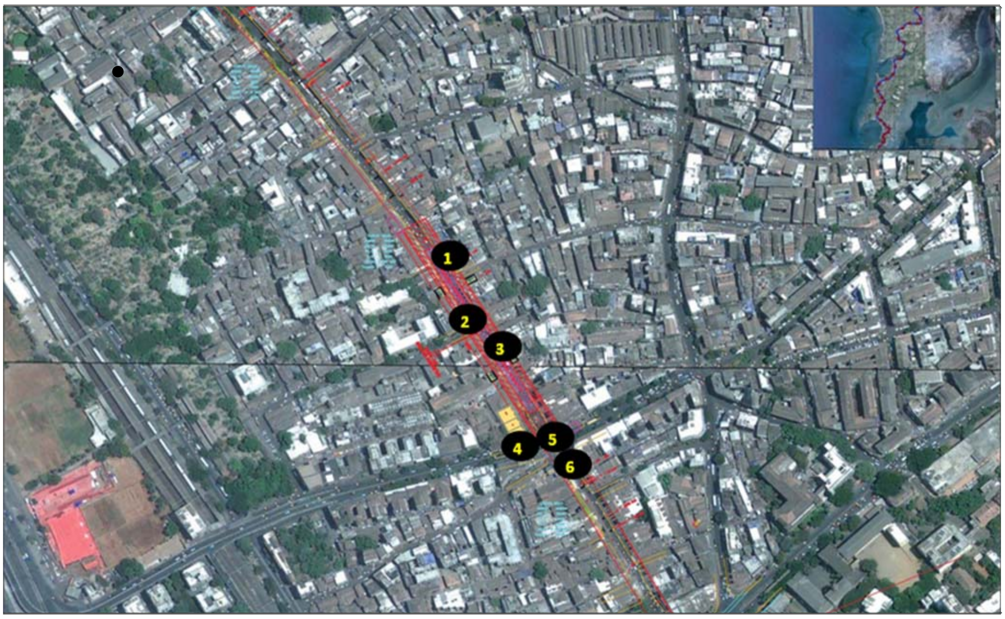
3. Heavy pedestrian crossing traffic

4. Encroachment on footpath

5. Heavy pedestrian movement on road due to encroachment on footpath

6. On-street parking of vehicles on fotpath

vii. Kalbadevi



1. Traffic chaos due to on-street parking along with pedestrian spillover on road

2. Insufficient width of footpath results in pedestrian movement on carriageway

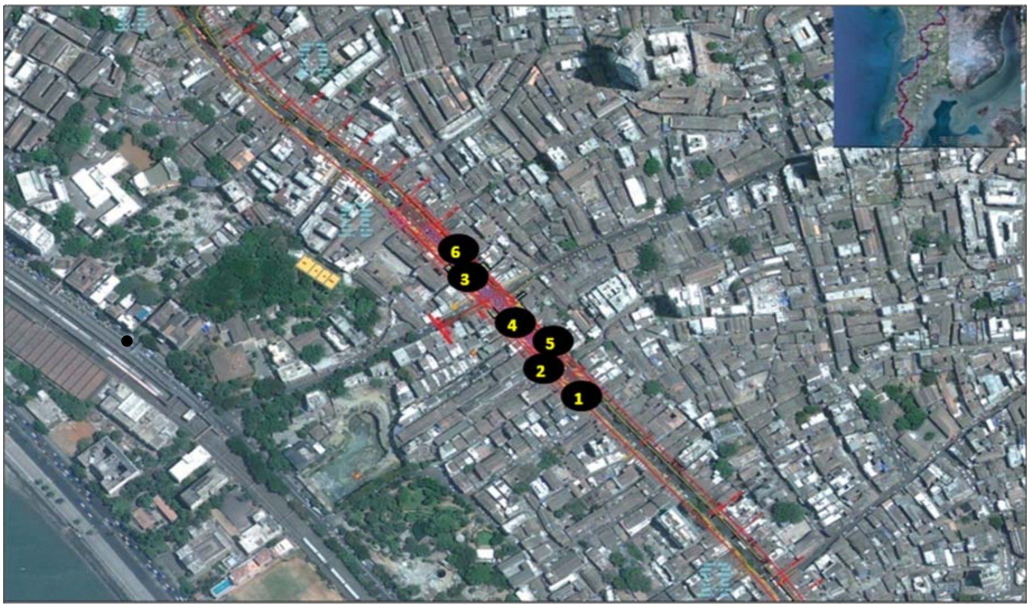
3. Passengers waiting on the road due to absence of footpath and proper bus shelter

4. Encroachment on footpath hinders the pedestrian movement

5. Pedestrian – vehicle conflict at the junction

6. On-street parking of vehicles on footpath obstructs the pedestrians

viii. Girgaon



1. Passengers waiting on the road due to absence of bus shelter

2. Pedestrian spillover on the road

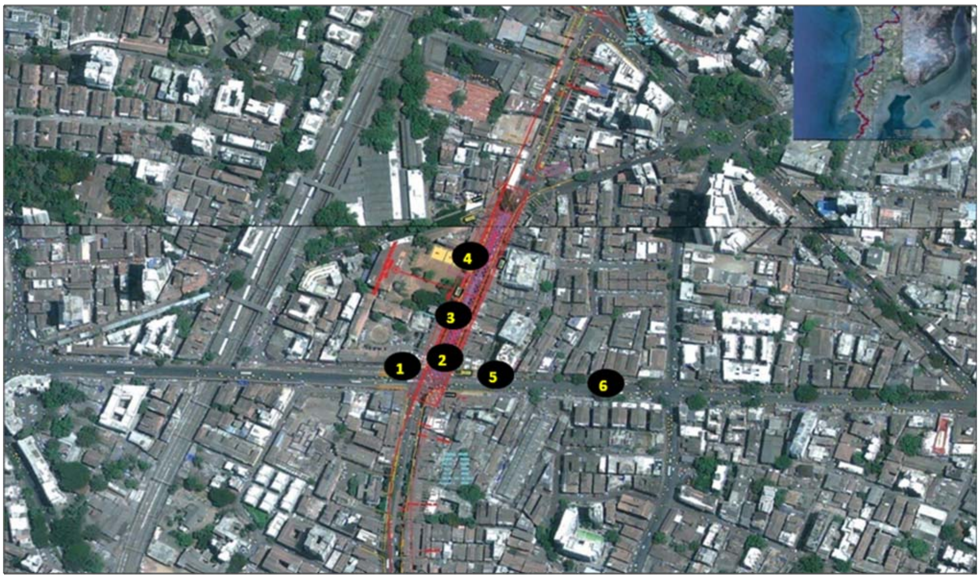
3. Heavy pedestrian traffic with limited width of footpath

4. Pedestrian – vehicle conflict

5. Encroachment on footpath along with on-street parking of vehicles

6. On-street parking of vehicles reduces the effective carriageway width

ix. Grant Road Metro



1. Encroachment on footpath by informal activities along with pedestrian movement

2. Encroachment on footpath by informal activities hinders pedestrian movement

3. Pedestrian – vehicle conflict due to absence of pedestrian crossing facilities

4. Parking of vehicles on footpath due to lack of parking facilities

5. Pedestrian spillover on road in absence of sufficient footpath width

6. Encroachment on footpath by unauthorized shops

x. Mumbai Central Station

1. Heavy traffic with major share of taxis on Jehangir Boman Road

2. Pedestrian – vehicle conflict at the junction during peak hours

3. Encroachment on footpath near the station entry

4. Closure of footpath forces pedestrian to walk on road creating conflicts with vehicle

5. Encroachment on footpath by informal activities obstructs pedestrian movement

6. On-street parking of vehicles on footpath

xi. Mahalaxmi

1. Congested street with heavy vehicular traffic

2. Encroachment on footpath creates obstruction to pedestrians

3. Pedestrian-vehicle conflict on Bapurao Jagtap Marg

4. Absence of footpath forces pedestrians to walk on carriageway

5. Encroachment along with on-street parking of vehicles on the footpath

6. Encroachment on footpath and road with haphazard on-street

xii. Science Museum

1. Bad condition of footpath creates difficulty for pedestrians

2. Haphazard on-street parking of taxis in absence of organized taxi stand

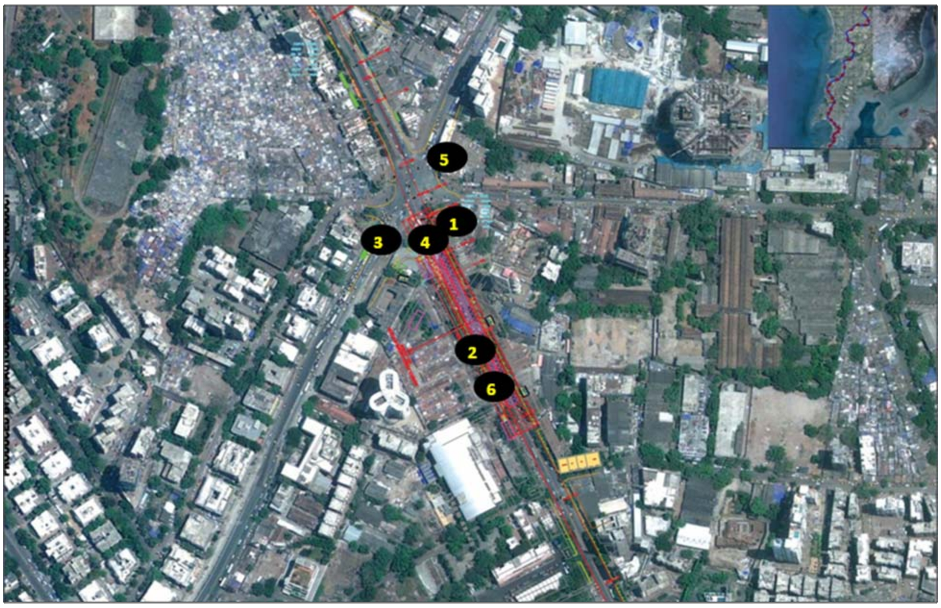
3. Encroachment on footpath by informal activities

4. Closure of footpath due to encroachment obstructs the pedestrian movement

5. Traffic characteristics with major share of taxis

6. Absence of footpath with on-street parking of trucks

xiii. Acharya Atrey Chowk



5. Footpath encroached by unauthorized shops forces pedestrian to walk on

6. Encroachment on footpath by slums results in pedestrian spillover on road

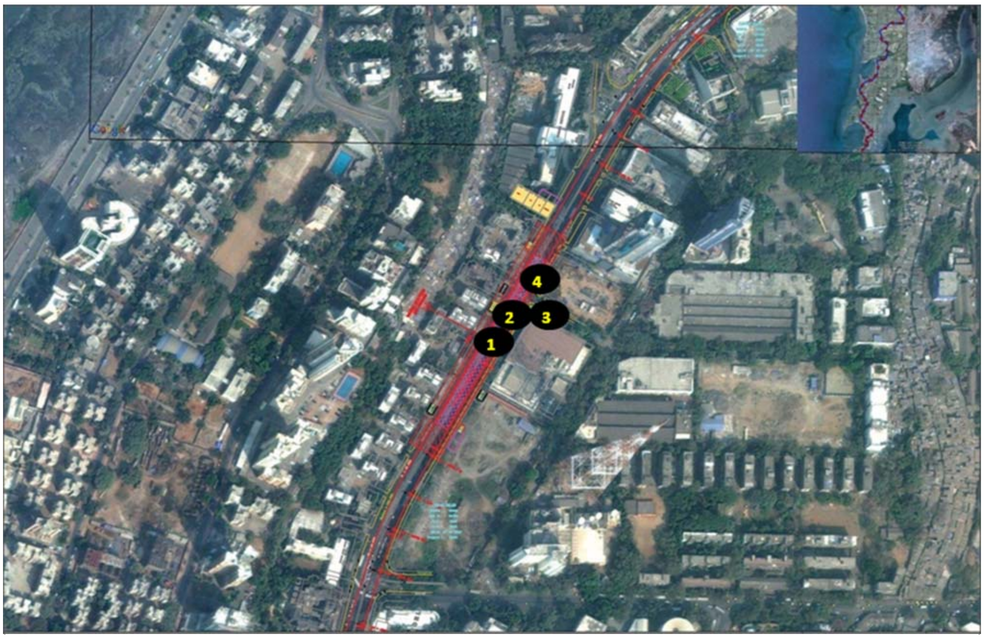
1. On-street parking of vehicles on footpath due to absence of parking facilities

2. On-street parking of taxis in absence of organized taxi stand

3. Encroachment on footpath by informal activities hinders pedestrian movement

4. Pedestrian – vehicle conflict at the junction

xiv. Worli



1. Passengers spillover on road near the bus stop

2. On-street parking of taxis in absence of organized taxi stand

3. Encroachment on footpath by informal activities results in pedestrian spillover on

4. Traffic during peak hour

xv. Siddhi Vinayak

1. Encroachment and on-street parking of vehicles on footpath

2. Traffic characteristics on the road with major share of private vehicles

3. Lack of organized taxi stand/bays results in on-street parking of taxis

4. Pedestrian – vehicle conflict at the junction

5. Parking of vehicles on the road obstructing the pedestrians

6. Heavy pedestrian movement on back side of the temple

xvi. Dadar Metro Station

1. On-street parking of vehicles on footpath

2. Pedestrian – vehicle conflict due to absence of pedestrian crossing facilities

3. Encroachment on footpath by informal activities obstructing pedestrian movement

4. Haphazard on-street parking of taxi due to absence of organized taxi stand

5. Encroachment on footpath by informal activites

6. On-street parking of vehicles on internal road due to absence of proper parking

xvii. SheetlaDevi Temple

1. Encroachment on footpath by informal activities near the temple

2. On-street parking of vehicles on footpath

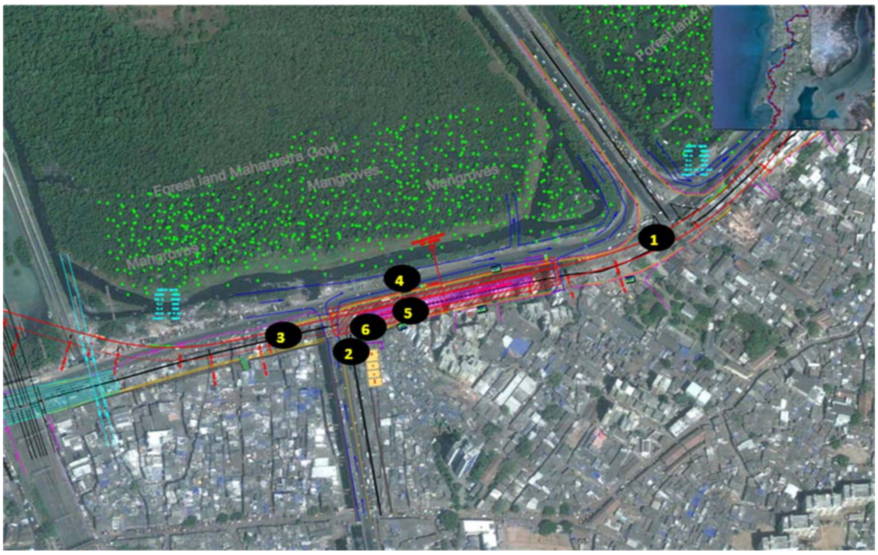
3. Encroachment on footpath by informal activities disrupts the pedestrian movement

4. Encroachment on footpath by unauthorized shops

5. Pedestrian – vehicle conflict can be seen at the junction

6. Movement of cycles on the footpath along with parking of vehicles

xviii. Dharavi Metro Station



1. Haphazard on-street parking of autos in absence of organized auto stand

2. Traffic characteristics showing mixed traffic conditions

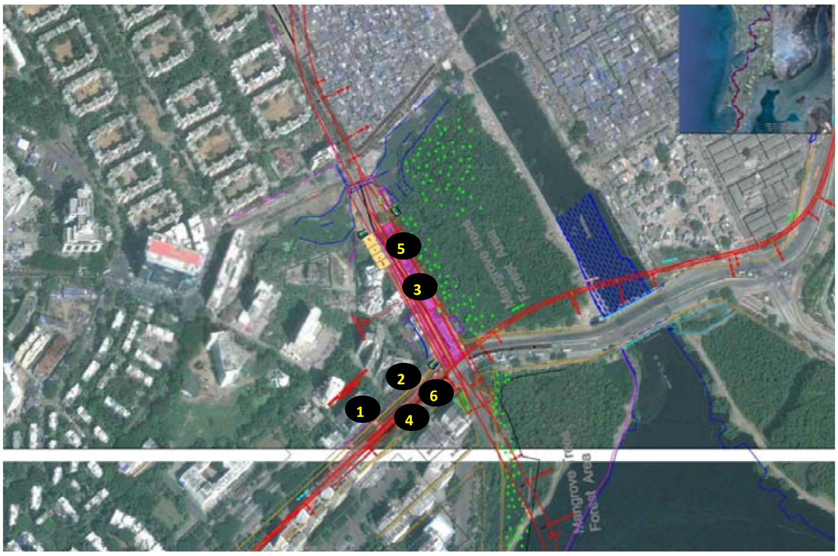
3. No space for pedestrians due to encroachment on footpath

4. On-street parking of taxis

5. Parking of vehicles on footpath

6. Encroachment on footpath along with parking of vehicles obstructs the

xix. Bandra Station



1. Wide sidewalks on Andheri Kurla Road

2. Presence of bus stops near employment centers

3. Location of metro station is proposed on St. Dynaeshwar road

4. Buses are the existing main mode of public transport to the area

5. Metro Line II will provide integration with Bandra Kurla Complex along the

6. Undefined/ Informal IPT stands

xx. Santacruz Station

1. Skywalk connecting Western Expressway with Suburban Railway Station – Potential for Integration

2. Underutilized subway

3. High incidence of parking of commercial vehicles on service road and beneath the western express flyover

4. Chaotic traffic conditions on station road – lack of enforcement resulting in at grade pedestrian crossing on western expressway

5. Misuse of provided facilities – encroachment and parking of

7. Encroachment by shopkeepers on footpaths and parking on road forcing pedestrians to

xxi. CSIA (Domestic)

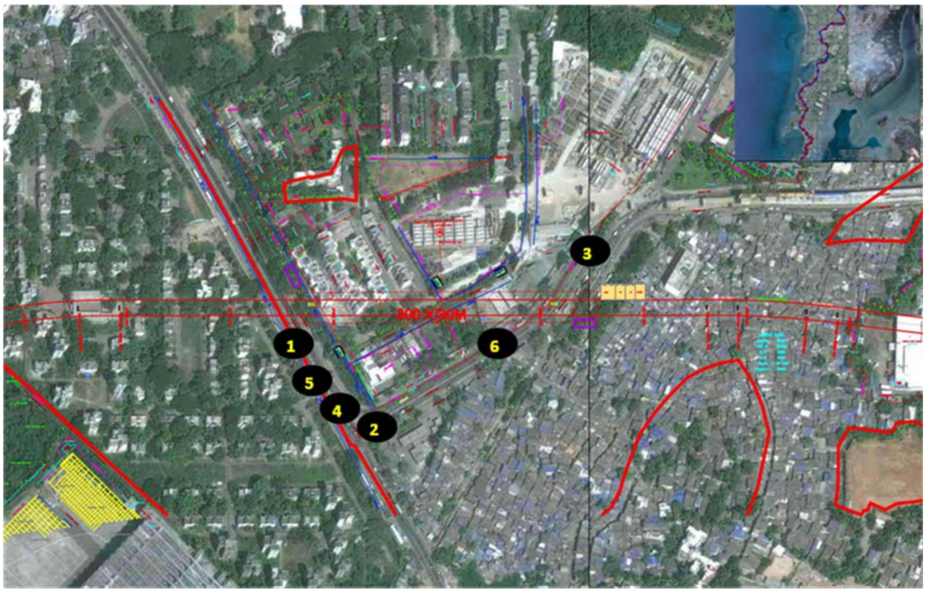
1. Traffic on the road adjacent to Sahara Star Hotel

2. Long queue of taxis waiting for the turn

3. On-street parking at the side of Sahara Star Hotel

4. Parking of taxis at Taxi stand

xxii. Sahar Road Metro Station



1. Haphazard on-street parking of autos affect the traffic flow

2. Formation of slums along the road

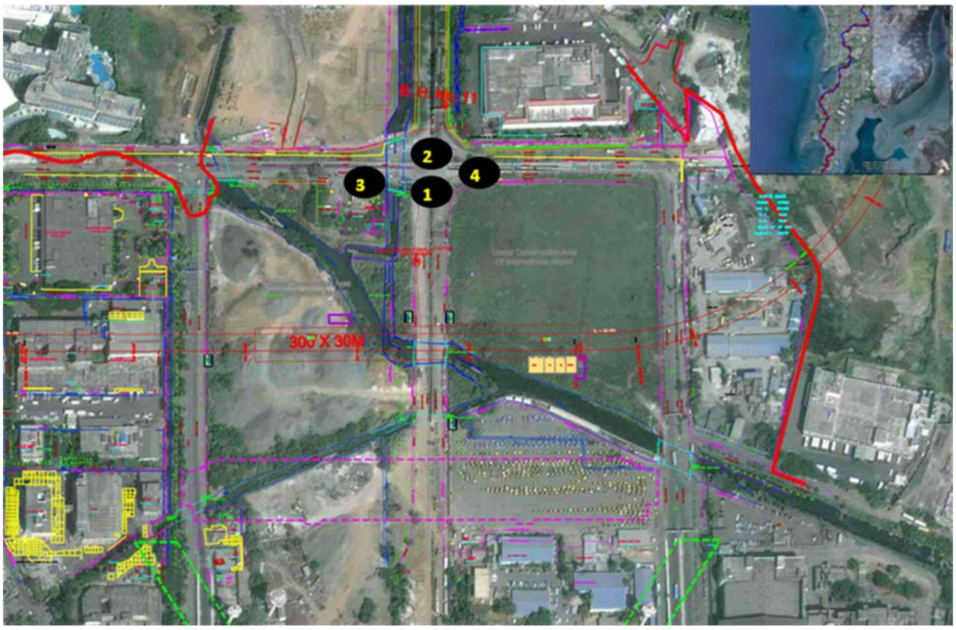
3. On-street parking characteristics

4. Pedestrian – vehicle conflict at the

5. Pedestrian movement on the road

6. Traffic characteristics near station area

xxiii. CSIA (International)



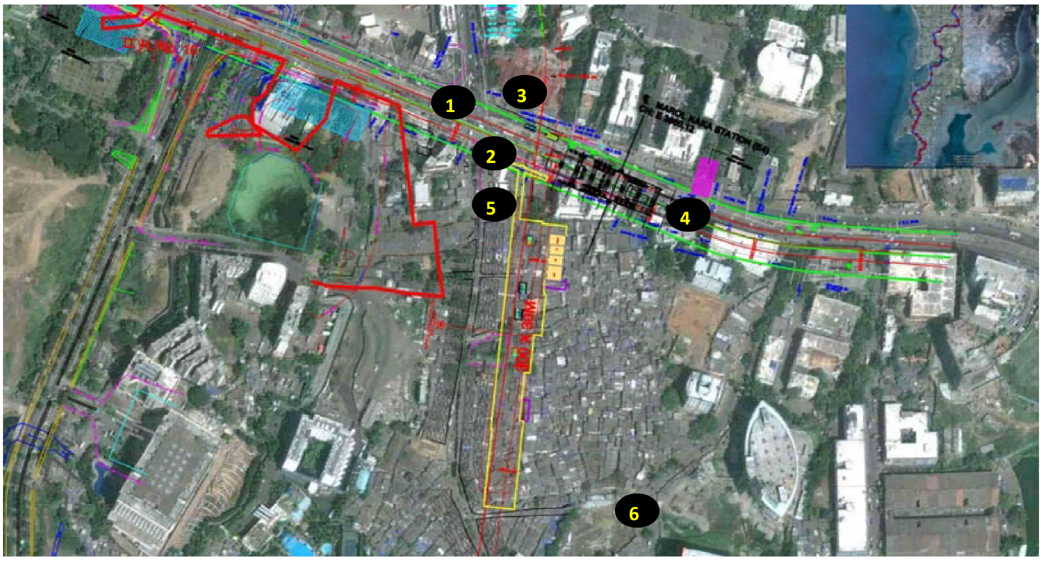
1. Construction at the site of proposed metro station

2. Traffic characteristics at the junction

3. On-street parking of taxis due to absence of organized taxi stand

4. Existing construction disturbs the smooth flow of traffic

xxiv. Marol Naka Station



1. Mixed traffic conditions on Andheri Kurla Road near Marol Naka Intersection

2. Heavy traffic flow during peak hour on Andheri Kurla Road near Marol Naka Intersection

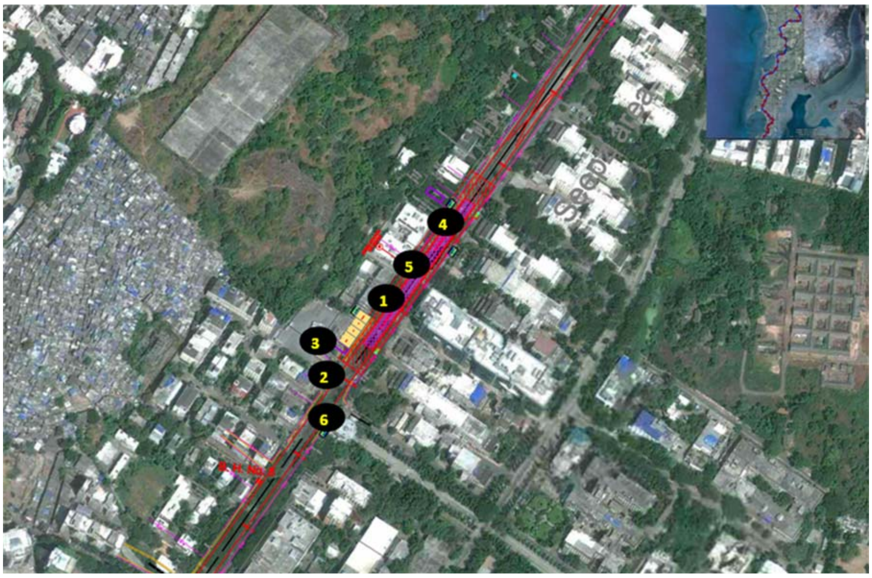
3. Discontinuous footpaths forcing pedestrians to use roadway

4. Encroached footpaths resulting in pedestrian movement on road and hence slow traffic movement

5. Proposed Station location near Chimatpada Hutment – land acquisition/ redevelopment required

6. Proposed Station area near Himatpada hutment – Catchment area includes upcoming commercial establishments

xxv. SEEPZ Station



1. Haphazard on-street parking of autos create hindrance to traffic

2. Pedestrian – vehicle conflict due to absence of pedestrian crossing

3. Seepz bus stand near the station entry

4. Pedestrian spillover on road due to encroachment on footpath

5. Encroachment on footpath by informal activites

6. Mixed traffic condition on KLS Marg in front of Seepz Main gate

5.4.2 Proposed Traffic Dispersal and Circulation Plan

The proposals have been formulated for facilitating efficient dispersal and circulation, based on the following considerations,

- Minimizing Pedestrian/Vehicle Conflicts: The circulation area adjoining the station building be properly designed to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic. The circulating area provide adequate parking space, nominated space for embarking and disembarking for vehicular traffic (pick-drop zones). The availability of total carriageway widths and footpath widths required to cater to the increase in traffic volumes is proposed to be augmented through strengthening of road shoulder areas and relocation of vendors/hawkers, On-street parking and all encroachments from the Service access Roads and Station Roads.
- Facilitating Passenger Interchange: As far as possible, facilities be planned to ease passenger interchange. Dedicated linkages be provided like Subway/FOB landings directly into the circulating areas of respective stations, provision of Bus Stops, IPT stands etc.
- Pedestrian Safety: For pedestrian safety, it becomes essential that pedestrians are guided into and out of station through a system of footpaths, foot over bridges, skywalks , etc; as feasible.

Hence, the proposals highlight the measures required to meet the shortfall in capacity in terms of road capacity, traffic movement/ circulation, pedestrian facilities, bus stops, IPT stands/ Pick-Drop areas and parking.

The Traffic Dispersal and Integration facilities proposed for individual metro stations are presented in **Tables 5.9** to **5.35**.

The street level intermodal integration plans indicating the traffic circulation and proposed road infrastructure / argumentation in the station precinct areas are also presented (**Figures 5.32** to **5.43**) for the major interchange and terminal stations viz.

- Colaba/ Cuffe Parade
- Churchgate Metro
- CST Metro
- Mumbai Central Metro
- Mahalaxmi Metro
- Sidhivinayak
- Dadar Metro
- Sheetla Devi
- Bandra Metro
- Santacruz Metro
- Marol Naka
- SEEPZ Metro

Table 5.9: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Colaba/ Cuffe Parade Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
G.D. Somani Road	18.5 m	9250 PCU	1890 PCU	• Encroachment and on-street parking	• Removal of encroachments and On -street parking	9250 PCU	2540 PCU
Cuffe Parade Rd	22m	11000 PCU	2650 PCU	• On-street parking and vendors constrain vehicular movement	• Relocation of venders , Removal of encroachments and On-street parking	10000 PCU	3570 PCU
Pedestrian Facilities							
G.D. Somani Road	6.0 m	6000 persons	1620 persons	• Pedestrian movements conflicting with vendors and IPT movements,	• Provision of continuous & uniform footpaths, pedestrian guardrails, zebra crossing, road markings and traffic signages • Removal of vendors from foot path	6000 persons	5800 persons
Cuffe Parade Road	5.5 m	5500 persons	2475 persons	• Discontinuous and encroached Footpath along with parking	• Station Entry/ Exits provided across all directions for facilitating convenient access • Removal of encroachments from footpath and continuous uniform footpath width	7000 persons	6350 persons
Bus Stops							
		On-Street	1 Bus/ minute	• The on-street and undefined Bus Stops impede traffic flow	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits and also at Colaba Backbay bus depot	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Bus / minute
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	1 Taxi/ minute	• The on-street Taxi Stops impede traffic flow • No Designated Pick-Drop Areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 4 Taxi / minute in peak hour per direction	2 Taxi / minute
Parking							
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Limited parking facilities with defined parking bays (about 75) is suggested near the station, along service road on Cuffe Parade Road		

Table 5.10: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Badhwar Park Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
General Jaganath Roa Bhosale Road	22m	11000 PCU	4890 PCU	• On-street parking and vendors constrain the vehicular movement	• Removal of encroachments and on-street parking	9000 PCU	6580 PCU
Pedestrian Facilities							
General Jaganath Rao Bhosale Road	3.5m	3500 persons	2430 persons	• Discontinuous and encroached foot path with vendors and IPT movements,	• Removal of vendors from foot path and provision of continuous uniform footpath	6000 persons	5600 persons
Bus Stops							
		On-Street	1 Bus / minute	• The on-street Bus Stands conflict with the heavy pedestrian volumes and IPT Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	1 Bus bays to handle a total of at least 2 buses/ minute in peak hour per direction	2 bus /min
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	3 Taxi / minute	• Haphazard on-street taxi stand impede traffic flow • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	3 Taxi bays to handle a total of at least 7 Taxi / minute in peak hour per direction	5 Taxi / minute

Table 5.11: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Vidhan Bhavan Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Barrister Rajini Patel Marg	18m	9000 PCU	4820 PCU	• Encroachment and on-street vendors on reduce the effective carriageway width.	• Strengthening of Road shoulder areas, Relocation of Vendors/ Hawkers from roadway	9000 PCU	6490 PCU
Free press journal road	15m	7500 PCU	6820 PCU	• High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts, Haphazard pedestrian Crossings	• Provision of continuous & uniform footpaths, pedestrian guardrails, zebra crossing, road markings and traffic signages • Strengthening of Road shoulder areas	7500 PCU	8000 PCU
Pedestrian Facilities							
Barrister Rajini Patel Marg	8m	8000 persons	2350	• Discontinuous and encroached foot path with vendors and IPT movements,	• Removal of vendors from foot path and re-organised pick and drop area.	8000 persons	5300 persons
Free press journal road	9m	9000 persons	2680	• Encroached footpaths by informal activities	• Removal of vendors from foot path.	9000 persons	5700 persons
Bus Stops							
		On-Street	2 buses /minute	• The on-street Bus Stops impede traffic flow	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	3 buses / minute
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	2 Taxi / minute	• The on-street Taxi Stops impede traffic flow • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 5 Taxi / minute in peak hour per direction	4 Taxi / minute

Table 5.12: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Churchgate Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
				Roads			
Jamshedji Tata Road	22.5m	11250 PCU	8200 PCU	• On-street parking of vehicles	• Removal of on-street parking by providing off-street parking near the station.	11250 PCU	11047 PCU
Maharshi Karve Road	21m	10500 PCU	8785 PCU	• Lack of formal taxi stand	• Strengthening of Road shoulder areas for increasing road traffic capacity	10500 PCU	10035 PCU
Veer Naraiman Road	21m	10500 PCU	8820 PCU	• Encroachment of vendors and on-street parking	• Strengthening of Road shoulder areas, Relocation of Vendors/ Hawkers from roadway.	10500 PCU	10165 PCU
				Pedestrian Facilities			
Jamshedji Tata Road	8m	8000 persons	6618 persons	• Discontinuous and Encroached footpaths	• Station Entry/ Exits provided across all directions for facilitating convenient access • Existing subway near Churchgate suburban station proposed to be augmented with connections to the Metro station and across intersection	14000 persons	11500 persons
				Bus Stops			
		On-Street	2 Buses/ Minutes	• Undefined and inadequate Bus stop area • Conflict with the heavy pedestrian volumes and Taxi Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	3 Bus bays to handle a total of at least 5 buses/ minute in peak hour per direction	3 Buses / Minutes
				IPT (*Taxi*) Stands/ Pick-Drop Areas			
		On-Street	6 Taxi / minute	• Conflict with the heavy pedestrian volumes and Taxi Movements • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	7 Taxi bays to handle a total of at least 17 Taxi / minute in peak hour per direction	9 Taxi / minute
				Parking			
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Formal parking facilities can be provided at Oval Maidan, subject to land availability		

Table 5.13: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Hutatma Chowk Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Dr. Dadabhai Naoroji Road	25m	12500 PCU	2080 PCU	• on-street vendors, High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts, Haphazard pedestrian Crossings	• Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages • Removal of on-street parking by providing off-street parking near the station.	12500 PCU	2800 PCU
Mahatma Gandhi Road	23m	11500 PCU	3280 PCU	• Discontinuous and Encroached footpaths resulting in pedestrian spillover on road.	• Strengthening of Road shoulder areas for increasing road traffic capacity, Relocation of Vendors/ Hawkers from roadway.	11500 PCU	4420 PCU
Pedestrian Facilities							
Dr. Dadabhai Naoroji Road	5m	5000 persons	4930 persons	• Encroached footpaths.	• Relocation of Vendors from footpath and strengthening of shoulder area • Pedestrian subways linking Churchgate, Oval Maidan and Cross Maidan	14000 persons	10000 persons
Sir Phirozshah Mehta Road	6m	6000 persons	1595 persons	• Encroached and Discontinuous footpaths by vendors	• Relocation of Vendors from footpath	6000 persons	5500 persons
Bus Stops							
		On-Street	4 Buses/ Minutes	• Conflict with the heavy pedestrian and traffic volumes • Undefined and inadequate Bus stop area	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	4 Bus bays to handle a total of at least 7 buses/ minute in peak hour per direction	6 Buses/ Minutes
IPT (**Taxi*****) Stands/ Pick-Drop Areas***							
		On-Street	6 Taxi / minute	• Conflict with the heavy pedestrian volumes and Taxi Movements • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	7 Taxi bays to handle a total of at least 17 Taxi / minute in peak hour per direction	9 Taxi / minute

Table 5. 14: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at CST Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Maha palika marg	18.5 m	9250 PCU	4030 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Removal of on-street parking of vehicles • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	9250 PCU	5425 PCU
Dr. Daabhai Naroji Road	22 m	11000 PCU	2774 PCU	• Lack of taxi stand • High volume of Vehicular traffic	• Strengthening of Road shoulder areas for increasing road traffic capacity	11000 PCU	3737 PCU
Pedestrian Facilities							
Maha palika marg	12m	12000 Persons	3340 Persons	• Discontinuous and Encroached footpaths	• Station Entry/ Exits provided across all directions for facilitating convenient access • Existing subway near CST suburban station proposed to be augmented with connections to the Metro station and across intersection	11500 Persons	9000 Persons
Dr. Daabhai Naroji Road	8m	8000 Persons	1410 Persons	• Encroached and footpath parking	• Removal of encroachments parking from footpath	8000 Persons	6500 Persons
Bus Stops							
		On-Street	4 Buses/ Minutes	• Undefined and inadequate Bus stop area	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	4 Bus bays to handle a total of at least 6 buses/ minute in peak hour per direction	6 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	14 Taxi / minute	• The on-street Taxi Stops impede traffic flow • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	8 Taxi bays to handle a total of at least 20 Taxi / minute in peak hour per direction	16 Taxi / minute
Parking							
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Limited parking facilities with defined parking bays (about 40) is suggested near the station, along service road on Mahapalika Marg		

Table 5. 15: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Kalbadevi Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Jagannath Shankar Sheth Road	12.5m	6250 PCU	2980 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Removal of on-street parking • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	6000 PCU	4000 PCU
Shamaldas Gandhi Marg	17m	8500 PCU	7180 PCU	• Encroachment and on-street parking on the road reduces the effective carriageway width	• Strengthening of Road shoulder areas, Relocation of Vendors/ Hawkers from roadway.	10000 PCU	9670 PCU
Pedestrian Facilities							
Jagannath Shankar Sheth Road	4	4000	2590	• Discontinuous and Encroached footpaths result in pedestrian spillover on road.	• Relocation of Vendors/ Hawkers from footpath • Widening of footpath in front of station Entry/Exits. • Provision of pedestrian guardrails along footpath	4000 persons (10000 opp. Station Entry/ Exits)	7100 persons
Shamaldas Gandhi Marg	6	6000	4700	• Encroached and parking on footpath	• Removal of parking and encroachment from footpath • Widening of footpath in front of station Entry/Exits. • Provision of pedestrian guardrails along footpath	6000 persons (12000 opp. Station Entry/ Exits)	11000 persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Undefined and inadequate Bus stop area	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	1 Taxi / minute	• Lack of defined Taxi stand/bays • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 5 Taxi / minute in peak hour per direction	3 Taxi / minute
Parking							
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion			

Table 5. 16: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Girgaon Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Jagannath Shankar Sheth Road	15.5m	7750 PCU	3500 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Removal of on-street parking • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	7750 PCU	4710 PCU
Thakurdwar Road	9m	4500 PCU	3080 PCU	• Encroachment and on-street parking on the road reduces the effective carriageway width.	• Strengthening of Road shoulder areas for increasing road traffic capacity • Relocation of Vendors/ Hawkers from roadway.	4500 PCU	4150 PCU
Pedestrian Facilities							
Jagannath Shankar Sheth Road	4m	4000 Persons	2280 Persons	• Discontinuous and Encroached footpaths, • Absence of pedestrian crossing facilities	• Relocation of Vendors/ Hawkers from footpath and Strengthening of footpath. • Provide zebra crossing for pedestrian facilities • Widening of footpath in front of station Entry/Exits.	4000 Persons (9000 opp. Station Entry/ Exits)	6600 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Undefined and inadequate Bus stop area	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (Taxi ***) Stands/ Pick-Drop Areas***							
		On-Street	1 Taxi / minute	• No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 5 Taxi / minute in peak hour per direction	2 Taxi / minute

Table 5. 17: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Grant Road Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Dr.Dadasaheb Bhadkamakar Road	15m	7500 PCU	5350 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Removal of on-street parking • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages • Strengthening of Road shoulder areas for increasing road traffic capacity	7500 PCU	7550 PCU
Pedestrian Facilities							
Dr.Dadasaheb Bhadkamakar Road	8m	8000 Persons	5070 Persons	• Discontinuous and Encroached footpaths by informal activities.	• Relocation of Vendors/ Hawkers from footpath and Strengthening of footpath.	8000 Persons (9000 opp. Station Entry/ Exits)	9000 Persons
Bus Stops							
		On-Street	2 buses /minute	• Conflict with the pedestrian volumes and Auto Movements. • Vendors near the bus stop conflict the pedestrian movement.	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits . • Relocation of Vendors/ Hawkers	2 Bus bays to handle a total of at least 4 buses/ minute in peak hour per direction	3 buses/ minute
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	4 Taxi / minute	• The on-street Taxi Stops impede traffic flow • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	4Taxi bays to handle a total of at least 10 Taxi / minute in peak hour per direction	6 Taxi / minute

Table 5. 18: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at MumbaiCentral Metro station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Dr. Nair Marg	10.5m	5250 PCU	7450 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Strengthening of Road shoulder areas for increasing road traffic capacity • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	52500 PCU	10040 PCU
Jahangir Boman Mehram Road	24m	12000 PCU	7320 PCU	• Encroachment and on-street parking on the road reduces the effective carriageway width.	• Relocation of Vendors/ Hawkers from roadway. • Strengthening of Road shoulder areas for increasing road traffic capacity	12000 PCU	9860 PCU
Pedestrian Facilities							
Dr. Nair Marg	5m	5000 Persons	6400 Persons	• Discontinuous and Encroached footpaths, • Lack of pedestrian facilities	• 8 m wide Pedestrian subway and Skywalk connecting with the suburban station and westwards towards Sane Guruji Marg • Relocation of Vendors/ Hawkers from footpath and Strengthening of footpath. • Provide zebra crossing for pedestrian facility. • Widening of footpath in front of station Entry/Exits.	21000 Persons	18000 Persons
Bus Stops							
		On-Street	2 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements.	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	3 Bus bays to handle a total of at least 4 buses/ minute in peak hour per direction	3 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	6 Taxi / minute	• The on-street Taxi Stops impede traffic flow • limited capacity of taxi stand and no Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	6 Taxi bays to handle a total of at least 15 Taxi / minute in peak hour per direction	9 Taxi / minute

Table 5. 19: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Mahalaxmi Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
				Roads			
Sane Guruji Road	15m	7500 PCU	3180 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Removal of on-street parking . • Relocation of Vendors/ Hawkers from roadway. • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	6000 PCU	4280 PCU
Keshavrao Kaday Road	12m	6000 PCU	1715 PCU	• Encroachment and on-street parking on the road reduces the effective carriageway width.	• A new one-way ROB proposed to relieve traffic load from existing Bapurao Jagtap Marg ROB (Junction with E moses Road proposed to be made signal free with construction of North-south Half flyover) • Relocation of Vendors/ Hawkers from roadway.	5500 PCU	2310 PCU
G. Babu Sakpal Marg	12m	6000 PCU	940 PCU	• Constrained road capacity in comparison to the heavy vehicular traffic	• Strengthening of Road shoulder areas for increasing road traffic capacity	8500 PCU	1195 PCU
				Pedestrian Facilities			
Sane Guruji Road	6m	6000 Persons	4240 Persons	• Discontinuous and Encroached footpaths by informal activities	• Station Entry/ Exits provided across all directions for facilitating convenient access • A new subway proposed connecting the proposed Metro, monorail and existing suburban stations • Widening of footpath in front of station Entry/Exits.	14000 Persons	8500 Persons
				Bus Stops			
		On-Street	2 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements.	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 4 buses/ minute in peak hour per direction	4 Buses/ Minutes
				IPT (*Taxi*) Stands/ Pick-Drop Areas			
		On-Street	5 Taxi / minute	• The on-street Taxi Stops impede traffic flow • Lack of defined Taxi stand/bays and no Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	8 Taxi bays to handle a total of at least 20 Taxi / minute in peak hour per direction	10 Taxi / minute
				Parking			

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Limited parking facilities with defined parking bays (about 10) is suggested near the station, subject to land availability		

Table 5. 20: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Science Museum Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Dr. E.Moses Road	24 m	12000 PCU	6490 PCU	• Constrained road capacity in comparison to the heavy vehicular traffic	• Strengthening of Road shoulder areas for increasing road traffic capacity	12000 PCU	8740 PCU
Senapati Bapat Road	20 m	10000 PCU	4210 PCU	• High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Strengthening of Road shoulder areas for increasing road traffic capacity. • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	10000 PCU	5670 PCU
Pedestrian Facilities							
Dr. E.Moses Road	3m	3000 Persons	4240 Persons	• Discontinuous and Encroachment on footpaths by informal activities	• Relocation of Vendors/ Hawkers from footpath and Strengthening of footpath. • Widening of footpath in front of station Entry/Exits.	3000 Persons (9000 opp. Station Entry/ Exits)	7300 Persons
Senapati Bapat Road	4 m	4000 Persons	2780 Persons	• Absence of footpath, • lack of pedestrian facilities	• Strengthening of footpath area • Widening of footpath in front of station Entry/Exits.	4000 Persons (9000 opp. Station Entry/ Exits)	5300 Persons
Bus Stops							
		On-Street	2 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	3 Bus bays to handle a total of at least 4 buses/ minute in peak hour per direction	3 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	1 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	1Taxi bays to handle a total of at least 4 Taxi / minute in peak hour per direction	3 Taxi / minute

Table 5. 21: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Acharya Atrey Chowk Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
				Roads			
Dr. E.Moses Road	24	12000	8100	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity	12000	10910
Dr. Annie Besant Road	27	13500	8300	• High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	13500	11180
G.M.Bhosle Marg	15.5	7750		• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	7750	
				Pedestrian Facilities			
Dr. E.Moses Road	10m	10000 Persons	3000 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• . Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	10000 Persons	7100 Persons
Dr. Annie Besant Road	6m	6000 Persons	2280 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Strengthening of footpath area, removal of parking	6000 Persons	5900 Persons
				Bus Stops			
		On-Street	5 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	8 Bus bays to handle a total of at least 10 buses/ minute in peak hour per direction	8 Buses/ Minutes
				IPT (*Taxi*) Stands/ Pick-Drop Areas			
		On-Street	3 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	3 Taxi bays to handle a total of at least 8 Taxi / minute in peak hour per direction	4 Taxi / minute

Table 5. 22: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Worli Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Dr. Annie Besant Road	25 m	12000 PCU	9560 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity	12500 PCU	12870 PCU
Road Durdarshan	6 m	3500 PCU	170 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	3500 PCU	240 PCU
Pedestrian Facilities							
Road Durdarshan	5 m	5000 Persons	2240 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities • Widening of footpath in front of station Entry/Exits.	5000 Persons (9000 opp. Station Entry/ Exits)	5900 Persons
Dr. Annie Besant Road	6 m	6000 Persons	2420 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Strengthening of footpath area, removal of parking	6000 Persons (9000 opp. Station Entry/ Exits)	6200 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	2 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 5 Taxi / minute in peak hour per direction	3 Taxi / minute

Table 5. 23: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Siddhi Vinayak Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Vir Savarkar Road	27.5	13750 PCU	7990 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	13750 PCU	10760 PCU
Kakasaheb Gadgil Marg	9.5	4750 PCU	270 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	4750 PCU	370 PCU
Pedestrian Facilities							
Vir Savarkar Road	8.5	8500 Persons	2670 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access • A pedestrian subway access is planned to integrate with the proposed MTHL Metro Corridor underground station • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	8100 Persons	6600 Persons
Kakasaheb Gadgil Marg	5	5500 Persons	1340 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Strengthening of footpath area, removal of parking	5500 Persons	4800 Persons
Bus Stops							
		On-Street	3 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	5 Bus bays to handle a total of at least 6 buses/ minute in peak hour per direction	4 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	7 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	7 Taxi bays to handle a total of at least 17 Taxi / minute in peak hour per direction	9 Taxi / minute
Parking							
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Limited on-street parking facilities with defined parking bays (about 25) is suggested near the station		

Table 5. 24: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Dadar Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
				Roads			
Namdar Gopal Krushna Gokhlay Road	18 m	9000 PCU	3660 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	9000 PCU	5930 PCU
Rav Bahadur S.K. Bole Road	13.5m	6750 PCU	2580 PCU	• Vendors on street conflicting the vehicular movement	• Relocation of Vendors/ Hawkers from roadway	6750 PCU	3470 PCU
				Pedestrian Facilities			
Namdar Gopal Krushna Gokhlay Road	10 m	10000 Persons	1900 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	10000 Persons	7700 Persons
Ranade Road	5.5m	5500 Persons	4075 Persons	• Discontinuous and unpaved footpath	• Proposed new Skywalk connection upto Dadar suburban station • Widening of footpath in front of station Entry/Exits.	5500 Persons (10000 opp. Station Entry/ Exits)	10000 Persons
				Bus Stops			
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	1 Bus bays to handle a total of at least 2 buses/ minute in peak hour per direction	2 Buses/ Minutes
				IPT (*Taxi*) Stands/ Pick-Drop Areas			
		On-Street	2 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 4 Taxi / minute in peak hour per direction	3 Taxi / minute

Table 5. 25: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at SheetlaDevi Temple Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Lady Jamshedji Marg	18.5 m	9250 PCU	6450	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	9250 PCU	8690 PCU
Pedestrian Facilities							
Lady Jamshedji Marg	10 m	10000 Persons	3890 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	12000 Persons	8500 Persons
Mai Mohd Chhotani Road	7 m	7000 Persons	2910 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Proposed new 6m Skywalk connection upto Mahim suburban station • Strengthening of footpath area, removal of parking • Widening of footpath in front of station Entry/Exits	9000 Persons	7200 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	1 Bus bays to handle a total of at least 2 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (*Taxi*) Stands/ Pick-Drop Areas							
		On-Street	4 Taxi / minute	• Undefined Taxi/ Auto stand and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	5 Taxi bays to handle a total of at least 11 Taxi / minute in peak hour per direction	7 Taxi / minute

Table 5. 26: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Dharavi Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Mahim Sion Link Road	33 m	16500 PCU	5570 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	16500 PCU	8280 PCU
Sixty Futta Road	19 m	9500 PCU	3880 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	9500 PCU	5770 PCU
Pedestrian Facilities							
Mahim Sion Link Road	5 m	5000 Persons	1110 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	5000 Persons	4600 Persons
Sixty Feet Road	4m	4000 Persons	810 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Strengthening of footpath area, removal of parking	4500 Persons	4200 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	1 Bus bays to handle a total of at least 2 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (Taxi ***) Stands/ Pick-Drop Areas***							
		On-Street	2 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Taxi bays to handle a total of at least 5 Taxi / minute in peak hour per direction	3 Taxi / minute

Table 5. 27: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Bandra Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Bandra Kurla Complex Road	30.5	15250	8960 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	15250	13310 PCU
Bharat Nagar Road	23.5	11750	5235 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	11750	7710 PCU
Pedestrian Facilities							
Bandra Kurla Complex Road	6	6000	1210 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Widening of footpath in front of station Entry/Exits.	6000 (9000 opp. Station Entry/ Exits)	7000 Persons
Bharat Nagar Road	6	6000	1010 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Station Entry/ Exits provided across all directions for facilitating convenient access • Strengthening of footpath area, removal of parking • Widening of footpath in front of station Entry/Exits.	6000 (9000 opp. Station Entry/ Exits)	6800 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	1 Bus bays to handle a total of at least 2 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (Taxi ***) Stands/ Pick-Drop Areas***							
		On-Street	• 1 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	1 Taxi bays to handle a total of at least 3 Taxi / minute in peak hour per direction	2 Taxi / minute
Parking							
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Planned off-street parking facilities with defined parking bays (about 50) is suggested near the station		

Table 5. 28: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Kalina University Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
University road	7m	3500	400	• No major issues	• Development of uniform road cross-section	3500	600
Pedestrian Facilities							
University road	3	3000	1000	• Road shoulder area used on footpath	• Development of continuous footpath cross-section	6000	1900
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (*Auto*) Stands/ Pick-Drop Areas							
		On-Street	1 Auto / minute	• Unorganized Auto stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Auto bays to handle a total of at least 5 Auto / minute in peak hour per direction	2 Auto / minute

Table 5. 29: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Santacruz Metro Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Western Express Highway	24	12500	8630 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	12500	12830 PCU
				Pedestrian Facilities			
Western Express Highway	8.5m	8500 Persons	5560 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access • Integration with Santacruz Suburban station via augmented approach arms of Skywalk • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities . • Widening of footpath in front of station Entry/Exits.	8500 Persons	10000 Persons
				Bus Stops			
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
				IPT (*Auto*) Stands/ Pick-Drop Areas			
		On-Street	3 Auto / minute	• Unorganized Auto stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	4 Auto bays to handle a total of at least 9 Auto / minute in peak hour per direction	6 Auto / minute
				Parking			
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Limited off-street parking facilities with defined parking bays (about 15) is suggested near the station		

Table 5. 30: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at CSIA (Domestic) Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Airport road	12.5m	6250 PCU	2290 PCU	• No issues	• Strengthening of Road shoulder areas for increasing road traffic capacity.	6250 PCU	3400 PCU
Airport road near sahara star hotel	14m	7000 PCU	1370 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	7000 PCU	2040 PCU
Pedestrian Facilities							
Airport road	3m	3000 Persons	163 Persons	• Encroachment on foothpath creates hindrance to pedestrian movement	• Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	4000 Persons	2550 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT Stands/ Pick-Drop Areas							
		On-Street	7 IPT / minute	• Unorganized IPT stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	8IPT bays to handle a total of at least 18 IPT / minute in peak hour per direction	12 IPT / minute
Parking							
					• The common airport parking facilities will be shared with the Metro station		

Table 5. 31: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Sahar Road Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Sahar road	20m	10000 PCU	4750 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity	10000 PCU	7060 PCU
IA Project road	22.5m	11250 PCU	7420 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	11250 PCU	11030 PCU
				Pedestrian Facilities			
Sahar road	10m	10000 Persons	920 Persons	• Unpaved and discontinues footpath • Lack of pedestrian facilities	• Provide pedestrian facilities • Strengthening of footpath area	10000 Persons	3000 Persons
IA Project road	6m	6000 Persons	1610 Persons	• Lack of pedestrian facilities • Parking of vehicles on footpath	• Strengthening of footpath area and removal of parking from footpath	6000 Persons	4200 Persons
				Bus Stops			
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
				IPT Stands/ Pick-Drop Areas			
		On-Street	3 IPT / minute	• Unorganized IPT stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	4 IPT bays to handle a total of at least 10 IPT / minute in peak hour per direction	6 IPT / minute

Table 5. 32: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at CSIA (International) Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Airport Road	24m	12000 PCU	4860PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity	12000 PCU	7220 PCU
IA Project road	20.5m	10000 PCU	6790 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles • Strengthening of Road shoulder areas for increasing road traffic capacity	10250 PCU	10090 PCU
Pedestrian Facilities							
Airport Road	6m	6000 Persons	820 Persons	• Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access	6000 Persons	3300 Persons
IA Project road	6m	6000 Persons	940 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Strengthening of footpath area, removal of parking	6000 Persons	3500 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT Stands/ Pick-Drop Areas							
		On-Street	4 IPT / minute	• Unorganized IPT stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	6 IPT bays to handle a total of at least 15 IPT / minute in peak hour per direction	10 IPT / minute
Parking							
					• The common airport parking facilities will be shared with the Metro station		

Table 5. 33: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Marol Naka Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Mathuradas vasanji	15m	7500 PCU	3710 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity	7500 PCU	5520 PCU
Arya Coloni Road	8.5m	4250 PCU	2510 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	4250 PCU	3730 PCU
Pedestrian Facilities							
Mathuradas vasanji	6	6000 Persons	4930 Persons	• Lack of footpath and pedestrian facilities	• Station Entry/ Exits provided across all directions for facilitating convenient access • Strengthening of footpath area and provide facilities for pedestrian • Widening of footpath in front of station Entry/Exits.	6000 Persons (11000 opp. Station Entry/ Exits)	11000 Persons
Arya Coloni Road	6m	6000 Persons	2060 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities • Strengthening of footpath area,	6000 Persons	5500 Persons
Bus Stops							
		On-Street	3 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	5 Bus bays to handle a total of at least 7 buses/ minute in peak hour per direction	5 Buses/ Minutes
IPT (*Auto*) Stands/ Pick-Drop Areas							
		On-Street	2 Auto / minute	• Unorganized Auto stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	2 Auto bays to handle a total of at least 5 Auto / minute in peak hour per direction	3 Auto / minute
Parking							
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Planned off-street parking facilities with defined parking bays (about 100) is suggested near the station		

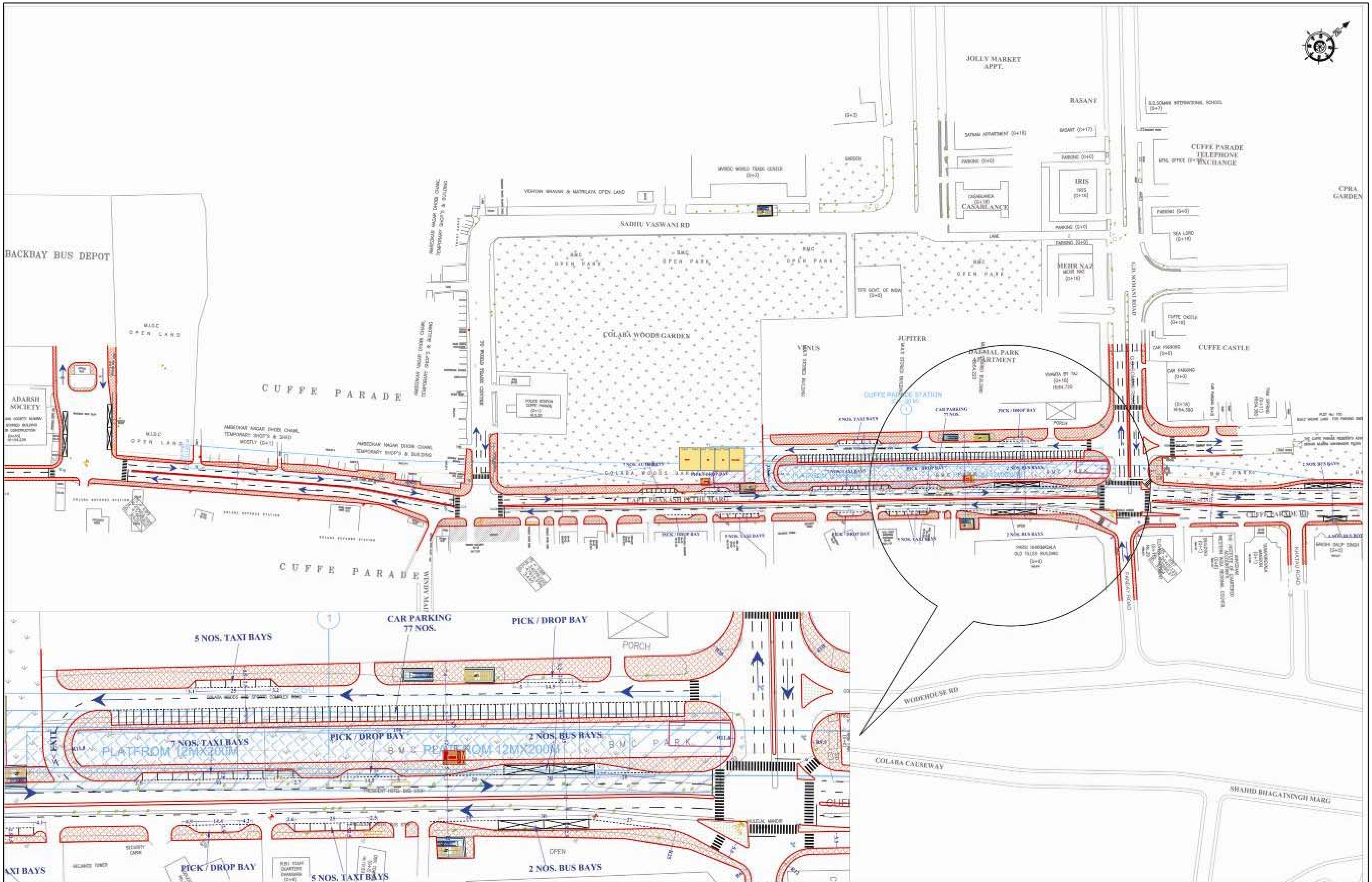
Table 5. 34: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at MIDC Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Road no. 7	14m	7000 PCU	4000 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles •	7000 PCU	6000 PCU
Pedestrian Facilities							
Road no. 7	3m	3000 Persons	1510 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Station Entry/ Exits provided across all directions for facilitating convenient access • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	3000 Persons	2200 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (*Auto*) Stands/ Pick-Drop Areas							
		On-Street	3 Auto / minute	• Unorganized Auto stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	4 Auto bays to handle a total of at least 10 Auto / minute in peak hour per direction	Auto / minute

Table 5. 35: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at SEEPZ Station

	Existing width	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
				Roads			
Krantiveer Akhuji Salve Marg	22.5m	11250 PCU	3295 PCU	• On-street parking of vehicles • High volume of Vehicular traffic, intense Pedestrian – Vehicle conflicts	• Removal of on-street parking by providing off-street parking near the station. • Provision of pedestrian guardrails along footpath, zebra crossing, road marking and traffic signages	10500 PCU	5950 PCU
Adi Shankaracharya Marg	30m	15000 PCU	2990 PCU	• Lack of taxi stand • High volume of Vehicular traffic	• Demarcation of planned IPT Stands and Bus Stops by developing Road shoulder areas.	10500 PCU	4440 PCU
				Pedestrian Facilities			
Krantiveer Akhuji Salve Marg	3.5m	3500	590 Persons	• Discontinuous and Encroached footpaths	• Station Entry/ Exits provided across all directions for facilitating convenient access • Relocation of Vendors/ Hawkers from footpath and provide pedestrian facilities	6000 Persons (9000 opp. Station Entry/ Exits)	3800 Persons
				Bus Stops			
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	2 Bus bays to handle a total of at least 3 buses/ minute in peak hour per direction	2 Buses/ Minutes
				IPT (*Auto*) Stands/ Pick-Drop Areas			
		On-Street	4 Auto / minute	• The on-street Auto Stops impede traffic flow • No Designated Pick-Drop Areas result in traffic congestion	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	5 Auto bays to handle a total of at least 11 Auto / minute in peak hour per direction	7 Auto / minute
				Parking			
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Planned off-street parking facilities with defined parking bays (about 70) is suggested near the station by utilizing the spare road width along the access road (north of Road 23) opposite SEEPZ main gate		

Figure 5.32: Proposed Traffic Dispersal and Circulation Plan – Colaba / Cuffe Parade



Title

Proposed Traffic Dispersal and Circulation Plan - Colaba

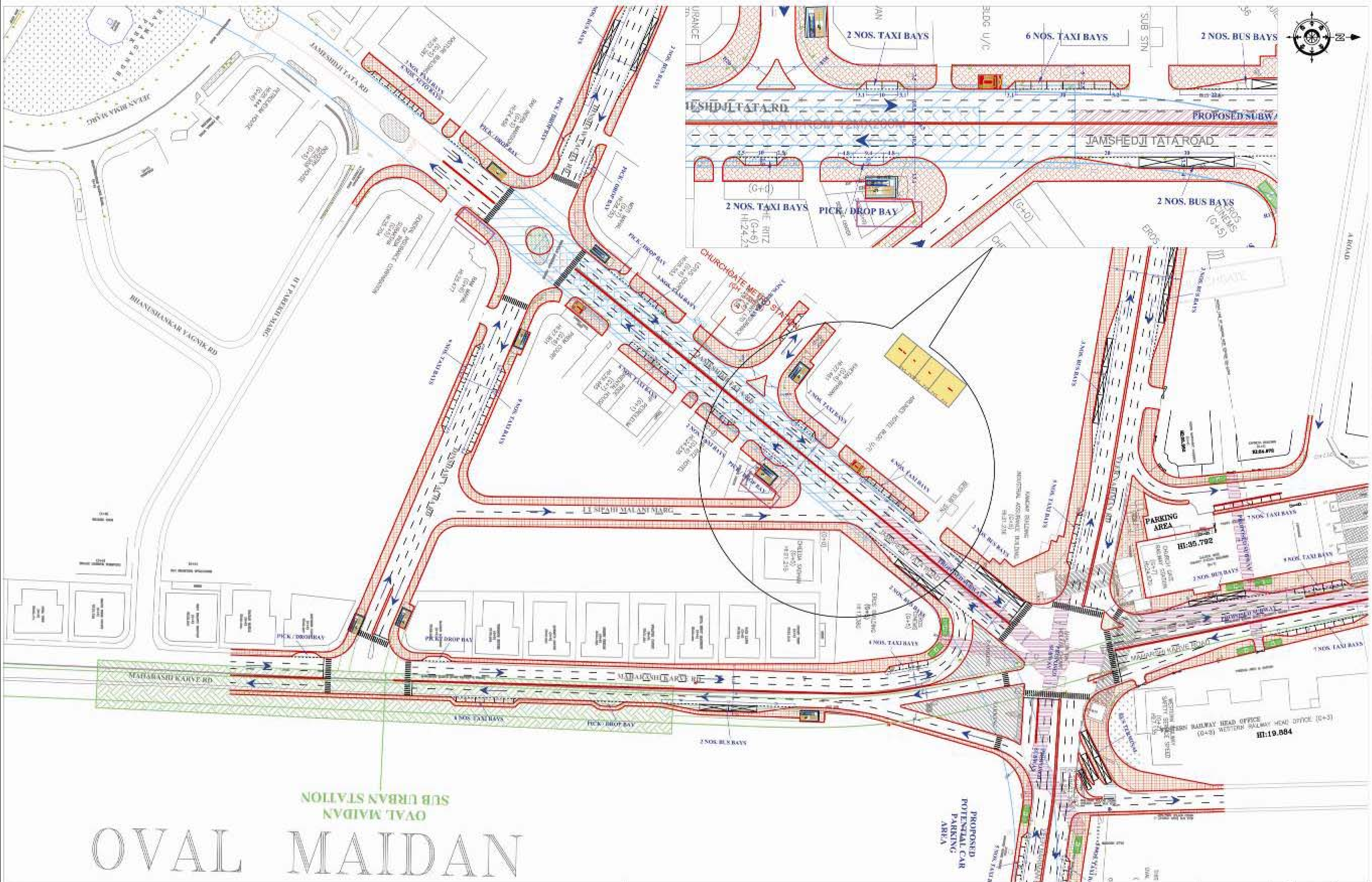
Legend

Station box	Steel Railings
Metro Alignment	Table top crossings
Foot Over Bridge / Subway	Bus Stand at Ground Level

Figure No.

Page No.

Figure 5.33: Proposed Traffic Dispersal and Circulation Plan – Churchgate Metro



Title	Legend			Figure No.
Proposed Traffic Dispersal and Circulation Plan - Churchgate	Station box	Steel Railings	Foot Over Bridge / Subway	Page No.
	Metro Alignment	Table top crossings	Bus Stand at Ground Level	

Figure 5.34: Proposed Traffic Dispersal and Circulation Plan – CST Metro

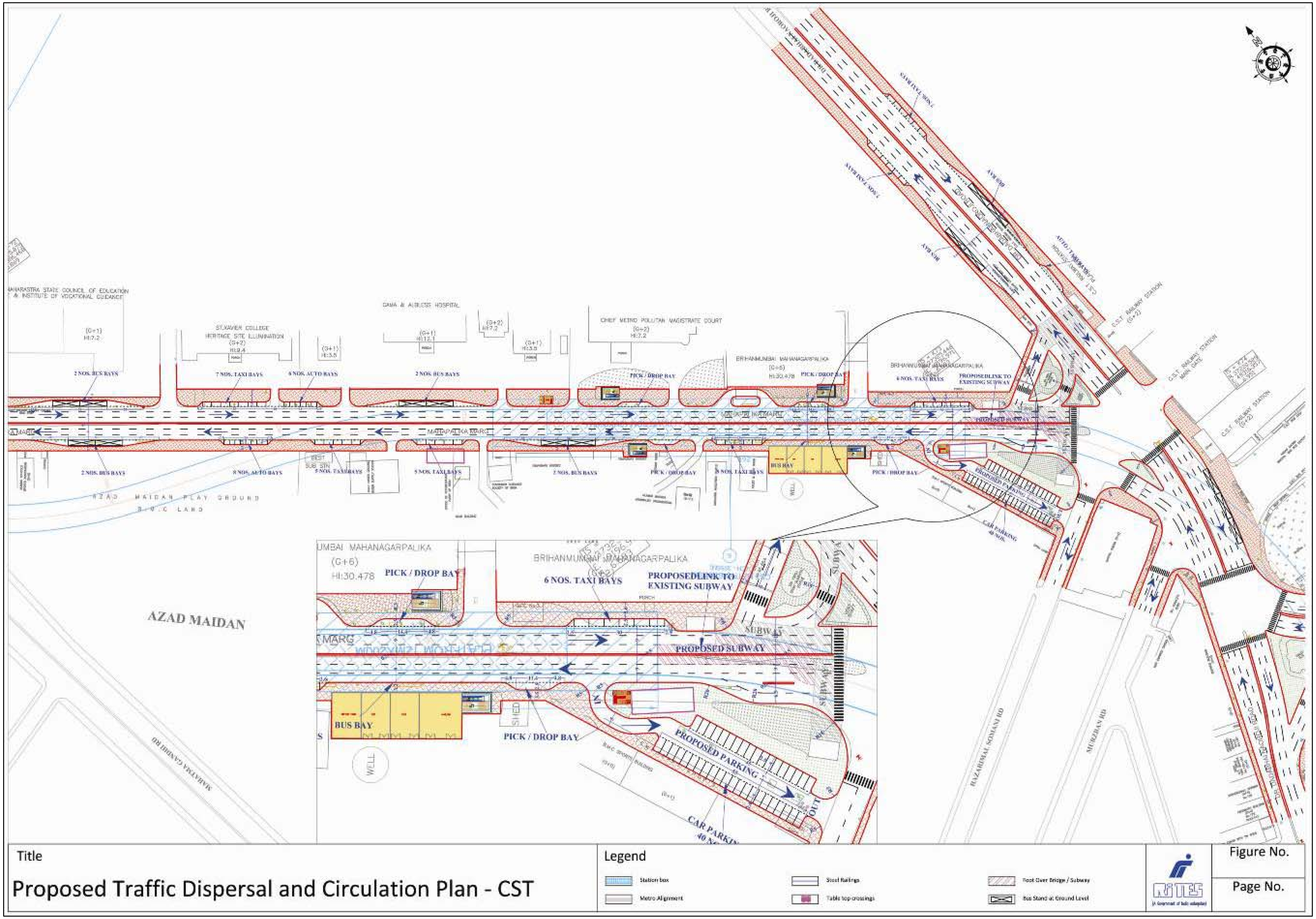


Figure 5.35: Proposed Traffic Dispersal and Circulation Plan – Mumbai Central Metro

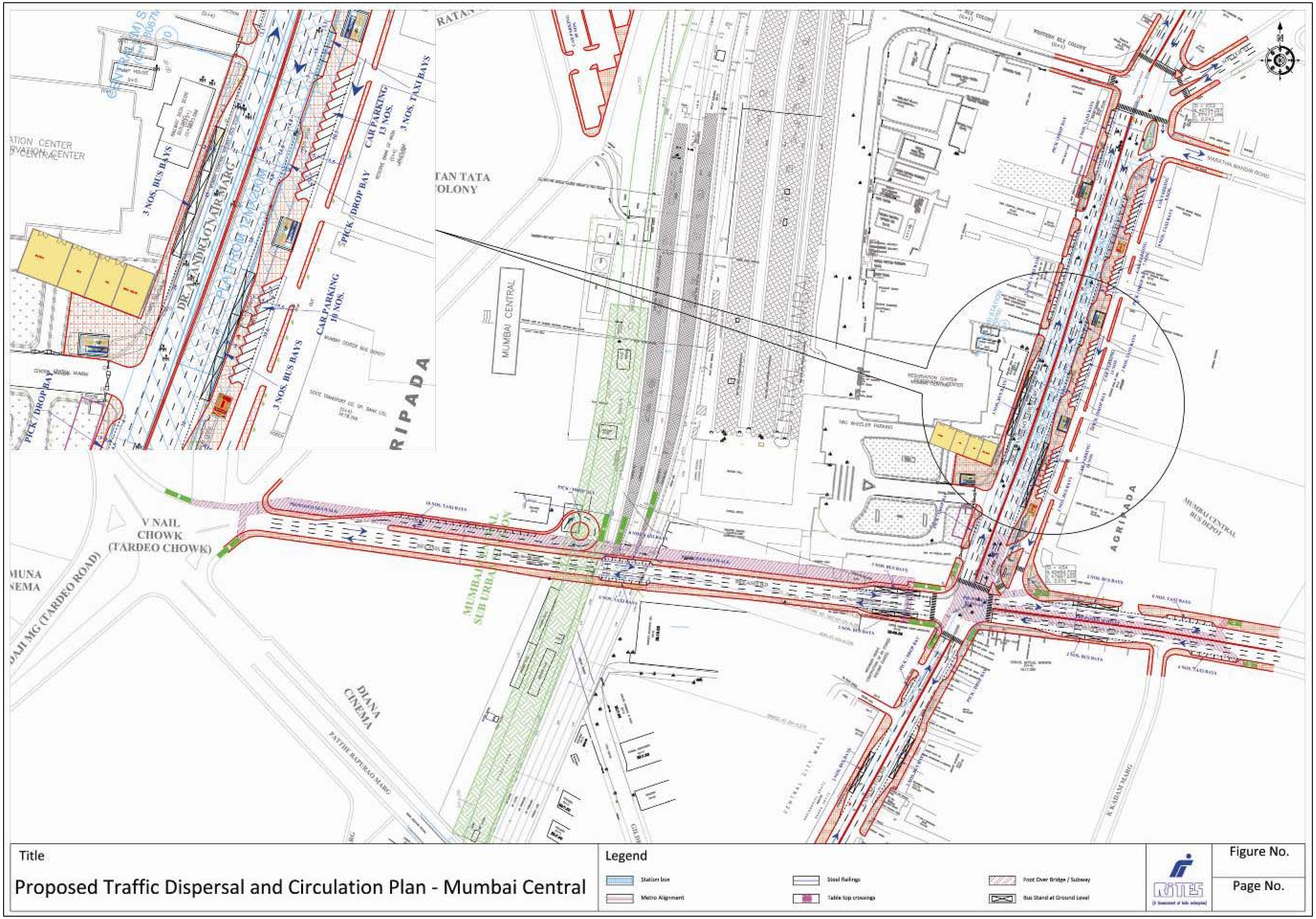
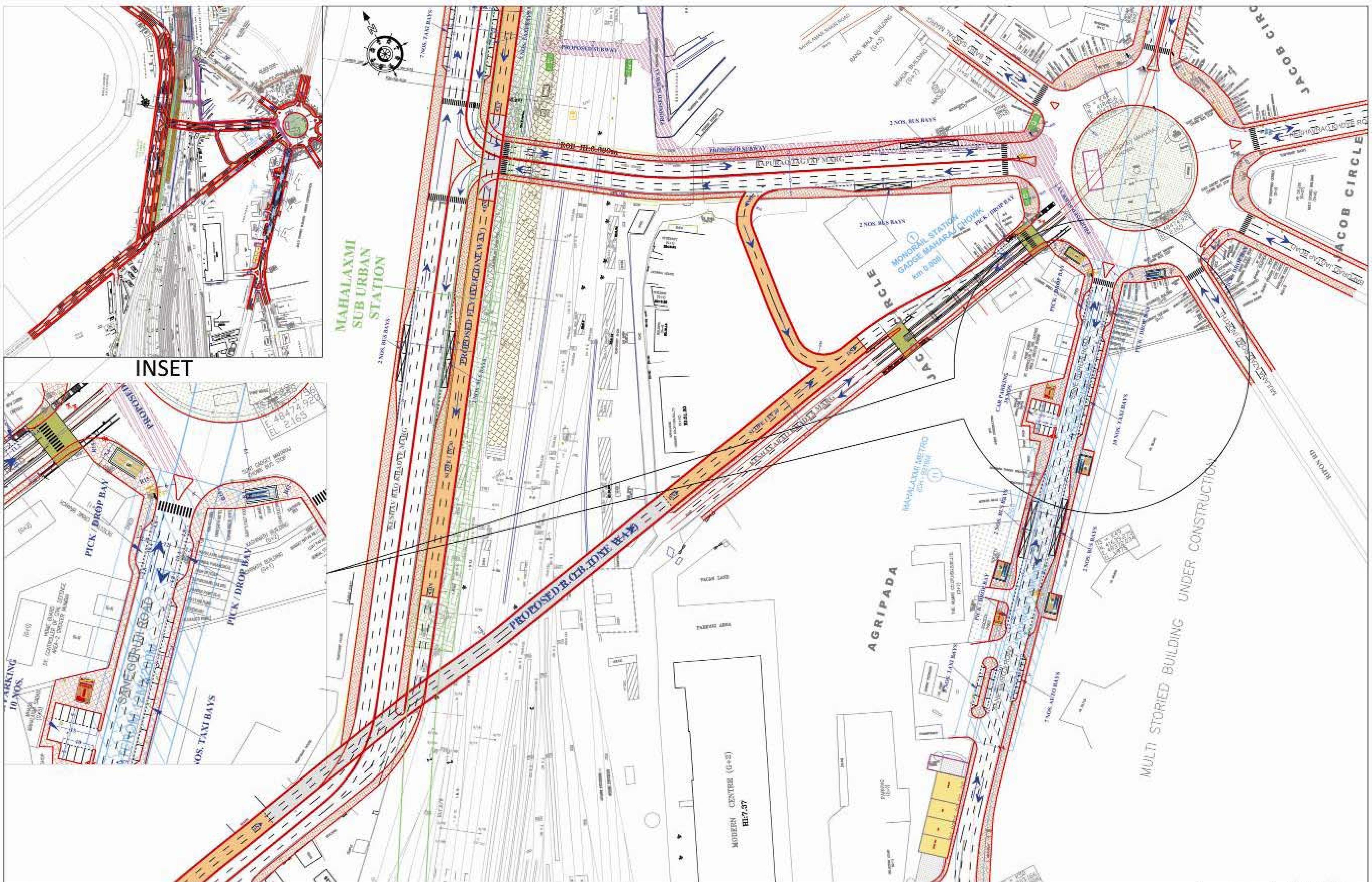


Figure 5.36: Proposed Traffic Dispersal and Circulation Plan – Mahalaxmi Metro



Title

Proposed Traffic Dispersal and Circulation Plan - Mahalaxmi

Legend

Station box	Steel Railings	Foot Over Bridge / Subway
Metro Alignment	Table top crossings	Bus Stand at Ground Level

Figure No.

Page No.

Figure 5.37: Proposed Traffic Dispersal and Circulation Plan – Sidhivinayak

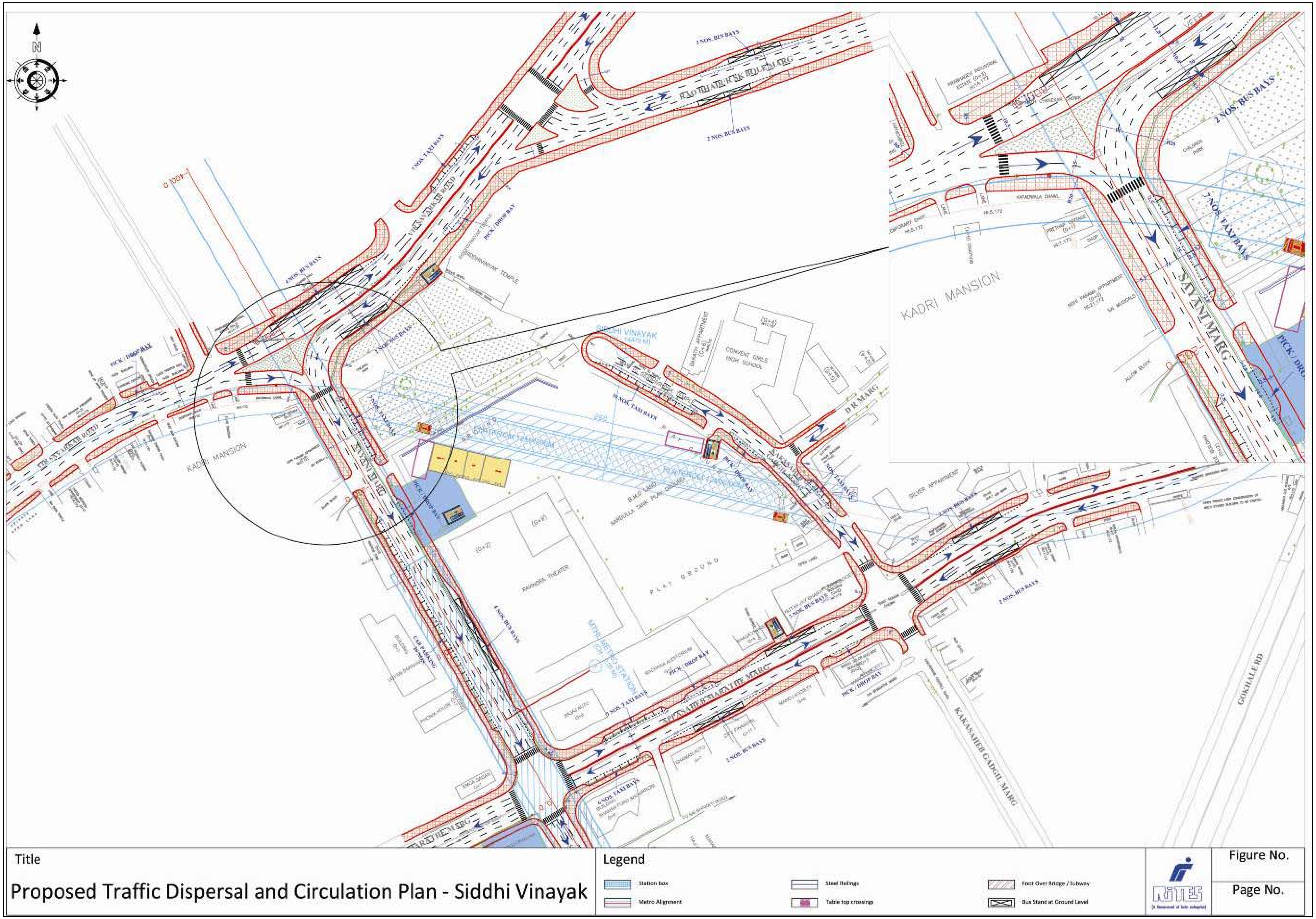


Figure 5.38: Proposed Traffic Dispersal and Circulation Plan – Dadar Metro

Title	Legend			Figure No.
Proposed Traffic Dispersal and Circulation Plan - Dadar	Station box	Steel Railings	Foot Over Bridge / Subway	Page No.
	Metro Alignment	Table top crossings	Bus Stand at Ground Level	

Figure 5.39: Proposed Traffic Dispersal and Circulation Plan – Sheetla Devi

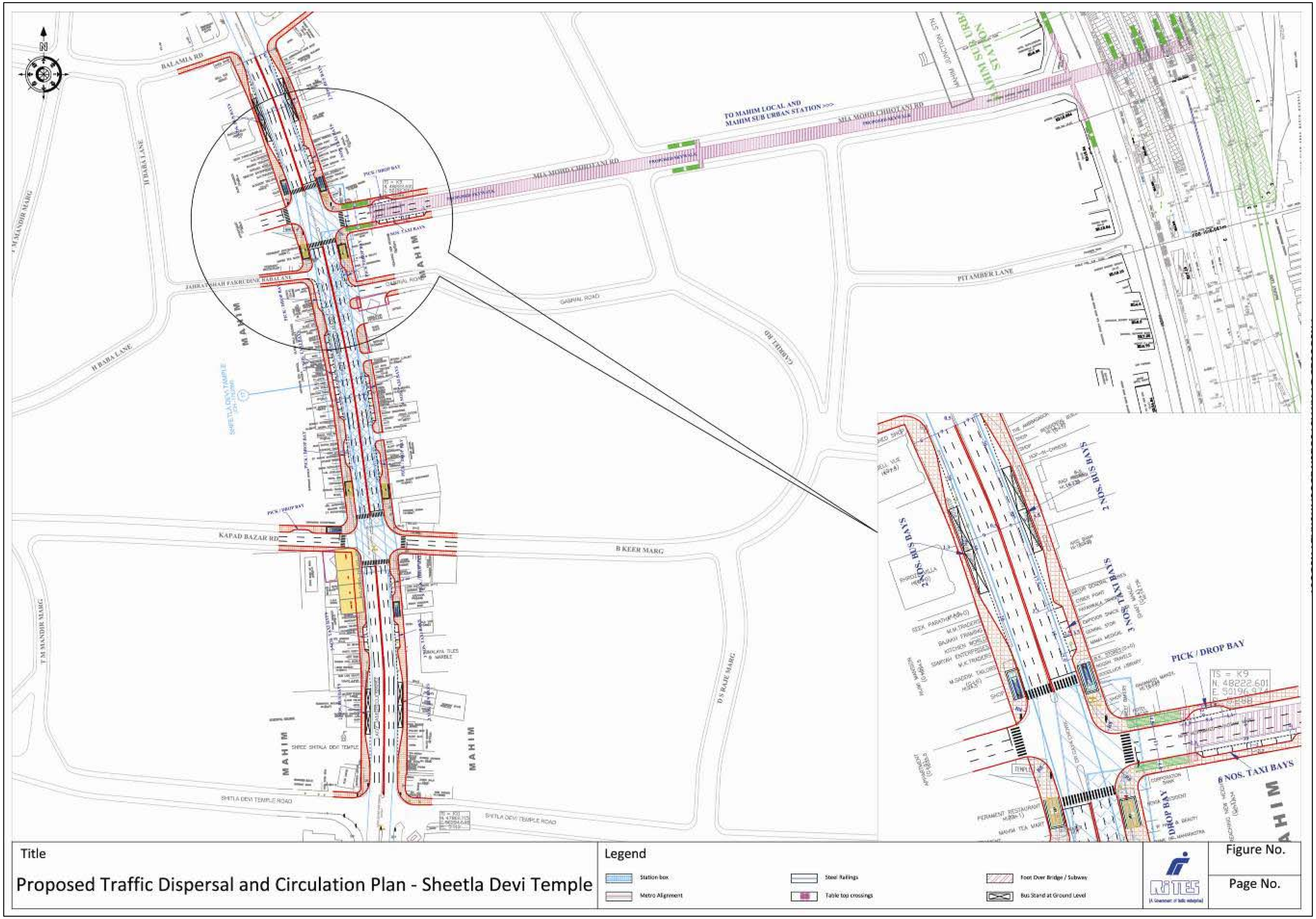


Figure 5.40: Proposed Traffic Dispersal and Circulation Plan – Bandra Metro (BKC)

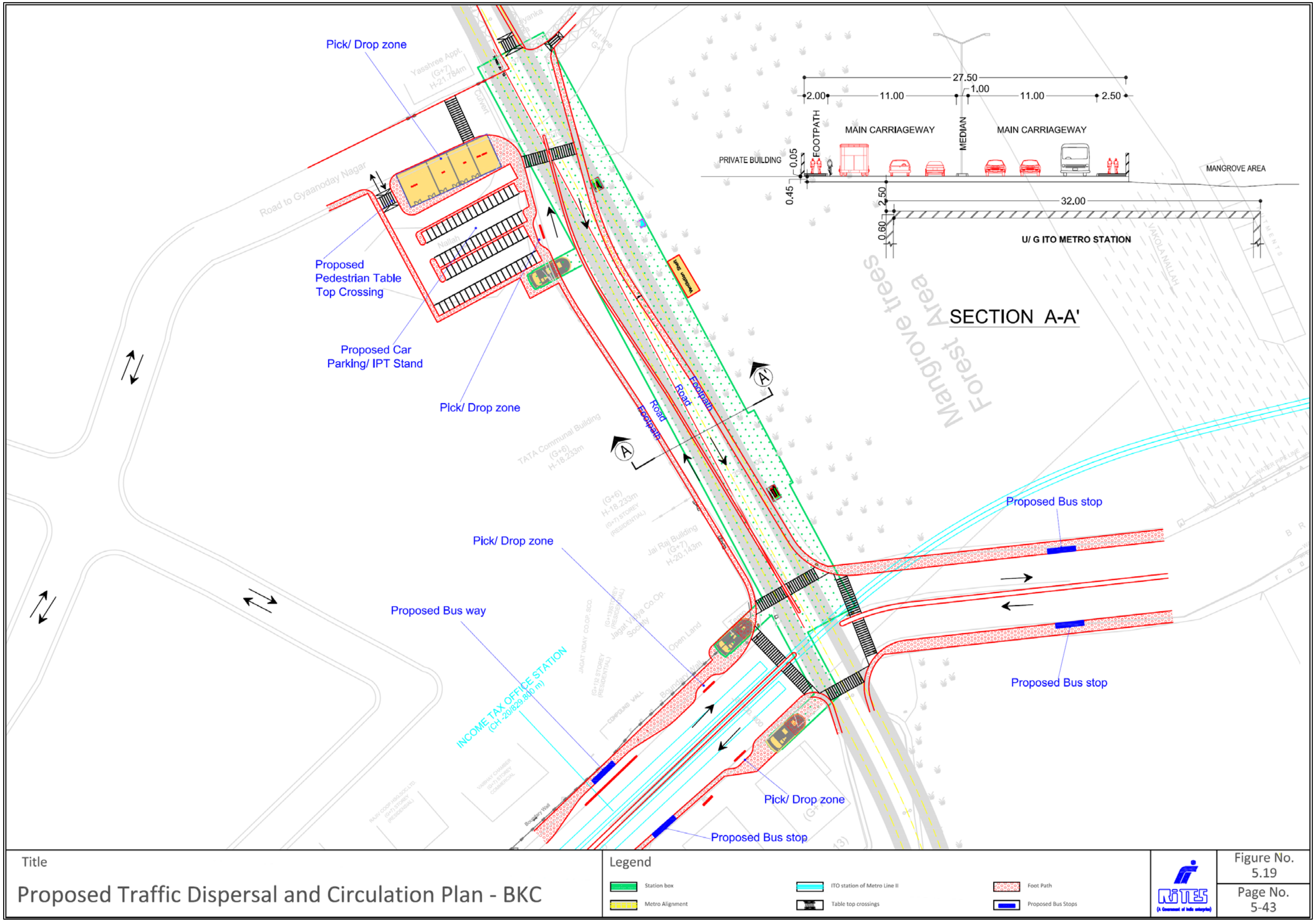


Figure 5.41: Proposed Traffic Dispersal and Circulation Plan - Santacruz

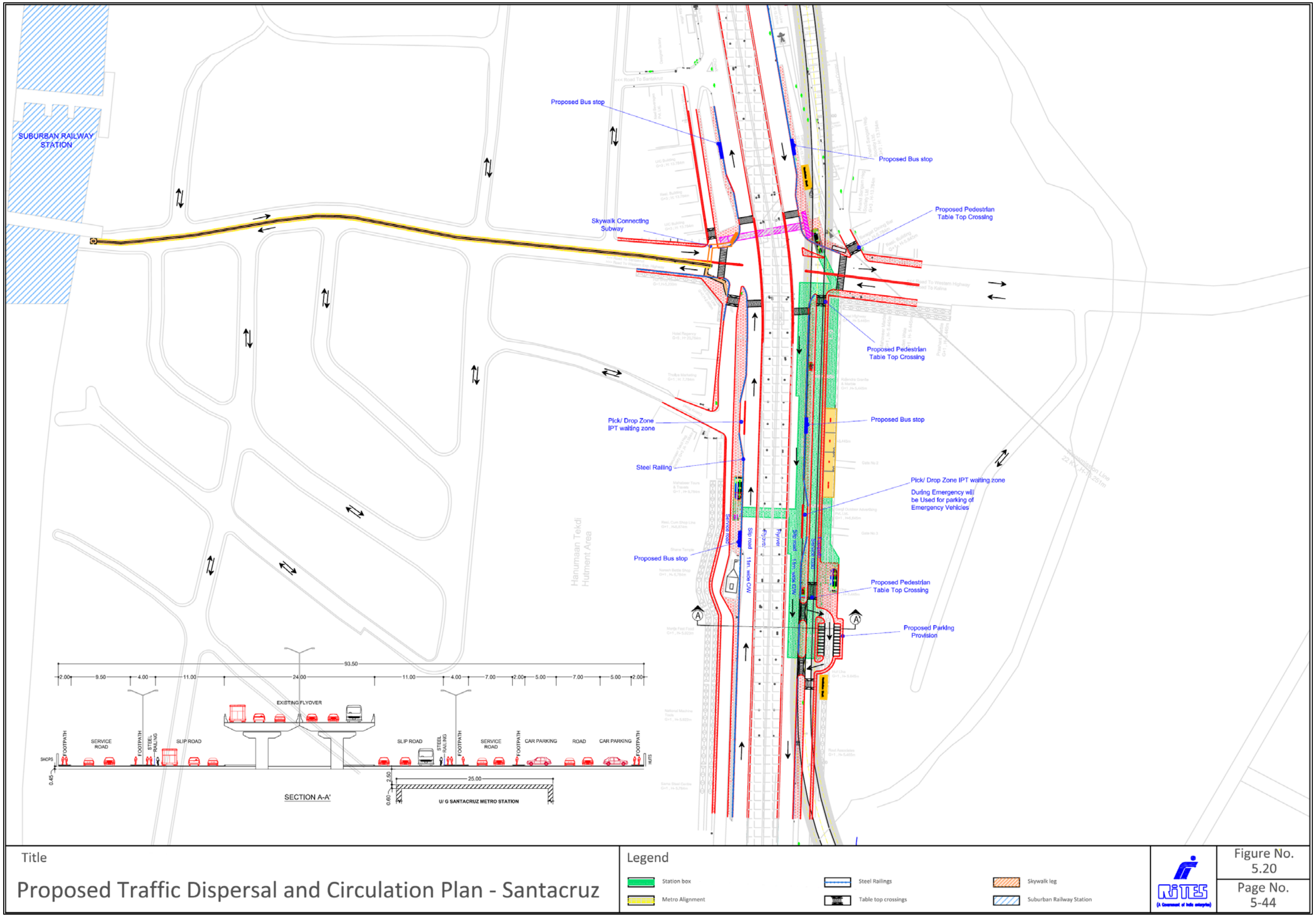


Figure 5.42: Proposed Traffic Dispersal and Circulation Plan – Marol Naka

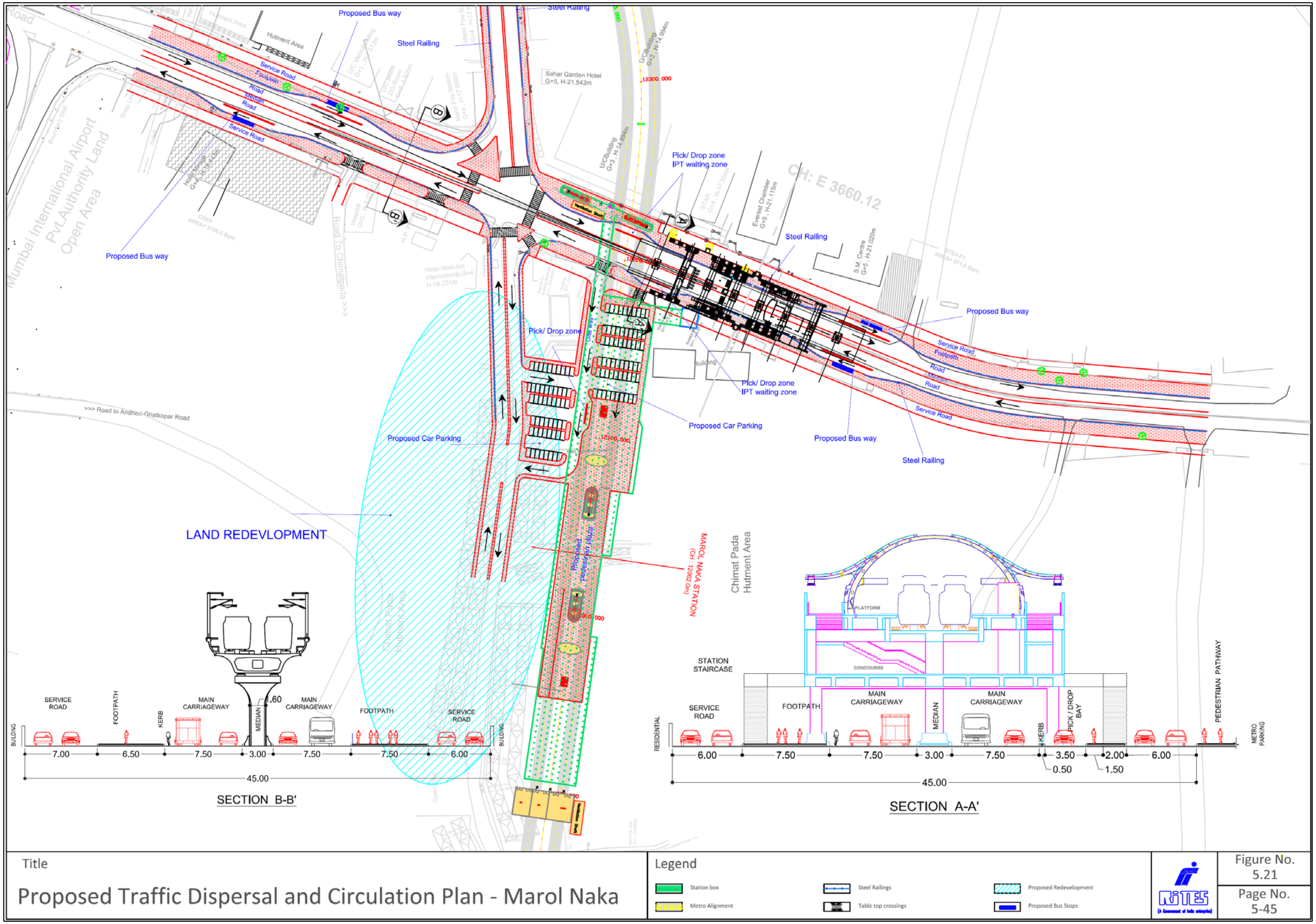
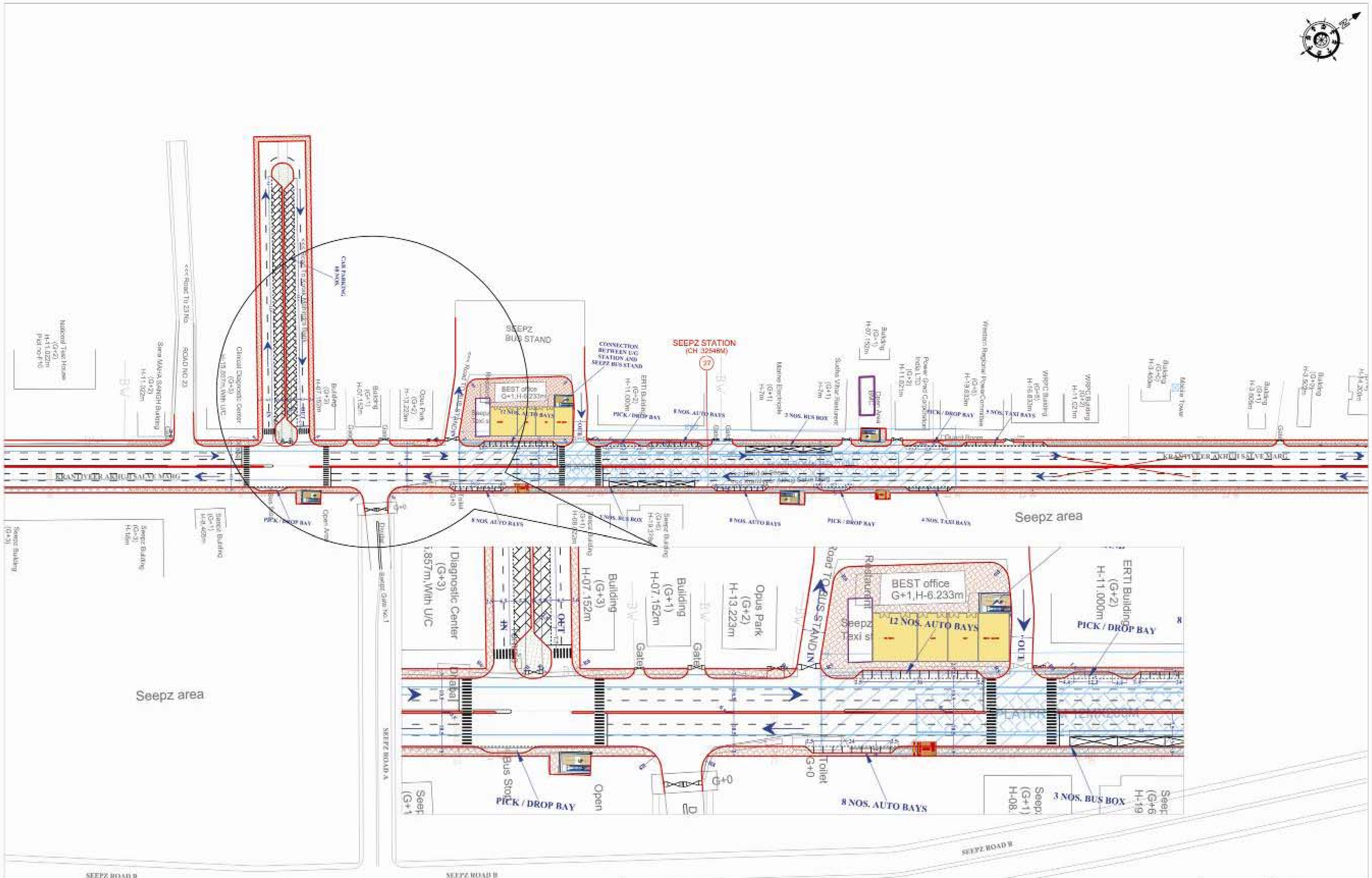


Figure 5.43: Proposed Traffic Dispersal and Circulation Plan - SEEPZ



Title	Legend			Figure No.
Proposed Traffic Dispersal and Circulation Plan - SEEPZ	Station box	Steel Railings	Foot Over Bridge / Subway	Page No.
	Metro Alignment	Table top crossings	Bus Stand at Ground Level	

6. TRAIN OPERATION PLAN

6.1. INTRODUCTION

Train operation plan for the complete corridor from Colaba to SEEPZ via Bandra and Airport has been envisaged based on the ridership assessment/data provided by MMRDA. The peak hour peak direction trips (PHPDT) for Colaba-Bandra section is 42000 and that for Bandra-SEEPZ section as 21000 for the horizon year 2031. However, all the systems and infrastructure on the corridor have been designed for 8 car rake composition/train operation at 150 sec. headway for Colaba-Bandra section and 300 sec. headway for Bandra-SEEPZ section to account for future growth/requirement beyond the year 2031.

Traction system for the corridor will be 25 kV ac 50 Hz single phase. The traction system, designs and layouts of electrical ventilation and air-conditioning installations of the underground portion shall be similar to the one installed in underground Metro Corridor of Delhi Metro. Whereas, the underground portion will have rigid OHE system, flexible Overhead Equipment system will be provided outside the tunnel.

The Rolling Stock shall be standard 1435 mm track gauge, air-conditioned, 3200mm wide having state of the art three phase propulsion system powered through 25 kV ac OHE.

The system, under normal operating conditions, will be utilizing Automatic Train Control and Automatic Train Protection (ATP) under the overall control of a train driver and OCC operators.

6.2. ROLLING STOCK OPERATION PHILOSOPHY

The underlying operation philosophy is to provide Mass Rapid Transit Services at economical cost with fixed Infrastructure and Rolling Stock planning.

- Selecting optimum frequency of Train services to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency during lean period so as to keep the option of this service attractive during lean period also.
- The train consisting of 6 cars with high frequency service has been considered which can be increased up to 8-car for increasing Passenger Carrying Capacity of Trains with the consideration of matching the growing traffic demand.
- Basic unit selected is one motor car and one trailer car.

6.3. TRAIN OPERATION PLANNING

The salient features of the proposed train operation plan are:

- Train operation plan for complete Colaba – Bandra – SEEPZ corridor with consideration of mid terminal at Bandra.

- Running of normal services for 19 hours of the day (5 AM to 12 PM i.e. midnight) with average station dwell time of 30 seconds,
- Airport traffic will be served with a frequency of 20-30 minutes during midnight to 2 AM.
- Make up time of 5-10% (on the tangent track) with 8-12% coasting.
- Scheduled average speed for Corridor shall be 30 kmph.

6.4. TRAFFIC DEMAND

Peak hour peak direction traffic demand (PHPDT) in the year 2016, 2025 and 2031 for the purpose of planning of train services, are indicated below in **Table 6.1**.

Table 6.1: Traffic Demand in PHPDT for the different years

Sr. No.	Stations	Traffic Demand in PHPDT in the year					
		2016		2025		2031	
		Colaba-SEEPZ	SEEPZ-Colaba	Colaba-SEEPZ	SEEPZ-Colaba	Colaba-SEEPZ	SEEPZ-Colaba
1	Colaba/ Cuffe Parade	3666	0	5052	0	6192	0
2	Badhwar Park	6400	4252	8820	5858	10809	7180
3	Vidhan Bhavan	8066	7369	11116	10154	13623	12444
4	Churchgate Metro	8387	10770	11558	14840	14166	18188
5	Hutatma Chowk	11406	12253	16018	17184	19631	20761
6	CSTM Metro	11250	16591	15803	23162	19067	28087
7	Kalbadevi	12679	20230	17772	28578	21181	34426
8	Girgaon	14352	22395	20077	31960	23606	38572
9	Grant Road Metro	15788	23219	22056	33598	25731	40178
10	Mumbai Central Metro	16497	23284	23233	34087	27174	40278
11	Mahalaxmi Metro	17010	23005	24240	33903	28407	39252
12	Science Museum	17090	22032	24351	32762	28544	37054
13	Acharya Atrey Chowk	18238	21861	25933	32726	30183	36617
14	Worli	18462	22920	26441	34684	30706	38218
15	Siddhi Vinayak	19410	24797	27747	37472	32007	40834
16	Dadar Metro	19830	25711	28327	38930	32717	42021
17	SheetlaDevi Temple	19230	23803	27200	35801	31336	38187
18	Dharavi	18247	22617	25746	32867	30154	34591
19	Bandra Metro	15944	19898	22372	28120	26619	29273
20	Mumbai University	14439	16857	20298	22430	24777	23299
21	Santacruz Metro	13639	17222	18946	22732	23120	23966
22	CSIA(Domestic)	11417	14881	15784	19507	19244	20709
23	Sahar Road	10307	13928	14203	18694	17307	19912
24	CSIA (International)	7851	12458	10820	16668	13260	17828
25	Marol Naka	5778	12376	7963	16556	9759	17891
26	MIDC	3276	8755	4515	11565	5533	12575
27	SEEPZ	0	5291	0	7291	0	8036

The section-wise PHPDT figures reveals that the corridor has two distinct sections in terms of passenger loading viz Colaba - Bandra with higher peak section loads, and Bandra – SEEPZ with comparatively lower section loads.

The train operation plan is, therefore, envisaged with a mid-terminal facility at Bandra Metro station to enable differential train frequencies in these two sections.

The PHPDT values considered for the two sections for formulating the train operation plan for different horizon years are given in **Table 6.2**.

Table 6.2: Year Wise Peak Hour Peak Direction Traffic (PHPDT) Demand

Corridor	2016	2025	2031
COLABA-BANDRA	25000	36000	42000
BANDRA-SEEPZ	16000	18000	21000

6.5. TRAIN FORMATION

To meet the above projected traffic demand, the possibility of running trains with composition of 4 car, 6 car, and 8 car with different headways has been examined.

6.5.1. Composition

Car composition to be adopted for year 2016, 2025 & 2031 is given as under;

- DTC : Driving Trailer Car
- MC : Motor Car
- TC : Trailer Car
- 6 Car Train Composition : DTC + MC + TC + MC + MC + DTC
- 8 Car Train Composition : DTC + MC + TC + MC + MC + TC + MC+ DTC

6.5.2. Capacity

For the purpose of calculating rake requirement of rolling stock, passenger carrying capacity is considered on the basis of ***6 standees per square meter*** of standing area.

- DTC : 282 passenger (Sitting-43, Crush Standing –239)
- TC/MC : 307 passenger (Sitting-50, Crush Standing –257)
- 6 Car Train : 1792 passenger (Sitting-286, Crush Standing – 1506)
- 8 Car Train : 2406 passenger (Sitting-386, Crush Standing – 2020)

Table 6.3: Train Capacity according to the number of cars

Train capacities	6-car train	8-car train
Seated + Standees (6 p/m²)	1,792	2,406
Seated + Standees (8 p/m²)	2,280	3,000

Based on the ridership figures, it is proposed to initially operate 6-car trains. Subsequently, the passenger carrying capacity can be increased either by varying the train configuration to 8-car trains or by decreasing the headway.

6.6. HEADWAY

Based on the projected PHPDT demand tabulated in **Table 6.2**, train operation with 6-Car train at headway of 260/400 seconds for the year 2016, train operation with 6-car at headway of 180/360 seconds for the year 2025 & train operation with 6-Car train at headway of 150/300 seconds for years 2031 has been planned for Colaba - Bandra/ Bandra – SEEPZ Corridor.

Train operation plan with train carrying capacity @ 6 persons per square meter of standee area on Colaba - Bandra/ Bandra – SEEPZ sections is given below:

6.6.1 Train Operation - Year 2016

Train operation with **6 car Train** composition with average headways of **260 sec** between Colaba to Bandra and **400 sec** between Bandra to SEEPZ is planned in first year of operation i.e. **2016** with Peak Hour Peak Direction Capacity of **25088 and 16128** respectively @ 6 persons per square meter of standee area (Capacity @ 8 persons per square meter of standee area would be 31920 and 20520 respectively).

With the proposed headway for both sections, the planned capacity is slightly more than PHPDT demand. Thus, with this planned capacity, optimum utilization of Rolling Stock will be achieved.

Table 6.4: Capacity Provided in 2016

Year	2016	
Section	**Colaba – Bandra**	**Bandra - SEEPZ**
Cars per train	6	6
Head way (Seconds)	260	400
Max. PHPDT Demand	25000	16000
PHPDT Capacity Available	25088	16128

6.6.2 Train Operation - Year 2025

Train operation with **6-car train** composition and with average headways of **180 Sec** between Colaba- Bandra and **360 Sec** between Bandra – SEEPZ is planned in year of operation **2025** with Peak Hour Peak Direction Capacity of **35840 and 17920 respectively** @ 6 persons per square meter of standee area (Capacity of 45600 and 22800 respectively @ 8 persons per square meter of standee area).

With the proposed headway for both sections, the planned capacity is slightly less than PHPDT demand. However the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections where PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock and the optimum utilization of Rolling Stock will be achieved.

Table 6.5 : Capacity Provided in 2025

Year	2025	
Section	**Colaba – Bandra**	**Bandra – SEEPZ**
Cars per train	6	6
Head way (Seconds)	180	360
Max. PHPDT Demand	36000	18000
PHPDT Capacity Available	35840	17920

6.6.3 Train Operation - Year 2031

Train operation with **6 car Trains** with average headways of **150 Sec** between Colaba-Bandra and **300 sec** between Bandra – SEEPZ is planned in first year of operation i.e. **2031** with Peak Hour Peak Direction Capacity of **43008 and 21504 respectively** @ 6 persons per square meter of standee area (Capacity of 54720 and 27360 respectively @ 8 persons per square meter of standee area).

With the proposed headway for both sections, the planned capacity is slightly more than PHPDT demand. Thus, with this planned capacity, optimum utilization of Rolling Stock will be achieved.

Table 6.6: Capacity Provided in 2031

Year	2031	
Section	**Colaba – BANDRA**	**BANDRA - SEEPZ**
Cars per train	6	6
Head way (Seconds)	150	300
Max. PHPDT Demand	42000	21000
PHPDT Capacity Available	43008	21504

6.7. TRAIN FREQUENCY

- The train operation plan provides for 260/400 seconds headway with 6-Car Train during peak hours and 20/30 minutes headway during lean hours to keep the services attractive in the year 2016.
- In the year 2025, train headway is planned at 180/360 seconds with 6-car train during peak hours and 20/30 minutes during lean hours.
- Peak time train headway is proposed to be 150/300 seconds with 6-Car Train in the year 2031 while lean time headway is kept at 20/20 minutes.
- Airport traffic will be served with a head way of 20-30 minutes between 00.00 hrs. to 2.00 hrs.

6.8. HOURLY TRAIN OPERATION PLAN

The number of train trips proposed to be operated daily during different hours in each direction for the year 2016 (first year of operation), 2025 and 2031 for each section of the network is presented in **Table 6.7** and **6.8** respectively**.**

Table 6.7 : Hourly Operation Plan for 2016 and 2025 : Colaba – Bandra - SEEPZ

Schedule Speed : 30 kmph					Total Turn-around time : 5 minutes			
Year	**2016**		**2016**		**2025**		**2025**	
Corridor	Colaba – Bandra		Bandra - SEEPZ		Colaba – Bandra		Bandra - SEEPZ	
Km	21.75		11.76		21.75		11.76	
Car per Train	6		6		6		6	
Time (Hours)	**Head way Sec**	**Trains/ hour per direction**	**Head way Sec**	**Trains/ hour per direction**	**Head way Sec**	**Trains/ hour per direction**	**Head way Sec**	**Trains/ hour per direction**
0500 - 0559	600	6	720	5	360	10	720	5
0600 - 0659	450	8	600	6	260	14	600	6
0700 - 0759	300	12	520	7	210	17	450	8
0800 - 0859	**260**	**14**	**400**	**9**	**180**	**20**	**360**	**10**
0900 - 0959	**260**	**14**	**400**	**9**	**180**	**20**	**360**	**10**
1000 - 1059	300	12	520	7	210	17	450	8
1100 - 1159	300	12	600	6	240	15	516	7
1200 - 1259	360	10	600	6	240	15	516	7
1300 - 1359	360	10	600	6	240	15	516	7
1400 - 1459	360	10	600	6	240	15	516	7
1500 - 1559	300	12	600	6	240	15	516	7
1600 - 1659	300	12	516	7	210	17	450	8
1700 - 1759	**260**	**14**	**400**	**9**	**180**	**20**	**360**	**10**
1800 - 1859	**260**	**14**	**400**	**9**	**180**	**20**	**360**	**10**
1900 - 1959	300	12	520	7	210	17	450	8
2000 - 2059	360	10	520	7	240	15	516	7
2100 - 2159	450	8	600	6	300	12	600	6
2200 - 2259	600	6	720	5	360	10	720	5
2300 - 2359	720	5	900	4	450	8	900	4
0000 - 0059	1200	3	1800	2	1200	3	1800	2
0100 - 0200	1200	3	1800	2	1200	3	1800	2
Trains/day per Direction		207		131		298		144
Total No. of Trains		**414**		**262**		**596**		**288**

Table 6.8 : Hourly Operation Plan for 2031 : Colaba – Bandra -SEEPZ

Schedule Speed : 30 kmph				
Turn-around time : 5 minutes				
Year	**2031**		**2031**	
Corridor	Colaba – Bandra		Bandra - SEEPZ	
Km	21.75		11.76	
Car per Train	6		6	
Time (Hours)	**Head way min**	**Trains/ hour per direction**	**Head way min**	**Trains/ hour per direction**
0500 - 0559	240	15	600	6
0600 - 0659	210	17	450	8
0700 - 0759	180	20	360	10
0800 - 0859	**150**	**24**	**300**	**12**
0900 - 0959	**150**	**24**	**300**	**12**
1000 - 1059	180	20	360	10
1100 - 1159	210	17	450	8
1200 - 1259	210	17	450	8
1300 - 1359	210	17	450	8
1400 - 1459	210	17	450	8
1500 - 1559	210	17	450	8
1600 - 1659	180	20	360	10
1700 - 1759	**150**	**24**	**300**	**12**
1800 - 1859	**150**	**24**	**300**	**12**
1900 - 1959	180	20	360	10
2000 - 2059	210	17	450	8
2100 - 2159	240	15	600	6
2200 - 2259	300	12	720	5
2300 - 2359	360	10	900	4
0000 - 0059	1200	3	1200	3
0100 - 0200	1200	3	1200	3
Trains/day per Direction		353		171
Total No. of Trains		**706**		**342**

6.9. ROLLING STOCK REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand in different years, Rake requirement has been calculated separately for Colaba – Bandra and Bandra to SEEPZ sections.

Requirements of coaches has been calculated based on the following assumptions -

i. Train Composition planned as under
   - 6 Car Train Composition : DTC + MC + TC + MC + MC + DTC

ii. Train Capacity
   - DTC = 282 (passengers)
   - MC/ TC = 307 (passengers)
   - 6 -Car Train = 1792 (passengers)

iii. Coach requirement has been calculated based on headway during peak hours.

iv. Traffic reserve/ Operational spares have been considered @5% of Bare requirement (minimum one trains per section) to cater to failure of train on corridor and to make up for operational time lost.

v. Repair and maintenance has been estimated as 8 % of total requirement (Bare +Traffic Reserve) based on Intermediate overhaul and periodic overhaul interval.

vi. The calculated number of rakes in fraction is rounded off to next higher number.

vii. Schedule speed has been taken as 30 Kmph.

viii. Total Turn round time at terminal stations has been taken as 5 minutes.

Based on Train length and headway as decided above to meet Peak Hour Peak Direction Traffic Demand in different years, Rake requirement has been worked out in **Table 6.9**:

Table 6.9: Year Wise Car and Rake Requirement

Time horizon	**Section Length**		**Bare Rake Requirement**		**Total Bare Rake Reqd.**	**Maint. Spare**	**Traffic spare**	**Total rake Reqd.**	**Total coach Reqd.**
	Colaba-Bandra	**Bandra-SEEPZ**	**Colaba-Bandra**	**Bandra-SEEPZ**					
2016	21.746	11.762	22	8	30	3	2	35	**210**
2025	21.746	11.762	31	9	40	4	3	47	**282**
2031	21.746	11.762	36	10	46	5	4	55	**330**

7. MAINTENANCE DEPOT & WORKSHOP

7.1 INTRODUCTION

The Colaba – Bandra - SEEPZ Corridor would require a dedicated Depot cum workshop facility for the maintenance of the rakes in the inception year 2016. As the Rake holding increases in the year 2025 to meet the traffic demand, a minor depot will have to be set up to cater to the maintenance requirement of the increased coach holding. This minor depot will have necessary facilities for stabling cum inspection. However, all the rakes will be serviced at main Depot cum workshop for the major schedules viz periodical overhaul (AOH/POH) and major unscheduled repairs. The main depot will also house Operation Control Centre (OCC), Administrative Building, maintenance facilities for Civil – track, buildings, water supply; Electrical – traction, E&M; Signalling & Telecomm.; Automatic Fare Collection etc. apart from necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor.

For starting the morning services, some rakes will have to be kept at terminal stations and stabling facilities for the remaining rakes will have to be provided at the depots.

All the systems at these depots would be designed to cater for 8 Car composition trains in order to serve the ultimate passenger traffic on Colaba - Bandra - SEEPZ corridor.

This chapter covers following aspects of depot -

- Conceptual design and layout of Stabling lines, Inspection Shed and Workshop to provide maintenance facilities and stabling facilities for the Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply system etc.
- Location for Depot cum Workshop
- Location for Minor Depot

This chapter provides conceptual design of the depot and will only work as a guide for the detailed design later.

7.2 MAINTENANACE PHILOSOPHY

The main outlines of the maintenance philosophy followed are:

- Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like "Daily Safety checks", "15 days check", "45 days check", "6 Months Insp.", "12 Months Insp."& "POH" etc.

- Unit replacement and to get essential repairs done by the OEMs, will be preferred. Since the cost is a constraint, certain activities of the workshop can be outsourced.
- Labour intensive procedures will be kept to the minimum. More automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation shall be given due attention

7.3 PLANNING OF THE MAINTENANCE FACILITIES SETUP

The projected Rolling Stock requirements for the corridor are as follows:

Year	2016	2025	2031
Headway (seconds)	260/400	180/360	150/300
No of Cars/Train	6	6	6
Rakes Required	35	47	55
Cars Required	210	282	330

The operation plan envisages 6 car rakes operation at varying headway of 260 seconds to 150 seconds on Colaba - Bandra section and 400 seconds to 300 seconds on Bandra - SEEPZ section as the demand grows. As per train operation plan, the rake requirement is 55 rakes of 6-car configuration for the horizon year 2031. However, all the infrastructure is planned with 8 car composition to take care of requirement beyond the horizon year 2031. Accordingly, Depots will have necessary facilities for maintenance of ***55 rakes of 8 car i.e 440 coaches***.

7.4 ROLLING STOCK MAINTENANCE NEEDS

The servicing requirement is to be determined from the Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;
- Wheels (Rediscing / reaxling is planned at workshop only);
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;

- Batteries;
- Rolling stock air conditioning;
- Brake modules;
- Vehicle doors, windows and internal fittings.

The modern, fully equipped facilities are proposed to be provided to meet these requirements efficiently and in full. In meeting these requirements, it is envisaged that the average daily distance travelled by each rolling stock unit is approximately **350 km**. The following maintenance schedule **(Table 7.1)** has been followed for conceptual design –

Table 7.1 Proposed Maintenance Schedule

Type of Schedule	Interval	Work content	Locations Time Taken
Daily	Daily	Check on the train condition and function at every daily service completion. Internal cleaning / mopping of floor and walls with vacuum cleaner.	Stabling Bays **2 hours**
'A' Check	5,000 Km (15 days)	Check on the safety and reliability of critical equipment, General visual inspection, testing of systems, replacement of oils & lubricants and consumables	Inspection Bays **4 hours**
'B' Check	15,000 Km (45 days)	Detailed inspection of 'A' type tasks plus items included in 'B' type tasks	Inspection Bays **8 hours**
'C' Check	60,000 Km (6 Months)	Detailed inspection of 'A' type tasks, 'B' type tasks plus items included in 'C' type tasks	Inspection Bays **3 Days**
AOH (Annual Inspection/ Overhaul)	120,000 Km (12 Months)	Checking and testing of all sub-assemblies (Electrical + Mechanical). Replacement of parts and rectification, trial run etc.	Inspection Bays **5 Days**
POH (Periodical Overhaul)	350,000 Km (3 Years)	Dismantling of all sub-assemblies, bogies, suspension system, traction motor, gear, control equipment, air-conditioning units etc. Checking repair and replacement as necessary. Inspection and trial	Workshop **24 Days**

7.5 WASHING NEEDS OF ROLLING STOCK

To maintain high degree of cleanliness, following schedules **(Table 7.2)** are proposed for cleaning of rakes –

Table 7.2 Schedule of Cleaning

S. No.	Kind of Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside Cleaning (wet washing on automatic washing plant)	3 Days	10 mins	Automatic washing plant of Depot Single Pass
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/ Buffer area, Floor, walls inside/ outside and roof Manually)	30 days	3 Hrs	Automatic washing Plant & heavy cleaning / stabling line

7.6 DEPOT CUM WORKSHOP

The layout plans of proposed Main Depot cum Workshop and Minor Depot are shown in **drawing no. T-AD-1-01 (Annexure-I**.) & **T-KD-L-1-01 (Annexure-II**.) respectively. The concept layout is evolved for maintenance & POH of ***55 Rakes of 8 car length***.

Operational Features

The rake induction and withdrawal from depot to the open line will have to be so planned that the headway of open line is not affected. For the purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line should be created. The stabling area should be interlocked with the open line so that the induction of train from the stabling can be done without loss of time. The rake washing can be done at automatic coach washing plant provided at the entry of depot i.e before rake is placed on stabling lines.

The other movements in the depot, viz from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. An ART line and 2 emergency rerailing lines have been provided from which emergency rescue vehicles can be dispatched to open line in the event of any emergency. To cater to the peak requirements, all trains would be in the service, only trains under maintenance would be in the shed. However during the off-peak hour in daytime, approximately half of the trains will be withdrawn from the service. To economize on the air-conditioning energy, 50% of the total stabling lines would be under covered stabling shed. There would be pathways between the stabling lines, which are necessary for the "Safe to Run" examination and to facilitate the workers to move trolleys for the sweeping work. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night.

The stabling and the yard layout would be at grade level for least power requirements in shunting movements and to avoid accidental rolling of Rolling Stock resulting into accidents and damages to the property.

7.7 INFRASTRUCTURE FACILITIES PLANNED AT DEPOT

As per the above frequency of inspections, the visits of rakes to Depots are as given below:

Table 7.3 Rake visits to Depots and Workshops

Schedule	Inspection Arising in 3 Years per rake	Inspection Arising in 3 Years for total holding (55 rakes)	Average visits per year for designed holding of 55 rakes
A check	48	2640	880
B check	18	990	330
C check	3	165	55
AOH	2	110	37
POH	1	55	18

To assess the number of lines required to maintain the rakes, following assumptions are made:

i) For Washing of rakes, an automatic washing plant is proposed. Hence no separate washing line is needed exclusively for washing. However, one line is provided for heavy cleaning (Manual cleaning of Floor, walls inside/outside and roof).

ii) In a day, two rakes are taken for 'A check' on a pit line.

iii) In a day, one rake is taken for 'B check' on a pit line.

iv) Pit line occupancy for 'C check' is taken for 3 days and 'AOH' for 5 days.

v) Based on the number of holidays as given below, total number of working days is taken as 300 for calculating the requirement of lines.

No. of days of Public holidays in a year : 13

No. of Sundays in a year : 52

No. of available working days in a year : 365 - 65 = 300 days

Table 7.4 Requirement of Inspection lines

Type of Schedule	Arisings / year for the designed holding of 55 rakes	Time taken in schedule	No. of rakes to be attended on a line / day	Lines required for the designed holding
A check	880	4 hours	2	1.47
B check	330	8 hours	1	1.10
C check	55	3 days	1	0.55
AOH	37	5 days	1	0.61
POH	18	24 days	1	1.47

As against above requirement, the infrastructure provided for Schedule inspection and Periodic overhauling is indicated in **Table 7.5.**

Table 7.5 Infrastructure (Lines) provided for Design Capacity of Depots

S. No.	Schedule	Designed capacity (8 car length)	No. of lines required for Designed capacity	No. of lines provided		
				Main Depot	Minor Depot	TOTAL
Inspection shed						
1	A check (15 days)	55 rakes	2	3	2	**5**
2	B check (45 days)	55 rakes	2			
3	C check (6 Month)	55 rakes	1	1	1	**2**
4	AOH (12 Month)	55 rakes	1	1	-	**1**
5	Adjustment line	Insp./Unsch. repair rakes adjustment	-	1	1	**2**
Workshop						
6.	Periodical Overhaul (POH)	55 rakes	2	5	**-**	**5 ***

* All lines in workshop to be provided with Lifting facility (4 lines for POH & 1 line for unscheduled Repair / Lifting etc.)

The main depot will have infra-structure for inspection of 35 Rakes and periodical overhaul (AOH/POH) capacity for 55 Rakes of 8 car. The minor depot is envisaged to have necessary facilities for stabling & inspection of remaining 20 rakes of 8 car. Accordingly, 6 lines have been provided for the schedule inspections & 5 lines for periodical overhaul / major unscheduled repairs in the main depot and 4 lines in minor depot for inspection of rakes.

7.7.1 Stabling Lines in Depot

As per the requirement of the rakes for the different horizon years, the requirement of the stabling to be catered in the depot, at the terminal stations and stabling areas for different horizon years are summed in the **Table 7.6**.

Table 7.6 : Stabling Line Requirements

Year	2016	2025	2031
Stabling Requirements	35	47	55
Rake Length (no. of cars)	6	6	6

Stabling Line Provisions :

The train operation plan envisages operation with 6 car composition. However, as indicated in the preceding paras, all the infra structure facilities are proposed to be provided for 8 car length. Therefore, all the stabling lines may also be provided for 8 car length and accommodate trains as detailed in **Table 7.7** below :

Table 7.7 : Stabling Line Provisions

Year	2016	2025	2031
Total Stabling Lines of 8 car length required	35	47	55
Stabling at the Colaba terminal station & mid terminal Bandra	6	6	6
Rakes to be stabled in the Depots	29	41	49

Twenty Four (24) number of 8-car length-stabling lines and Six (6) number of inspection lines have been provided in the main depot to house total 30 rakes. For starting the morning services, it will be necessary to stable the rakes at the terminal station as well. It is planned to keep four rakes at the terminal station i.e. Colaba/Cuffe Parade and two rakes at Bandra mid terminal.

Since, the main depot will have capacity to stable 30 rakes of 8 car, the stabling facilities provided in the depot are adequate to meet the requirement up to year 2024. As the rake holding increases in the year 2025, a minor depot with stabling cum inspection facilities for about 20 rakes will have to be set up in the financial year 2024-25. These depots will have a combined capacity to stable 50 rakes of 8 car, which is adequate to meet the requirement up to horizon year 2031.

Design of Stabling Lines

The length of 8 cars Rolling Stock is approx 179 m. Stabling lines are designed for 200 m length or more to cater for provision of the friction buffer stops and the signaling / interlocking needs - assuming the speed of the Rolling Stock in the depot to be 15 kmph. The breakup is as follows :

179m (length of 8 car Rolling Stock) + 15 m (length of the Buffer for 8 car Rolling Stock & signaling / interlocking needs) + 1m (clear distance between Rolling Stock & buffer) + 5m (clearance between two 4 car trains running initially) = 200m.

Accordingly, stabling lines as well as inspection & workshop lines are designed for 200m lengths. The track centre in stabling lines would be 4.9~5.3m and in inspection lines 6.25~8.5m. Thus, sufficient space has been provided to construct pathway in stabling area and in inspection shed to provide easy access for internal train cleaning / attention to equipments in passenger area.

7.7.2 Inspection Shed

15-days inspection, 45 days inspection, 6 monthly inspections and Annual overhauling (AOH) will be carried out in the Inspection shed. The minor inspection viz 15-days inspection & 45 days inspections may be done in off peak period and during night when the services are completely stopped for maintenance. For other inspections, rakes will have to be withdrawn in a planned manner as per due date of inspection/AOH. The size of covered shed provided for inspection is 200 x 45 m^2 for main depot & 200 x 33 m^2 for minor depot. In addition, an area of 200 x 20 m^2 has been earmarked for the inspection offices & maintenance sections.

Material Movement Inside the Inspection Shed

Ramps of 1 : 8 slopes, 3.5 meter wide have been provided with sunken floor for movement of material for the cars. Further pathways have been provided at each end of shed & workshop for movement of material by fork lifter/ Lister / hand trolley etc.

7.7.3 Test Track Line

A test track of 675 m length has been provided for testing of 8-car train in the main depot. This line can also be used for stabling of rakes in case of emergency.

7.7.4 Automatic Coach Washing Plant

Provision is made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately six trains per hour.

7.7.5 Washing Apron

Monthly heavy Cleaning of interior walls, floors, seats, windows glasses etc, outside heavy Cleaning, Front/Rear face, Vestibule/ Buffer area, outside walls and roof may be done manually, for which lines have been provided by the side of the covered stabling lines.

7.7.6 Power Supplies

An auxiliary substation of 2500 KVA capacity has been planned for catering to the power supply requirement of the main depot and 1500 KVA capacity for the minor depot. Details of connected load, feeder may be worked out during detailed designing stage.

7.7.7 Standby Power Supply

The standby power supply is proposed through silent DG set of 3X320 KVA capacity to supply all essential loads without over loading.

7.7.8 Water Supply, Sewerage and Drainage Works

In-house facilities should be developed for water supply for the entire depot cum workshop. Sewerage, storm water drainage may be given due care while designing the depot for efficient system functioning. Rainwater harvesting should be given due emphasis to charge the underground reserves.

7.7.9 Engineering Train Unit Workshop

Since the workshop cum depot is designed optimally, it would not be wise to waste its capacity in maintaining the other than passenger Rolling Stock vehicles. Carrying these vehicles to the inspection shed affects the RS maintenance as shunting is also involved. Therefore other vehicles like diesel locomotive, tower wagons, wagon for material trains etc may be housed and given required inspection attention in a separate shed called ETU workshop, for which 2 lines have been provided in the main depot. However for the heavy lifting needs, these vehicles may be taken to main workshop for required attention.

7.7.10 Facilities For Rolling Stock Overhaul in Workshop (Main Depot)

The size of the workshop shed is 200 x 50 m^2 and an additional covered space of 200 x 20 m^2 has been provided to cater for offices cum maintenance sections, costly item store, locker room, toilet etc. Following equipment repair/overhaul facilities are planned in the workshop.

- Body furnishing.
- Bogie.
- Wheels.
- Traction Motor.
- Axle box and axle bearing.
- Power Collector.
- Electrical equipment like transformer, converter/inverter, circuit breaker, relays etc.
- Battery.
- Air compressor.
- Air conditioning equipments.
- Brake equipment.
- Door actuators.
- Control and measuring equipments.
- Pneumatic equipments

Cross track equipped with bogie turntables have been provided for movement between bays.

7.8 ANCILLARY SHED AND BUILDINGS

The ancillary shed and buildings in the depots with their sizes and brief functions are indicated in **Annexure-III(a) & Annexure-III(b)**.

7.9 PLANT AND MACHINERY

Requirement of major plants and machinery, which are vital for operational needs, is given in **Annexure-IV**.

7.10 DEPOT LOCATION

The proposed Corridor would require a dedicated Depot cum Workshop (Main Depot) in the inception year 2016 and a Minor Depot to be set up by the year 2025 for the maintenance of the Rakes. It is envisaged that an area of about ***25 Ha*** would be required for the main depot and about ***15 Ha*** for the minor depot.

7.10.1 Car Depot Site requirements

The pre requisites of coach maintenance depot site are as under –

i. A plot size of adequate area - about 25 Ha for main depot & 15 Ha for minor depot,

ii. Proximity to alignment : Site must be located as close to the alignment as possible so that no time is wasted in placement/retrieval of rakes from depot. In addition, it will save expenditure in constructing link from corridor to depot,

iii. Ease of movement – there should not be any obstruction to movement of rakes in either direction so that defective rakes can be withdrawn from service & placed in depot for maintenance and healthy rakes can be retrieved from depot & pressed in service.

7.10.2 Depot Sites along the alignment

Following sites (Figure 7.1) having vacant areas of the requisite size along the alignment have been identified for setting up of depots;

i. Mahalaxmi Race Course
ii. Exhibition grounds at BKC
iii. Kalina University land
iv. Aarey milk colony land, which is located at the end of corridor, about 1 Km from SEEPZ.

Figure 7.1 : Alternative Depot Locations

All the above four locations were visited by the team of RITES alongwith MMRDA officials and feasibility of setting up depot at these locations studied.

7.10.3 Choice of underground / over ground depot

The entire Corridor is proposed to be underground. The alignment passes through densely populated, developed island city. The depot area requirement is also huge - considering the limited availability of land in a congested city such as Mumbai.

Accordingly, while examining the feasibility of the Depot site, the possibility of planning for an underground depot (with area on and above ground utilized for commercial purposes) is worth exploring.

However, an underground depot has its unique characteristics and cost implications. A case study of .Kim Chuan underground Depot at Singapore has been examined to better appreciate this.

Underground maintenance depot - Case Study (Kim Chuan underground Depot, Singapore)

Rolling stock maintenance depots are generally constructed at grade. However, with successful commissioning of Kim Chuan Depot for the Mass Rapid Transit system in Singapore on 4th March 2009, new options of providing underground Rolling stock maintenance depot have opened up.
The salient features & project statistics of Kim Chuan underground Depot, which serve the MRT Circle Line (CCL) and the future Eastern Regional Line (ERL), are indicated below to get an insight to the technical details / challenges involved with underground depot -

<u>Unique Features</u>

- Kim Chuan Depot is Singapore's first underground depot and touted as the world's biggest underground Rolling stock maintenance depot

- It has a ***capacity to stable 70 three-car trains*** and provide maintenance facilities for the entire MRT Circle Line (CCL)

- Houses the Operation Control Centre (OCC) for CCL.

- Provision for two future OCCs & development on part of the Depot roof to maximise land-use. About ***three hectares*** of land left empty at ground level will be used for light industrial development which can have buildings of up to nine storeys

<u>Project Statistics</u>

- The Depot is about 800m long, 160m wide and 17m deep.
- The site area is about 110,000 sqm. (11 Ha)
- A total of 2.16 million m^3 of material was removed from the site
- 340,000 m^3 of concrete was used.
- There are more than 1000 nos. of bored piles constructed.

- Pre-cast concrete elements are extensively used in the project for labour-saving consideration. More than 6000 items, ranging from precast beams to hollow-core slabs are detailed for the completion of the project.
- The building electrical supply is distributed through 3 load centres via 200 sub main and distribution boards.
- The facility has a 23-metre high automatic storage and retrieval system, a first for a train depot.
- Due to the vast area 70 fire rated smoke extract fans, 130 intake air fans and 132 exhaust air fans have been provided to ventilate the depot.
- Elaborate fire protection system, consisting of 3 clean gas systems, 4 wet riser pumps of capacity over 780 lps, 9 sub alarm panels and 35 control valves for the 21,500 sprinkles, has been provided.
- It took about 5 years to complete the construction of the depot
- Total project cost is reported to be $290 million



Depot Ground level ***Train lifted for maintenance*** ***Operation Control Centre***

7.10.4 Challenges involved with underground depot

Some of the challenges involved with underground depot are as follows:

- Safety of Rolling stock and maintenance personnel – very elaborate arrangements for fire & smoke, ventilation and air conditioning and flood relief will have to be made. In addition, since 25kv ac traction is envisaged for this corridor, adequate clearances and special safety measures will have to be taken to avert any untoward incidence.

- High cost of construction – the estimated cost of setting up a depot at grade is about Rs. 250 crores as against Rs 1500 crores (approx.) for underground depot of this size

- Completion period – whereas depot at grade can be constructed in about 2 years, constructing an underground depot may take up to 5 years

- Special provisions will have to be made for bringing rolling stock to the depot or for lifting it to take out from depot as proposed Colaba-Bandra-SEEPZ corridor will be completely underground.

- Disposal of large volume of earth extracted from underneath will be a challenging task especially in Metropolitan city of Mumbai

- No possibility of expansion in future – the underground depot will have to be planned for the ultimate requirement at the beginning itself to avoid constraint at a later stage

- High operation cost – as lighting, ventilation and air conditioning loads will have to be catered to round the clock

Notwithstanding above, the space at ground level above the underground depot can be utilised for property development / commercial exploitation but the cost economy needs to be worked out considering –

- an ***additional expenditure*** of about ***Rs.1250 crores*** in construction,

- ***recurring additional expenditure*** of about ***Rs.20 crores per annum*** in operation (including ventilation),

- some of the structures such as Receiving sub-station(RSS), Entry/Exit routes for men & material, opening for ventilation/exhaust fans will have to be constructed at-grade, therefore, space for commercial exploitation will have its limitations,

- other safety hazards – fire & smoke, flooding, ventilation etc. involved with underground depot.

In view of above, ***underground depot may be provided, in case, all other options to construct depot at grade have been exhausted***. For Colaba – Bandra – SEEPZ corridor, car depot can be constructed at grade at some of the identified locations as discussed in the following sections.

7.10.5 Site selection for maintenance depots

The merits and demerits of sites available for setting up of maintenance depots at the 4 locations, are discussed in the following sections;

7.10.5.1 Mahalaxmi Race Course

Mahalaxmi Race Course, spread over approx. 225 acres of land facing the sea, is located opposite Mahalaxmi Railway station of Western Railway on Dr.E.Moses Marg. The horse stable area of Race course measuring about 19.2 Ha has been identified for constructing car depot. A station viz Science Museum is planned near this location along the proposed metro alignment.

Site Characteristics

Area	19.2 Ha
Distance from Alignment	Less than 1 km
Land ownership	On lease from the Municipal Corporation of Greater Mumbai (MCGM) to Royal Western India Turf Club

Merits

i. Adequate area available for setting up of minor depot

ii. Proximity to alignment : Less than 1 Km from Science Museum station on the alignment

iii. Ease of movement – rakes can easily be placed & retrieved from depot from Science Museum station

iv. Maintenance depot at this location can serve the corridor from Colaba – Bandra and future expansion to SEEPZ, in case it is decided to take up the work in phases

Demerits

i. Land lease issue will have to be resolved with Royal Western India Turf Club, which has patronage of celebrities & high profile influential socialites

ii. Heritage status : The Grandstand, off the course, is a designated heritage structure, therefore, additional clearances would be needed

iii. Keeping in view the heritage status of Mahalaxmi Race Course, ***underground depot*** may have to be provided at this location with restrictions on the structures that can be erected at grade

iv. Horse stables will have to be shifted to start construction work

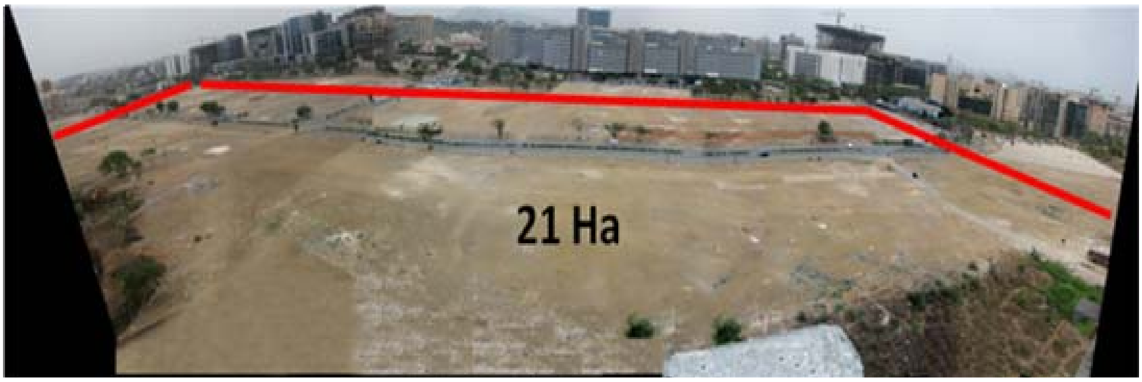
v. Complications in shifting of underground utilities

7.10.5.2 Exhibition grounds at BKC

BKC exhibition ground is located opposite Diamond Bourse development and north of Asian Heart Hospital. This site is close to Bandra (Metro) and Mumbai University Kalina stations on the proposed alignment.

Site Characteristics

Area	21 Ha
Distance from Alignment	Less than 1 km
Land ownership	MMRDA



Merits

i. Adequate area available for setting up of minor depot
ii. Proximity to alignment
iii. MMRDA being the owner, no delay in acquisition
iv. Free from encumbrances
v. No major complications involved in shifting of public utilities
vi. Maintenance depot at this location can serve the corridor from Colaba – Bandra or Bandra – SEEPZ and future expansion to SEEPZ/Colaba, in case it is decided to take up the work in phases

Demerits

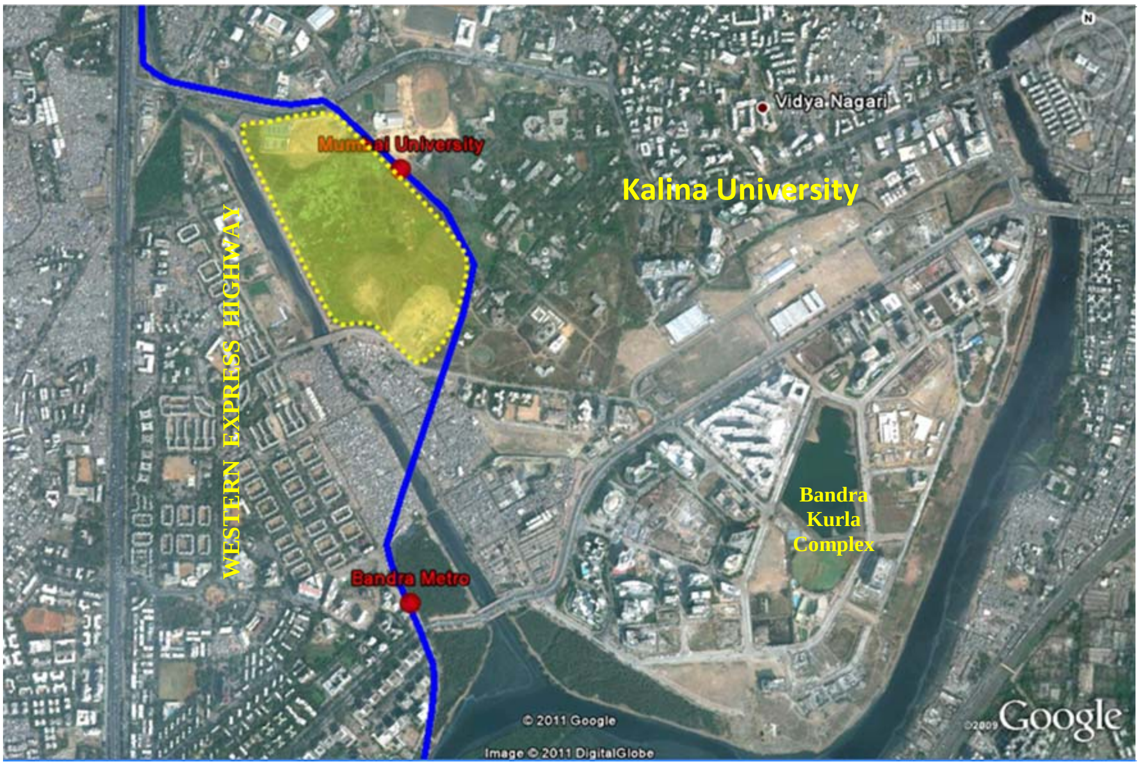
i. Notional loss due to use of property located in costly BKC area, which can be used more gainfully for property development / commercial exploitation
ii. Loss of revenue during construction
iii. Constraint on future development of the area that has tremendous commercial potential
iv. Opposition from buildings close to the site

7.10.5.3 Kalina University Land

Kalina University is located at the western edge of BKC with a total vacant area of 20 Ha. With regards to the metro alignment, a station is proposed at Mumbai University, Kalina.

Site Characteristics

Area	20 Ha
Distance from Alignment	Less than 1 km, Station located on the site
Land ownership	Kalina University



Merits

i. Adequate area available for setting up of minor depot
ii. Proximity to alignment, station is proposed at this site
iii. Free from encumbrances
iv. No major complications involved in shifting of public utilities
v. Depot can be constructed at grade
vi. Ease of movement – rakes can easily be placed & retrieved from depot in either direction
vii. Maintenance depot at this location can serve the corridor from Colaba – Bandra or Bandra – SEEPZ and future expansion to SEEPZ/Colaba, in case it is decided to take up the work in phases

Demerits

i. Difficulties in land acquisition as the land is owned by Kalina University and they have plans for expansion on the land
ii. Site being near to Vakola Nala, part of the plot falls in CRZ-II; hence additional clearances will be required for the site.

7.10.5.4 Aarey Milk Colony Land

Two sites have been identified in Aarey Milk Colony Land, one located along JVLR opposite SEEPZ, having an area of 34.3 Ha. and another adjacent to SEEPZ with total vacant area of 20 Ha.

Site Characteristics

	Plot – I	Plot – II
Area	34.3 Ha	20
Distance from Alignment	1 km from SEEPZ	1.5 km from SEEPZ
Land ownership	Aarey Milk	Aarey Milk

Plot – I

Merits

i. Adequate area available for setting up of main Depot cum workshop
ii. Depot can be constructed at-grade
iii. No major complications involved in shifting of public utilities
iv. Ease of movement – rakes can easily be placed & retrieved from depot, site being at the end of corridor
v. Future Expansion of depot possible as adequate vacant land available in the vicinity

Demerits

i. Difficulty in land acquisition as the land is owned by Aarey and they use the land for cow sheds, which will have to be rehabilitated
ii. Green land : site being in G1 zone as per DP; hence additional clearances will be required for the site
iii. Corridor will have to be extended by about 1 Km for the depot

Plot – II

Merits

i. Adequate area available for setting up of minor depot
ii. Depot can be constructed at-grade
iii. Need for crossing the JVLR highway and flyovers is obviated

Demerits

i. Shape of the plot is not conducive for depot layout
ii. Cowsheds located at the plot will have to be rehabilitated
iii. Corridor will have to be extended by about 1.5 Km for the depot
iv. Approach to the depot is constrained due to presence of multi-storied buildings between the alignment and the depot site
v. Green land : site being in G1 zone as per DP; hence additional clearances will be required for the site

In view of the above, Plot I appears more suitable than Plot II for depot location.

7.10.6 CONCLUSION

Based on the site visit, various Merits & Demerits indicated above for each site and discussions held with MMRDA officials, use of ***Aarey Milk Colony Land (Plot-I)*** and ***Kalina University land*** appears to be the most suitable locations for setting up of Main Depot cum Workshop and Minor Depot respectively. The comparative merits and demerits of these two locations is indicated below -

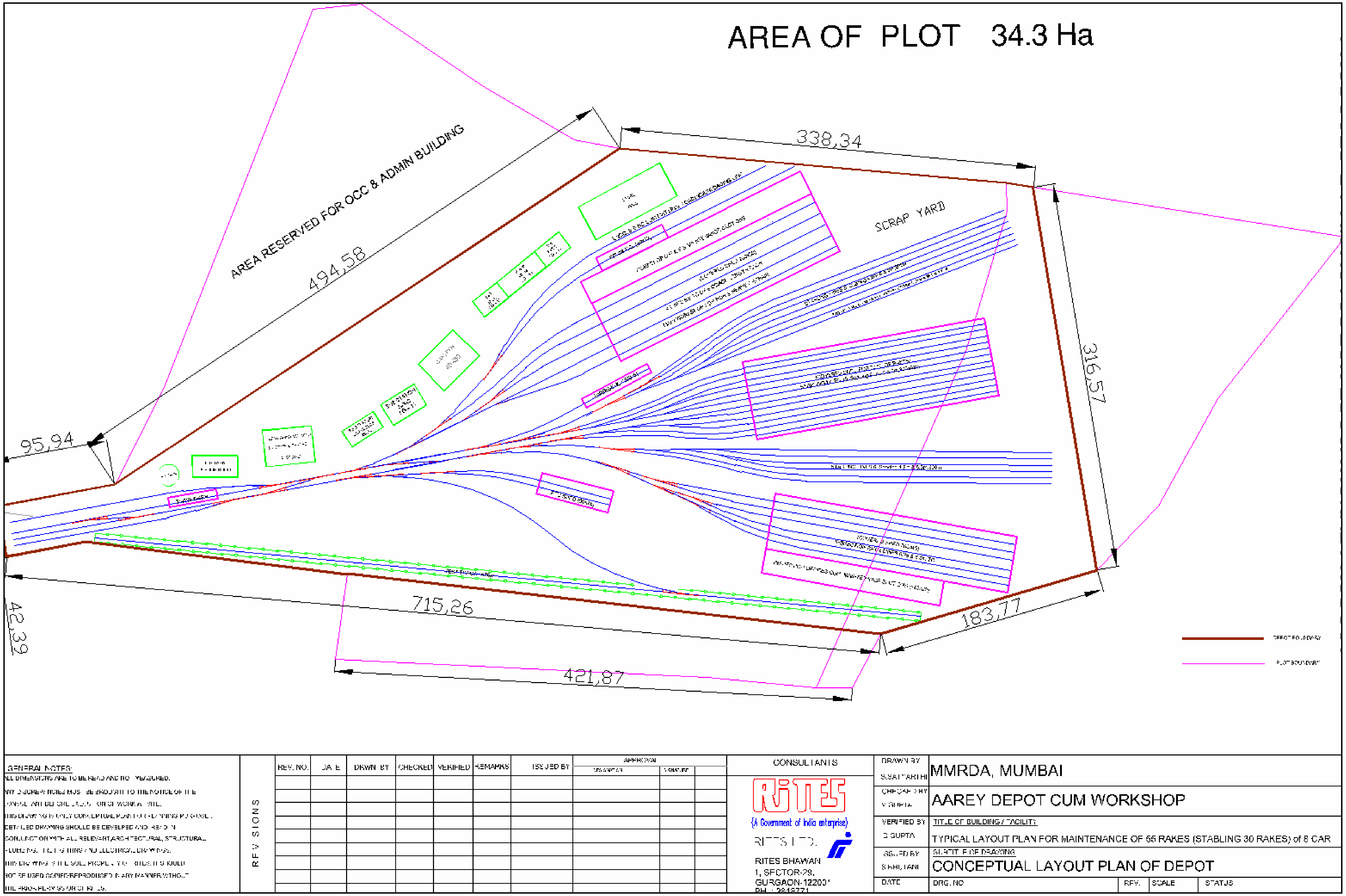
Table 7.8 : Comparative Evaluation of Kalina University and Aarey Milk Colony Depot sites

S.No.	Parameter	Aarey Milk	Kalina University
1.	Area of identified plot	34.3 Ha Sufficient land available for setting up of Main Depot	20 Ha Land available for setting up of Minor Depot only
2.	Distance from Alignment	Corridor will have to be extended by 1 Km. beyond	Less than 1 Km.

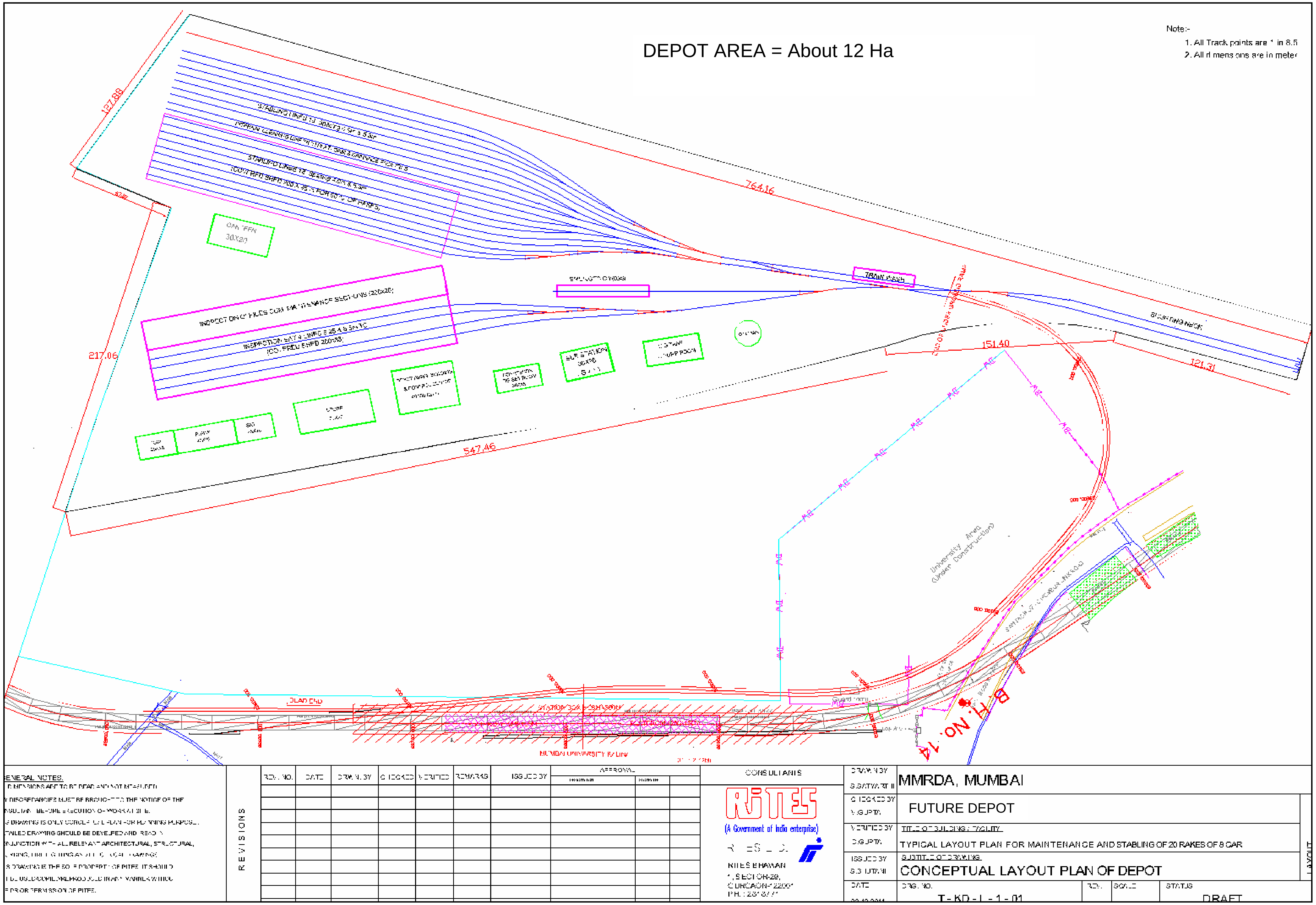
S.No.	Parameter	Aarey Milk	Kalina University
		SEEPZ	
3.	Land ownership	Aarey Milk (Govt.)	Kalina Uni. (Govt.)
4.	Heritage status	No	No
5.	Additional clearances required	Site in Green forested area (DP Zone1)	Site near Vakola Nala, part of plot is in CRZ-II
6.	Public utilities	Reliance HT line, Water supply line	No major public utility
7.	Free from encumbrances	Free	Free
8.	Feasibility of constructing depot at grade	Feasible	Feasible
9.	Ease of rake movement	Yes	Yes
10.	Other	Depot being at one end, will result in more empty running of rake	Depot at this location will result in less empty running of rakes

In view of above, Main Depot cum workshop may be set up at grade at ***Aarey Milk Colony Land (Plot-I)***. A Minor Depot may be set up at ***Kalina University land*** or an additional area at Aarey Milk Colony in future, as the demand increases - depending upon the land availability.

Annexure-I


AREA OF PLOT 34.3 Ha
AREA RESERVED FOR OCC & ADMIN BUILDING
494,58
338,34
SCRAP YARD
316,57
95,94
715,26
42,39
421,87
183,77
GENERAL NOTES:
CONSULTANTS
RITES
MMRDA, MUMBAI
AAREY DEPOT CUM WORKSHOP
TYPICAL LAYOUT PLAN FOR MAINTENANCE OF 65 RAKES (STABLING 30 RAKES) of 8 CAR
CONCEPTUAL LAYOUT PLAN OF DEPOT

Annexure-II


DEPOT AREA = About 12 Ha
Note:-
1. All Track points are 1 in 8.5
2. All dimensions are in meter
764.16
127.88
217.06
547.46
151.40
121.31
CANTEEN
30X20
DEAD END
MUMBAI UNIVERSITY R/ Line
University Area (Under Construction)
B.H. No.14
MMRDA, MUMBAI
FUTURE DEPOT
TYPICAL LAYOUT PLAN FOR MAINTENANCE AND STABLING OF 20 RAKES OF 8 CAR
CONCEPTUAL LAYOUT PLAN OF DEPOT
CONSULTANTS
RITES
(A Government of India enterprise)
REVISIONS
DRAWN BY
CHECKED BY
VERIFIED BY
ISSUED BY
DATE
DRG. NO.
STATUS
DRAFT

ANNEXURE-III(a)

LIST OF BUILDINGS FOR AAREY DEPOT- CUM WORKSHOP

S. No.	Name of Building	Size	Brief Function
1	**Inspection Shed** Associated sections **Workshop** Associated sections **Sun shade roof**	200 x 45 m^2 200 x 20 m^2 200 x 50 m^2 200 x 20 m^2 200 x 63 m^2	Servicing of 35 Rakes of 8 car : 15 day, 45 day, 6 Monthly inspections & AOH. Rooms for offices cum maintenance sections for the inspection activity POH at 3.5 Lakhs Km or 3 years whichever is earlier for 55 Rakes of 8 car Rooms for offices cum maintenance sections for the overhaul activity For stabling 12 rakes of 8 cars each, during daylight hours.
2.	Pit wheel lathe	60 x 12 m^2	For re-profiling of wheels upto 8 coaches Train length in situ
3	Auto Coach washing plant with washing apron	90 x 8 m^2	For automatic washing of coaches. Washing apron is for collection of dripping water and its proper drainage.
4.	ETU Shed cum Traction repair depot & E&M repair shop	2*(60 x 18 m^2) (Double storey)	Stabling and routine maintenance of shunting engine, tower wagon etc. & Traction maintenance depot For maintenance of lifts / escalators and other General service works.
5.	Repair shops for S&T	2*(25 x 16 m^2) (Double storey)	For the AFC gates, Signaling and telecom equipment
6.	P. Way Office, store & Workshop including Welding plant	2*(40 x 16 m^2) (Double storey)	For Track maintenance & to weld rails for construction period only To stable track Tamping machine.

S. No.	Name of Building	Size	Brief Function
7.	Depot Store & Offices including Goods Platform with Ramp	75 x 30 m^2	(i) Stocking of spares for regular & emergency requirement including consumable items. (ii) This store caters for the requirement of depot and workshop for rolling stock & other disciplines. (iii) To be provided with computerized inventory control. Loading/ Unloading of material received by road.
8.	Canteen	40X30 m^2	To cater staff of depot and workshop. Obligatory as per statutory requirements.
9.	Elect. Substation ASS	2*(30x20 m^2) (Double storey)	To provide for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, Essential power supply for essential loads and security light.
10.	Compressor & DG set room	30x15 m^2	To supply pneumatic air to workshop and servicing shed. DG set to cater to emergency requirement of power supply
11.	U/G water Tank and Pump house	1,00,000 Ltrs Capacity	Storage of water. Submersible type pump with 200 mm diameter bore well.
12.	Waste Water Treatment Plant	12x6 m^2	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
13.	Depot Adm. office & Control centre	4*(40x30 m^2) (Gr.+3 Storey)	Office of Depot, Workshop in charge, Traction supply, Engineering and S&T Control centre to control movement of trains in and out of the depot
14.	Security office & Time Office Garages (4 Nos)	15 x 8 m^2 10 x 8 m^2 6 x 8 m^2	For security personnel. For time Punching For parking vehicle jeep, truck etc.
15.	Check post (3 Nos)	5 x 3 m^2	For security check of incoming / outgoing staff, material and coaches.
16.	Watch tower (2 Nos)	3.5x2.5 m^2	For security of the depot especially during nighttime.

ANNEXURE-III(b)

LIST OF BUILDINGS FOR FUTURE DEPOT

S. No.	Name of Building	Size	Brief Function
1	**Inspection Shed** Associated sections **Sun shade roof**	200 x 33 m^2 200 x 20 m^2 200 x 45 m^2	Servicing of 20 Rakes of 8 car : 15 day, 45 day, 6 Monthly inspections Rooms for offices cum maintenance sections for the inspection activity For stabling 9 rakes of 8 cars each, during daylight hours.
2	Auto Coach washing plant with washing apron	90 x 8 m^2	For automatic washing of coaches. Washing apron is for collection of dripping water and its proper drainage.
3.	Repair shops for S&T	25 x 16 m^2	For the AFC gates, Signaling and telecom equipment
4.	P. Way Office, store & Workshop including Welding plant	40 x 16 m^2	For Track maintenance & to weld rails for construction period only To stable track Tamping machine.
5.	Depot Store & Offices	50 x 20 m^2	(i) Stocking of spares for regular & emergency requirement including consumable items. (ii) This store caters for the requirement of minor depot for rolling stock (iii) To be provided with computerized inventory control.
6.	Canteen	20X30 m^2	To cater staff of depot and workshop. Obligatory as per statutory requirements.
7.	Elect. Substation ASS	2*(30x20 m^2) (Double storey)	To provide for normal and emergency power supply for depot and all other ancillary buildings, Essential power supply for essential loads and security light.
8.	Compressor & DG set room	30x15 m^2	To supply pneumatic air to workshop and servicing shed. DG set to cater to emergency requirement of power supply
9.	U/G water Tank	25,000 Ltrs	Storage of water. Submersible type

S. No.	Name of Building	Size	Brief Function
	and Pump house	Capacity	pump with 150 mm diameter bore well.
10.	Waste Water Treatment Plant	12x6 m^2	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
11.	Depot Adm. office & Control centre	2*(40x30 m^2) (Gr.+1 Storey)	Office of Depot, Traction supply, Engineering and S&T Control centre to control movement of trains in and out of the depot
12.	Security office & Time Office Garages (4 Nos)	15 x 8 m^2 10 x 8 m^2 6 x 8 m^2	For security personnel. For time Punching For parking vehicle jeep, truck etc.
13.	Check post (2 Nos)	5 x 3 m^2	For security check of incoming / outgoing staff, material and coaches.
14.	Watch tower (2 Nos)	3.5x2.5 m^2	For security of the depot especially during nighttime.

Note

1 Some of the ancillary buildings are not depicted on the layout map. This may be suitably done at the detailed design stage incorporating the site topography, architectural nitty gritty and minor adjustment in sizes looking to the available land.

2 The buildings like inspection shed, workshop, stabling shed etc shall be pre-engineered structure. The decision in this regard may be taken at the detailed design stage.

3 The Administrative building of main Depot is proposed to be G+3 structure. However, the details of administrative building may be worked out at the detailed design stage

ANNEXURE-IV

LIST OF MAJOR PLANT & MACHINERY FOR DEPOTS

Sl no.	PLANT & MACHINERY	Aarey Depot	Kalina Depot
A.	MATERIAL HANDLING		
	TRAVELLING OVER HEAD EOT CRANES FOR WORKSHOP 25/5T	2	-
	TRAVELLING OVER HEAD EOT CRANES FOR INSPECTION BAY 1.5T	2	2
	TRAVELLING OVER HEAD EOT CRANES FOR ETU SHED 5T	1	-
	JIB CRANE FOR WORKSHOP 3 T	2	-
	Synchronized pit jacks system for car lifting	2	1
	Car body stands for keeping 8 car shells	32	8
	Dummy bogies	6	2
	Mobile lifting jacks-15T	2	1
	Mobile lifting jacks 10T	2	1
	Battery powered locomotive	2	1
	OHE Inspection car	2	-
	ROAD MOBILE CRANE 5T CAP	1	-
	FORK LIFT TRUCK 3T CAP	2	1
	FORK LIFT TRUCKS 2T CAP	2	1
	PALLET TRUCKS	4	4
	TATA TRUCK	1	1
	SCISSORS TYPE LIFTING TROLLEY - 2T CAPACITY	2	1
	HYDRAULIC TROLLEYS - 2T CAPACITY	2	1
B.	**Wheel shop**		
	500T wheel press	1	-
	Vertical boring m/c (Turret Lathe)	1	-
	Multipurpose Wheel Lathe	1	-
	Axle turning lathe	1	-
	Axle UST inspection machine	2	1
	Radial drill m/c	1	-
	Induction Heater	2	1
	Bearing Extractor	4	1
C.	**Bogie shop**		
	Bosch Tank : Bogie wash/cleaning plant	1	-
	Bogie static load testing m/c	1	-
	Shock absorber testing m/c	1	-
	Spring scragging &testing m/c	1	-
	Magnacheck crack detector	1	1
	Glowcheck crack detector	1	1
D.	**Rotating m/cs**		
	Baking Oven	1	-
	Dynamic balancing	1	-
	Traction motor test console	1	-
	Motor compressor test bench	1	-

Sl no.	PLANT & MACHINERY	Aarey Depot	Kalina Depot
	Tan Delta testing instrument	1	1
E.	**Other m/cs**		
	Under floor Pit wheel lathe	1	-
	Chip crusher and conveyor for pit wheel lathe	1	-
	Automatic Washing plant for Metro cars.	1	1
	High-pressure washing pump for front and rear end cleaning of cars.	1	1
	Turn table for one car	1	-
	Turntable for bogies	4	2
	Driving Cab Simulator	1	-
	Water de-mineralizing plant (Distillation plant)	2	1
	Painting booth for separate parts	1	-
	Floor cleaning machine	4	2
	Welding equipments	5	2
	Compressor 500Cfm	1	1
	DG set 320 KVA	3	1
	Battery charger	2	2
F.	**Machine shop**		
	Guillotine Shearing m/c	1	-
	Shearing, punching & cropping	1	-
	Universal tool cutter & grinder	1	-
	Vertical surface grinder	1	-
	Centre lathe 2m bed	1	-
	Centre lathe 1m bed	1	-
	Radial drill m/c	1	-
G.	**Test Benches/Instruments**		
	Brake test bench	2	1
	SPM test bench	2	1
	Door test bench	2	1
	Inverter test bench	1	1
	Other test benches (MCB, RMPU etc.)	1	1
	Oscilloscope	1	1
H.	**Furniture/material storage/Small tools**		
	Vertical storage system for DCOS store	1	-
	Computer MMIS with LAN connectivity	1	1
	Storage racks	LS	LS
	Industrial furniture	LS	LS
	Electric and pneumatic tools	LS	LS
	Measuring and testing equipments	LS	LS
	Tool kits	LS	LS
	Mobile safety steps	10	4

8. POWER SUPPLY

8.1 INTRODUCTION

Traditionally, electric traction is used in Metro systems as a prerequisite for requirement of high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz., 750V dc third rail, 1500V dc overhead catenary and 25kV ac overhead catenary system. Presently, all these three systems are in use in India (750 V dc third rail in Kolkata Metro, 1500V dc catenary in Mumbai suburban of Central & Western Railways and 25kV ac catenary in Delhi Metro & Indian Railways). 1500 V dc system of Central and Western Railways in Mumbai suburban is currently being converted to 25kV ac.

The alignment of proposed corridor is mostly underground. Keeping in view the ultimate traffic requirements, uniformity, standardization and other techno-economic considerations, ***25kV ac traction system*** is considered to be the best solution and hence, proposed for adoption.

This chapter broadly covers the Power supply system – power requirement for various horizon years, designed load, source of supply, broad description about the distribution network and major equipments etc. for Colaba – Bandra – SEEPZ Corridor.

8.2 POWER REQUIREMENT

Power supply is required for operation of Metro system for running of trains, station services (e.g. lighting, ventilation, air-conditioning, lifts, escalators, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications.

The Power supply system design for this corridor has been conceptualized considering 8 car rake composition/train operation at 150 sec. headway for Colaba-Bandra section and 300 sec. headway for Bandra-SEEPZ section with 8 car rake having passenger carrying capacity of 3000 (standing @ 8 passengers/m^2). Though, the Peak hour peak direction traffic demand (PHPDT) for the horizon year 2031 is realized with 6 car trains operating at 150 sec. headway for Colaba-Bandra section and 300 sec. headway for Bandra-SEEPZ section, yet train operation with 8 car having passenger carrying capacity of 3000 (standing @ 8 passengers/m^2) has been considered to design power supply system for more adverse operating conditions.

Broad estimation of auxiliary and traction power demand is made based on the following assumptions:-

i. Specific energy consumption of rolling stock – 70 KWh/1000 GTKM

ii. Train operation :

   Normal - 6 car at 260 to 150 seconds headway on Colaba-Bandra & 400 to 300 seconds headway on Bandra – SEEPZ section

Designed - 8 car at 150 seconds headway on Colaba-Bandra & 300 seconds headway on Bandra – SEEPZ section

iii. Underground station load – initially 2000kW, which will increase to 2500kW in the year 2031 (Designed load – 3000kW)

iv. Depot auxiliary load - initially 2000kW, which will increase to 2500 KW in the year 2031 (Designed load – 3000kW)

v. Power factor of load – 0.9 & Transmission losses @5%

Keeping in view the above norms, designed load and power requirement projected for the year 2016, 2025 and 2031 are summarized in **Table 8.1**.

Table 8.1: Power Demand Estimation (MVA) for Colaba – Bandra – SEEPZ

Year	2016	2025	2031	Designed Load
Traction	24.13	32.49	37.71	55.88
Auxiliary	65.33	73.50	81.67	98.00
Total	**89.46**	**105.99**	**119.38**	**153.88**

8.3 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed Mumbai metro system would be handling about 50,000 passengers during peak hours when the trains are expected to run at 150 seconds interval. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are already low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

In order to ensure higher reliability of power supply for essential services like metro, feed from more than one RSS have been planned. Under normal circumstances, each RSS will feed specific sections of the corridor. In case of emergency condition i.e. when the one RSS fails, the other RSS will feed the section of the RSS under outage. Therefore, it is essential that all the sources of Supply and connected transmission & distribution networks are reliable and have adequate built in redundancies.

8.4 SOURCES OF POWER SUPPLY

The high voltage power supply network of Mumbai city was studied in detail. The City has 220kV, 100kV, 33/22kV and 11kV network to cater to various types of demand in vicinity of the proposed corridor. Discussions were held with M/s Tata Power Company Ltd. (Licensee of the area) to finalize the Input Power Supply sources & Supply Voltage.

M/s Tata Power Company Ltd. indicated during discussions that their 33kV and 100kV network are highly reliable and stable to meet 33kV and 25kV power requirements of the proposed corridor. Keeping in view the reliability requirements and considering the complete corridor of 33.508 km length with all underground stations, ***three Receiving Sub-stations*** are proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 100 kV voltage through cable feeders for Colaba – Bandra – SEEPZ Corridor.

Table 8.2: Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of 100 kV cables
Colaba – Bandra – SEEPZ	Receiving Sub Station of Tata Power (100 kV) near Badhwar Park	Colaba (100/ 33/ 25 kV)	2 km. 100kV (Double Circuit cables).
	Mahalakshmi Receiving Sub Station of Tata Power (100 kV)	Race Course (100/ 33/25 kV)	1 km. 100kV (Double Circuit cables).
	Dharavi Receiving Sub Station of Tata Power (100 kV)	Dharavi (100/ 33/ 25 kV)	1 km. 100kV (Double Circuit cables).

The summary of expected power demand at various sources is given in **Table 8.3**. M/s Tata Power have confirmed availability of requisite power at their Mahalakshmi, Blackbay Grid substation vide letter no. COD/Prov.10031/11983; dated 23.02.2007 and at their Dharavi Grid sub-stations vide e-mail dated No 04.08.2010 **(Annexure 8.2).**

Table 8.3 : Power Demand Projection for various sources

Load	Peak Demand – Normal (MVA)				Peak Demand – Emergency (MVA)			
	2016	2025	2031	Designed	2016	2025	2031	Designed
Colaba RSS (Feeding Zone Colaba - Mahalaxmi 9.691 km)								
Traction	7.98	11.40	13.11	19.60	16.28	23.26	26.75	40.01
Auxiliary	21.00	23.63	26.25	31.50	42.00	47.25	52.50	63.00
Sub – Total (A)	**28.98**	**35.02**	**39.36**	**51.10**	**58.28**	**70.51**	**79.25**	**103.01**
Race Course RSS (Feeding Zone Mahalaxmi-Dharavi 10.09 km)								
Traction	8.31	11.87	13.65	20.41	16.28	23.26	26.75	40.01
Auxiliary	21.00	23.63	26.25	31.50	42.00	47.25	52.50	63.00
Sub – Total (B)	**29.31**	**35.49**	**39.90**	**51.91**	**58.28**	**70.51**	**79.25**	**103.01**
Dharavi RSS (Feeding Zone Dharavi - SEEPZ 13.727 km)								
Traction	7.84	9.23	10.96	15.87	16.15	21.09	24.60	36.28
Auxiliary	23.33	26.25	29.17	35.00	44.33	49.88	55.42	66.50
Sub – Total (C)	**31.18**	**35.48**	**40.12**	**50.87**	**60.48**	**70.97**	**80.02**	**102.78**
Total Load of Corridor								
Total Traction	24.13	32.49	37.71	55.88				
Total Auxiliary	65.33	73.50	81.67	98.00				
G.TOTAL(A+B+C)	**89.46**	**105.99**	**119.38**	**153.88**				

The 100 kV power supply will be stepped down to 25kV single phase for traction purpose at the RSSs of metro authority and fed to 25kV Rigid OHE system through cable feeders. Similarly 100kV power supply received directly from M/s Tata Power will be stepped down to 33kV & distributed along the alignment through 33kV Ring main cable network for feeding Auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the tunnel.

In normal conditions, Colaba RSS will feed the section from Colaba to Mahalakshmi, Race Course RSS will feed from Mahalakshmi to Dharavi and Dharavi RSS will feed from Dharavi to SEEPZ. In case Colaba RSS fails, then Race Course RSS will feed from Colaba to Dharavi. In case of failure of Race Course RSS, the feed can be extended from Colaba RSS (feeding zone Colaba to Mahalakshmi) or Dharavi RSS (feeding zone Mahalakshmi to SEEPZ) and in the eventuality of failure of Dharavi RSS, the Race course RSS will feed from Mahalakshmi to SEEPZ.

However, in case of total grid failure, all trains may come to a halt but station lighting, fire and hydraulics & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

Figure 8.1 : Typical High Voltage Receiving Sub – Station

The 100 kV cables will be laid through public pathways from TATA Sub-stations to RSS of Metro Authority. Each RSS shall be provided with 2 nos. (one as standby) 100/25kV single phase transformers with 30 MVA Capacity to meet peak traction demand in case of outage of adjoining RSS.

Indoor type 33kV and 25kV GIS switchgear is proposed for each RSS cum TSS to be located in approx. 50m x 40m (=2000 sqm) or (70x30 sqm.) land plot. 100kV Gas Insulated Switchgear (GIS) is also recommended in view of the advantage of considerable less space requirement and reduced maintenance.

8.5 AUXILIARY SUPPLY ARRANGEMENTS FOR STATIONS & DEPOT

Auxiliary sub-stations (ASS) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 2000 kW for underground station as indicated in Table 8.4 below, which is likely to increase to 2500 kW in the year 2031.

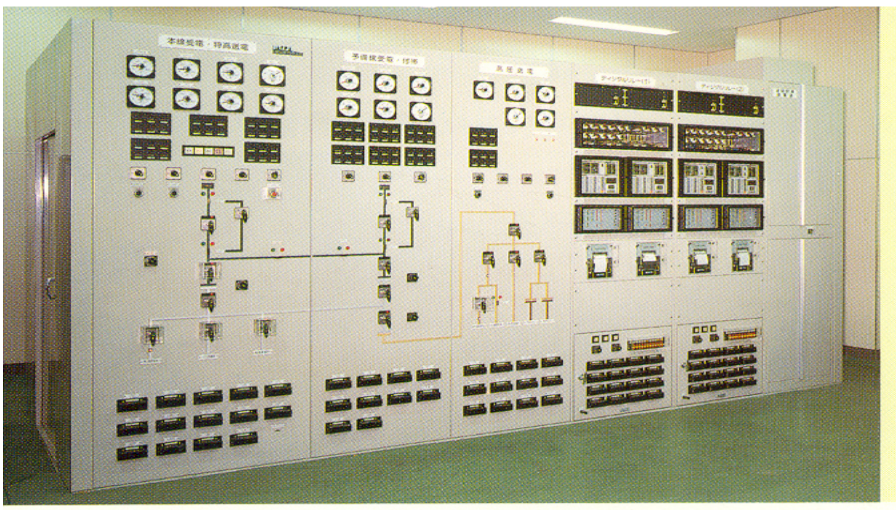
Table 8.4 : Summary of Loads (KW) for Typical Underground Station

S. No	Type of load	Underground Stn.		
		Connected	Diversity	ASS load
1	Lighting load	60	1	60
2	Other small power load, Fan, Power Plug etc.	150	0.6	90
3	HVAC load (Air conditioner -Chiller, Pumps, Cooling Tower, AHU etc.)	1000	0.75	750
4	Tunnel Ventilation	1000	0.75	750
5	Escalators (2Nos)@30Kw	60	1	60
6	Lifts (2Nos)@ 20Kw	40	1	40
7	Pumps	600	0.25	150
8	Signaling & Telecom, SCADA & AFC	75	1	75
9	Other Loads	25	1	25
	Total Load (KW)			**2000**
	Rating (KVA) of equipments selected			**2500**

NOTE: This is the average load considered for underground station to work out total power requirement. It will have to be fine tuned to suit station requirement at the time of detailed designing.

Apart from stations, a separate ASS is required at the depot. Accordingly, in order to meet the requirement of power for Property Development within the footprints of the station, two transformers of 2500 kVA at each underground ASS for the underground stations with a provision to add third transformer at a later date are proposed to be installed (one transformer as standby). This will cater for future loads due to property development within the foot – prints of the stations. At Depots ASS will also be provided with 2x2500 kVA auxiliary transformers.

Figure 8.2: Typical Indoor Auxiliary Sub-Station



8.6 ELECTROMAGNETIC INTERFERENCE (EMI) AND ELECTROMAGNETIC COMPATIBILITY

25kV ac traction currents produce alternating magnetic fields that cause induced voltages to be in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) system is proposed for EMI mitigation for elevated section.

Concrete structures of underground are not good electrical earths and therefore, Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc. Two earth conductors – Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with underground tunnel and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV Rigid OHE on the underground and 25 kV OHE on the elevated viaduct. Similar arrangements have been adopted on Delhi Metro as well.

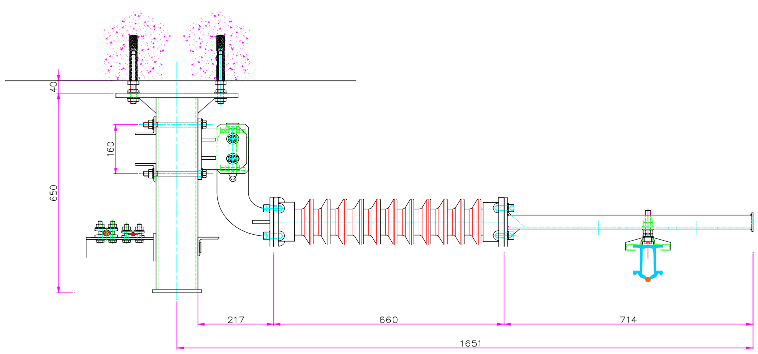
Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/EMC and Earthing & Bonding plan is required to be developed during detailed design stage.

8.7 25KV RIGID OHE SYSTEM

The proposed 25kV Rigid OHE system in underground section is similar to the one installed in underground Metro Corridor of Delhi Metro. 25kV Rigid OHE system comprises a hollow Aluminum Conductor Rail of adequate cross section with 150 sq.mm copper contact wire held with elastic pinch. The Al conductor rail is supported by an insulator & cantilever arrangement attached to drop-down supports fixed to tunnel roof. The supports are located at every 10 metre and there is no tension in the conductors and hence, no tensioning equipment is required in tunnel. The design of 25kv rigid OHE system shall be in accordance to electrical clearances & contact wire height as per IEC 60913 and EN50122, which is summarized below:

- Contact wire height = 4324mm (with Panto locked down height of 4048mm)
- Structure to Live parts clearances = 270/170/150mm (Static/Dynamic/Abs. min dynamic)
- Vehicle to Live parts clearances = 290/190/150mm (Static/Dynamic/Absolute min dynamic)

Figure 8.3 : 25kV Rigid OHE Arrangement



8.8 25 KV FLEXIBLE OVERHEAD EQUIPMENT SYSTEM

25 kV ac Flexible Overhead equipment system shall comprise 150 sq mm HD-copper contact wire and 65sqmm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq mm cross section. From safety considerations, Hydraulic type Anti-Tensioning Device (ATDs) are proposed on mainlines which does not require use of balance weight for tensioning of OHE conductors. Proven catenary fittings are proposed similar to DMRC system.

8.9 RATING OF MAJOR EQUIPMENT

Based on emergency demand expected at each RSS as shown in **Table 8.3**, 2 nos. 100/25kV traction transformers of 30 MVA capacity each at Colaba, Race Course RSS and Dharavi RSS are proposed. Similarly, 2 nos. 100/33kV Aux transformers of 50 MVA capacity each are proposed to be provided at all the three RSSs.

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 core x 400 mm^2 copper conductors XLPE insulated FRLSOH 33kV cable is proposed for ring main network.

Adequate no. of cables are required for transfer of traction power from Metro's RSS to 25kV Rigid OCS. Single-phase XLPE insulated cables with 240mm^2 copper conductors are proposed for traction power. Based on current requirements, 2 cables are required for each of the six circuits to feed power to 25kV OHE.

The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised and fine-tuned during detailed design stage of project implementation.

8.10 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 2 x 1000 kVA capacity at underground stations to cater to the following essential services:

- Essential lighting
- Signaling & telecommunications
- Fire fighting system
- Lift operation
- Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

8.11 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fibre cables provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 25kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

8.12 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Mumbai Metro includes the following energy saving features:

i. Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

ii. Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25kV Rigid OCS to be consumed by nearby trains.

iii. Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (operation or maintenance hours etc).

iv. Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

v. The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) has been incorporated in the system design.

vii. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

8.13 ELECTRIC POWER TARIFF

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25-35% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 260 million units in initial years (2016), which will increase to about 430 million Units by horizon year 2031. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for Mumbai Metro should be at effective rate of purchase price (at 100kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 5.50-6.00 per unit. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at "No Profit No Loss" basis.

Annexure 8.1

DESIGNED LOAD FOR COLABA - BANDRA- SEEPZ CORRIDOR

(A)	TRACTION LOAD			Colaba-Bandra	Bandra-SEEPZ
1	Average speed (KMPH)	S	=	30	30
2	Frequency of service (Sec.)	F	=	150	300
3	Headways (Km.)	H	=	1.3	2.5
4	Nos of trains per hour	N	=	24	12
5	Specific energy consumption (KWh/Thou GTKM)	SEC	=	70	70
6	Gross tonnage of ***8 car rake*** *(Passenger cap. 3000)*	T	=	516	516
7	Distance from Colaba - Bandra, Bandra - SEEPZ (Km)	D	=	21.746	11.762
8	Power factor of load	PF	=	0.9	0.9
	Max. demand on TSS (KW) {(2*SEC*D*T*N)/1000}		=	37702.34	10196.24
	Max. demand/Km in MW per km.			**1.73376**	**0.86688**
	Max. demand on TSS in MVA		=	41.9	11.3
	Max. demand on TSS in MVA incl 5% Tr. Losses			**43.99**	**11.90**
	Max. Traction demand in MVA incl 5% Tr. Losses			**55.88**	
(B)	AUXILIARY LOAD				
1	Load of each U/G stations (KW)		=	3000.0	3000.0
2	Nos of U/G stations		=	19.0	8.0
3	Load of Depot (KW)		=	0.0	3000.0
4	Total load of the stations & Depot (KW)		=	60000.0	24000.0
5	Power factor of the load		=	0.9	0.9
	Max. power demand of Stations and Depot (MVA)		=	66.7	26.7
	Max. demand on AT in MVA incl 5% Tr. Losses			**70.0**	**28.0**
	Max. Auxiliary demand in MVA incl 5% Tr. Losses			**98**	
	NET DEMAND (MVA) Traction + Aux.		=	**113.99**	**39.90**
	OVERALL NET DEMAND (MVA)			**153.88**	

Auxiliary Power Demand of Colaba – Bandra – SEEPZ Corridor

Sr. no.	Station name	Chainage (Km)	Elevation difference	Auxiliary Demand MW			
				2016	2025	2031	Design
1	Cuff Parade	0	Underground	2.0	2.25	2.5	3.0
2	Badwar Park	1000	Underground	2.0	2.25	2.5	3.0
3	Vidhan Bhavan	1600	Underground	2.0	2.25	2.5	3.0
4	Churchgate Metro	2285	Underground	2.0	2.25	2.5	3.0
5	Hutatma Chowk	3102	Underground	2.0	2.25	2.5	3.0
6	CSTM Metro	3956	Underground	2.0	2.25	2.5	3.0
7	Kalbadevi	4891	Underground	2.0	2.25	2.5	3.0
8	Girgaon	5616	Underground	2.0	2.25	2.5	3.0
9	Grant Road Metro	7156	Underground	2.0	2.25	2.5	3.0
10	Mumbai Central Metro	8067	Underground	2.0	2.25	2.5	3.0
11	Mahalakshmi Metro	9216	Underground	2.0	2.25	2.5	3.0
12	Science Museum	10316	Underground	2.0	2.25	2.5	3.0
13	Acharya Atrey Chowk	11516	Underground	2.0	2.25	2.5	3.0
14	Worli	12924	Underground	2.0	2.25	2.5	3.0

Sr. no.	Station name	Chainage (Km)	Elevation difference	Auxiliary Demand MW			
				2016	2025	2031	Design
15	Siddhi Vinayak	14479	Underground	2.0	2.25	2.5	3.0
16	Dadar Metro	15756	Underground	2.0	2.25	2.5	3.0
17	Shitaladevi Temple	17525	Underground	2.0	2.25	2.5	3.0
18	Dharavi	19306	Underground	2.0	2.25	2.5	3.0
19	Bandra Metro	21271	Underground	2.0	2.25	2.5	3.0
20	Mumb. University (Kalina)	22812	Underground	2.0	2.25	2.5	3.0
21	Santacruz Metro	24027	Underground	2.0	2.25	2.5	3.0
22	CSIA(Domestic)	26299	Underground	2.0	2.25	2.5	3.0
23	Sahar Road	27906	Underground	2.0	2.25	2.5	3.0
24	CSIA (International)	28958	Underground	2.0	2.25	2.5	3.0
25	Marol Naka	29829	Underground	2.0	2.25	2.5	3.0
26	MIDC	31225	Underground	2.0	2.25	2.5	3.0
27	SEEPZ	32546	Underground	2.0	2.25	2.5	3.0
28	Depot at Aarey & Kalina		Elevated	2.0	2.25	2.5	3.0
Total in MW				**56.0**	**63.0**	**70.0**	**84.0**
Total Demand in MVA with 0.9 P.F, 5% tran. losses				**65.33**	**73.50**	**81.67**	**98.00**

Annexure 8.2

TATA

23rd February, 2007
CDD/Prov.10031/11983

Delhi Metro Rail Corporation Ltd.,
N B C C Place
Bhishma Pitamah Marg
Pragati Vihar
New Delhi 110 003
Fax 91-11-24365762

Kind Attn: Mr Sharat Sharma
Chief Electrical Engineer

Dear Sir,

Sub: 100KV power supply to Metro Rail Project for Phase I

This has reference to our earlier letter dated 21st February, 2005 (copy enclosed) and subsequent meeting held with your officials and TPC's officials on 22nd February, 2007 at our office at Carnac.

TPC noted 100KV power requirement of 25 to 50 MVA for the proposed Metro link from Colaba to Bandra. This corridor consists of 20 stations with route length of 20 kms. TPC also noted that this Metro rail will be operated underground which requires electric supply with high reliability.

TPC proposes as under:

- TPC will be in a position to cater your power supply requirement at 100KV from TPC's Mahalaxmi Receiving Station which is midway between the tube rail project from Bandra to Colaba.
- TPC can give 100KV power supply from Backbay Receiving Station near Badhwar Park.
- TPC can also give power supply from Dharavi Receiving Station to your upcoming Bandra Terminal.

DMRC may choose the location based on power supply requirement from two different sources in line with international practices.

The modalities of power supply like requirement of single phase, locations will be discussed after we receive your detailed proposal on the above subject.

Thanking you and assuring you of our best attention at all times,

Yours faithfully,
THE TATA POWER COMPANY LTD

(D B RANE)
ASST. GENERAL MANAGER

Encl. As above

TATA POWER
The Tata Power Company Limited

9. SOCIAL & ENVIRONMENT IMPACT ASSESSMENT

9.1 ENVIRONMENTAL BASELINE DATA

The main aim of the Environmental and Social Impact Assessment study is to ascertain the existing baseline conditions and to assess the impacts of all the factors as a result of the proposed Coloba-Bandra-SEEPZ underground metro rail during its construction and operation phases. The changes likely to occur in different components of the environment viz. Natural Physical Resources, Natural Ecological (or Biological) Resources, Human/Economic Development Resources (Human use values), Quality of life values (socio-economics), would be studied and assessed to a reasonable accuracy. The environment attributes include Water Quality, Air Quality, Soils, Noise, Ecology, Socio-economic issues, Archaeological /historical monuments etc.

The information presented in this section stems from various sources such as reports, field surveys and monitoring. Majority of data on soil, water quality, air and noise quality, flora and fauna were collected during field studies between September-October, 2011. This data have been further utilized to assess the incremental impact, if any, due to the project. The development/compilation of environmental baseline data is essential to assess the impact on environment due to the project. The proposed metro rail corridor connects Coloba to SEEPZ via Airport with extension from BKC to Mahim and the total length of the alignment is 33.5 km.

9.1.1 Land Environment

The land environment includes physiography, land use, soil and geology and seismicity. These are presented in subsequent sections. The mean elevation of Mumbai is 11m above mean sea level. Most part of the Mumbai drains towards sea.

i. Physiographic

Mumbai (Bombay) is located at (Latitude 18.96^{o}N, Longitude 72.82^{o}E) in Maharashtra State and is the principal Indian port on the Arabian Sea. The original city was confined to island location. The island city of Mumbai stretches 20 km from the southern most tip of Colaba to Mahim Creek in the north, and an average 5 km from the Arabian Sea shore to the edge of Mumbai Harbour. It covers 65 sq.km, land reclamation from the sea is what gives the city its footing. One fourth of the city is below sea level. The mean elevation of Mumbai is 11 m above mean sea level. The Reduced Level along the route varies from 1.730 to 64.20 m above mean sea level.

ii. Geology

Mumbai and Konkan coastal area of Maharashtra state is underlain by Deccan Trap Basalts. These rocks are believed to be formed by a series of vast lava flows following volcanic eruptions towards the close of the Cretaceous period or early Tertiary era. The total thickness of the Deccan Traps is very variable, reaching an estimated maximum of 3000 metres along the coast.

A very wide variety of basalts and associated rocks such as volcanic Breccias, black tachylytic basalts, red tachylytic basalts seen at the surface as ‘Red Bole’ occur in the area covered by Deccan Trap basalts. All these volcanic rocks are hydrothermally weathered near the surface. The residual material resulting from the breakdown of the rock is known locally as “murrum” the properties of which vary in consistency and texture according to the degree of weathering and disintegration. On complete weathering of rock the soil becomes stiff yellow silty clay.

iii. Marine Clays of Mumbai

Marine clays cover extensive areas in Mumbai/Coastal region, which are found along the shore as well as in creeks, tidal flats and formerly submerged areas. On the eastern front of Mumbai, island and coastal region, thick deposits of marine clays are found overlying murrum tuff and basaltic rock. The marine clay deposits vary in thickness from 2m to 20m. These soils are characterized by their high compressibility, low co-efficient of consolidation and very low shear strength. Above the bedrock, the residual ‘murrum’ often occurs along with gravel and weathered boulders.

iv. Seismicity

Mumbai lies in seismic zone III but very near to zone IV. Suitable seismic coefficient may be adopted in the design of structures to commensurate with the Indian Standard seismic zoning of the country IS.1893-1984 which is under revision after the occurrence of Gujarat Earthquake in January’ 2001.

v. Soil Quality

The project corridor passes underground along built up (commercial and residential), open land and water body (i.e.Mithi River,Powai lake) areas.
During field visits it was observed that the soils are highly saline in the vicinity of creeks and non-saline at other places. In order to ascertain the soil quality, a representative of soil sample was collected from six locations namely 1. WTC 2. JSS Road 3. Dr.Dada Saheb Bhadkamkar Road 4. Sant Gadgey Maharaj Chowk 5.BKC (near ITO), 6.Kalina University.
The parameters for analysis have been considered are (i).pH, (ii).Texture, (iii).Organic matters, (iv).Nitrogen, (v).Phosphates, (vi).Sodium, (vii).Potassium, viii).Calcium, (ix)Magnesium. The results are given in Table 9.1.The texture of soil is mainly sandy. The higher concentration of phosphate and organic matter is an indication of good fertility value.

Table 9.1: Physico-Chemical Characteristics Of Soils

Parameters	Unit	1	2	3	4	5	6
pH		7.20	8.24	8.5	8.22	7.19	7.40
Texture							
i) Sand	%	28.20	83.64	91.25	83.89	57.4	56.3
ii) Silt	%	16.80	11.34	3.68	9.94	12.0	29.5
iii) Clay	%	55.00	5.02	5.07	6.17	30.6	14.2
Nitrogen as N	Kg/ha	1210.00	433.43	1513.15	2218	2496	2034
Phosphate	kg/ha	114.20	59.36	218.50	153.39	60.3	493
Potassium as K	meq/100gm	2.05	0.87	0.92	1.65	0.13	0.11
Calcium as Ca	meq/100gm	12.73	34.21	44.96	51.09	0.19	0.14
Magnesium as Mg	meq/100gm	6.99	6.63	4.83	6.61	1.34	1.52
Sodium as Na	meq/100gm	3.91	1.21	2.03	3.36	0.81	0.78
Organic matter	%	1.77	0.69	3.1	1.44	4.9	4.5

1. WTC 2. JSS Road 3. Dr.Dada Saheb Bhadkamkar Road
4. Sant Gadgey Maharaj Chowk 5.BKC (near ITO), 6.Kalina University,

vi. Land Use

The details of land use pattern is given in **Table 9.2**.The alignment is passing through underground. The proposed stations are located in commercial, commercial cum residential, open land, along the road and water body. However, most part of the alignment is passing along the road.

Table 9.2: Land Use Pattern along the Alignment

S. No	Station	Chainage(m)	Land use
1	Cuffe Parade Station	00	Open Garden
2	Badhwar Park Station	1000	Residential-Temporary shed
3	Vidhan Bhawan Station	1600	Office buildings
4	Churchgate Metro Station	2285	Commercial area
5	Hutatma Chowk	3102	Commercial cum residential
6	CST Metro Station	3956	Commercial area, official buildings
7	Kaladevi Station	4891	Commercial area
8	Girgaon Station	5616	Commercial area
9	Grant Road Station	7156	Commercial area
10	Mumbai Central Station	8067	Open area
11	Mahalaxmi Metro Station	9216	Commercial area
12	Science Museum Station	10316	Open green area
13	Acharya Atray Chowk Station	11516	Temporary shed, commercial area
14	Worli Station	12924	Open area
15	Sidhi Vinayak Station	14479	Open area
16	Dadar Metro Station	15756	Commercial & Residential area
17	Shitladevi Temple Station	17525	Commercial area
18	Dharavi Station	19306	Open area,residential,mangroves area
19	Bandra Station	21271	Mangrove trees,forest area
20	Mumbai University,Kalina	22812	Institutional area
21	Santa Cruz Station	24027	
22	CSIA(Domestic)Station	26299	Open area
23	Sahar Road Station	27906	Residential-Temporary shed
24	CSIA(International)Station	28958	Open area
25	Marol Naka Station	29829	Residential-Temporary shed
26	MIDC	31225	Open, commercial area
27	SEEPZ Station	32546	Open, commercial area

9.1.2 Water Environment (Water Quality)

Water availability and its quality play a significant role in any project. The water supply to Bombay from various sources such as surface water, ground water is about 563 million gallons per day (MGD). The monsoon precipitation is collected in six lakes and supplied to the city throughout the year. The Bombay Municipal Corporation (BMC) manages to supply between 70 to 75% of the city's water needs.

However, to ascertain the water quality, representative water samples from six locations were collected for the analysis of physical and chemical parameters. The results so obtained are summarised in **Table 9.3**. Surface water collected from Mithi River has high dissolved solids, high hardness, high chloride content, etc. - hence requires treatment for any use. Out of four ground water samples, three are almost within permissible limit which may be used after filtration followed by disinfection.

Table 9.3: Chemical Analysis of Water Sample

Parameters	Ambedkar Nagar 1	Ugrebadi (Near Church) 2	Dr.Dadasaheb Bhadkamkar Road 3	Mithi River, Mahim 4	SEEPZ 5
pH	7.60	8.46	8.7	6.77	7.54
Total Suspended Solids (mg/l)	36.00	11.6	8.22	18	1
Total Dissolved Solids (mg/l)	9854.00	418.6	486.8	8108	352
BOD (mg/l)	54.00	1.1	<2.0	0.4	<1
Chloride, Cl (mg/l)	4810.00	35.9	51.94	4498	26
Fluorides (asF) (mg/l)	<1.0	0.24	0.279	1.6	0.16
Sulphate, SO4 (mg/l)	552.00	23.1	22.38	728	3.0
Nitrates as NO3 mg/l	9.00	3.9	19.6	42.3	19
Alkalinity, mg/L	115.00	243.7	255.7	280	267
Total Hardness	2000.00	271.7	299.7	1794	125
Arsenic, mg/L	ND	ND	ND	<0.001	<0.001

ND-Not Detectable

Sample 1, 2 , 3 & 5 are from Bore Well Water while sample 4 is from surface water source.

9.1.3 Air Environment

The air environment includes climate, meteorology, air quality and noise level. The meteorological factors are responsible for dispersion and diffusion of air pollutants.

i. Climate

Mumbai has a tropical climate; mean humidity ranges between 57-88 per cent. The annual mean temperature is 25.3oC rising to a monthly maximum of 34.5°C in June and with a minimum of 14.3oC in January. Total annual mean precipitation is 2,078 mm with 34 per cent (709 mm) falling in the month of July. In the winter the predominant wind direction is northerly (NW-NE). However, in the monsoon season westernly and southernly winds predominate. There is virtually always a sea breeze during the day with mean wind speeds between 5-8 km/hour. The above analysis is based on the current meteorological data of nearer observatory i.e. Santacruz.

ii. Air Quality

As a part of this study, in order to establish the base line data, Ambient Air Quality Monitoring (AAQM) has been carried out by setting up ambient air quality monitoring stations through High Volume Sampler (HVS) at five locations, i.e. Churchgate, Grant Road, Mahim (Nr. Bus Depot), Mumbai University, Sahar Road (Nr. IOC) and SEEPZ for the parameters like RSPM, SPM, SO_2, NOx, CO and HC. The results so obtained are reported in **Table 9.4**. The SPM and RSPM level has been observed on higher side as compared with National Ambient Air Quality (NAAQ) standards while parameters like SO_2, NOx and CO are within the permissible limits.

Table 9.4: Air Quality at Project Site

S.No.	Location	RSPM µg/m^3	SPM µg/m^3	SO_2 µg/m^3	NOx µg/m^3	CO mg/m^3
1	Churchgate	196	351	33	50	2.19
	Permissible limit	60	100	80	80	4.00
2	Grant Road	161	235	29	38.5	2.65
	Permissible limit	60	100	80	80	4.00
3	Mahim	120	321	10.3	29.0	1.05
	Permissible limit	60	100	80	80	4.00
4	Mumbai University[2]	86	236	7.0	18	1.00
	Permissible limit	60	100	80	80	4.00
5	Sahar Road(Nr.IOC)[3]	130	338	15	41.3	1.20
	Permissible limit	60	100	80	80	4.00
6	SEEPZ	140	363	16	55	1.27
	Permissible limit	60	100	80	80	4.00

9.1.4 Noise Environment (Noise Level Quality)

Noise levels were measured at six locations, i.e. World Trade Centre, Churchgate, Mahim, Mumbai University, Sahar Road (Nr. IOC) and SEEPZ along the project alignment. The noise levels measured are summarised in **Table 9.5**. It is observed that the noise level at World Trade Centre, Churchgate, Mahim and Mumbai University are beyond permissible limits while noise level at Sahar Road and SEEPZ are within permissible limits. Predominant source of noise is the vehicular movement.

Table 9.5: Noise Levels along the Alignment Db (A)

Location	L_{eq}	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{DN}
World Trade Centre[1]	72.2	88.5	77.6	74.4	76.3	61	76.2	65	79.2
Limit	--	--	--	--	--	--	65	55	--
Churchgate	74.6	79.4	71.9	62.3	90.1	52.8	82.4	54.2	71.9
Limit	--	--	--	--	--	--	65	55	--
Mahim[1]	66.68	71.39	68.72	50.14	73.4	46.8	68.38	53.15	66.34
Limit	--	--	--	--	--	--	65	55	--
Mumbai University[2]	61.69	66.42	63.74	43.10	70.2	38.2	63.41	46.11	61.37
Limit	--	--	--	--	--	--	50	40	--
Sahar Road(Nr.IOC)[3]	65.55	70.21	67.79	51.47	72.8	45.3	67.20	54.48	65.15
Limit	--	--	--	--	--	--	75	70	--

Location	L_{eq}	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{DN}
World Trade Centre[1]	72.2	88.5	77.6	74.4	76.3	61	76.2	65	79.2
Limit	--	--	--	--	--	--	65	55	--
Churchgate	74.6	79.4	71.9	62.3	90.1	52.8	82.4	54.2	71.9
Limit	--	--	--	--	--	--	65	55	--
SEEPZ[4]	66.81	71.45	68.86	56.15	74.1	46.4	68.44	56.15	66.40
Limit	--	--	--	--	--	--	75	70	--

Note:*1.Busy commercial area,2.Institutional area,3.Industrial area,4.Industrial area,*

9.1.5 Ecological Environment

The ecological environment includes flora and fauna both from terrestrial and aquatic.

i. Flora & Fauna

Trees survey was carried out along the proposed alignment at station location. During site visit a few trees on both sides of the road have been observed. The type of species observed is Gulmohar, Peepal, Coconut Palms, Dhodkher, Kodumar, and Neem. No rare or endangered species of trees have been noticed during field studies. Most of the trees contain the girth size of about 35cm and more. Approximately 638 trees have been observed along the project alignment. Two alternative depot locations have been evaluated 1. Kalina University and 2. Aarey Milk Colony, out of which Aarey Milk Colony is the selected option. About 100 trees are anticipated at Aarey Milk Colony whereas Kalina University is open area.

Wild life reported in project site are mostly within mangrove area. It is noted to have species of birds, reptiles, prawns, crabs, fish, and numerous other organisms including mammals like mongoose, jackals and jungle cats, all within the Mahim creek area/Mithi river. The areas are undoubtedly a bird paradise, especially in the winters. Over a million birds fly this way during their winter migration, many of them roosting here for a long time. Mahim Bay Area, where Mithi River meets Arabian Sea is a nominated bird sanctuary called "Salim Ali Bird Sanctuary" where migratory birds come for nesting. This part is full of mangroves and this fragile ecosystem requires consideration from pollution point of view, so that it is not getting destroyed.

ii. Mangroves

Mangrove ecosystems are highly productive but extremely sensitive and fragile. Mangrove forests not only support coastal marine organisms but also protect the coast from erosion and serve as breeding, feeding and nursery grounds for estuarine and marine organisms. Vijay et al (2005) revealed in their study that mangrove coverage during 2001 in Mumbai was 56.4 km2, forming nearly 12.05% of the total area of 468km2. They were dominated by Avicennia marina near to the tidal waves, followed by Rhizophora mucronata.Progressing landward, the next zone was that of Bruguiera cylindrical, whereas Acanthus ilicifolius formed the fringe layer near to the land. Shurbs of Ceriops tagal and Aegiceras corniculatum were scattered among the other mangroves species. However, in the Mahim region where the proposed alignment is passing, Avicennia marina and Acanthus ilicifolius was found.

During field visits it was observed that the proposed alignment passes through forest and mangrove area of about 1440 m without affecting the same being underground project.

Metro station proposed at Bandra may affect about 30 mangrove trees during construction. The average girth size of mangrove trees is 24 cm and the average height is 2.8m. Approximate overall density of mangroves along the corridor is 8 individuals/10m2. Mahim

region had the highest density, whereas Dharavi and ITO region had the lowest density (**Table 9.6**).

Table 9.6 : Distribution of Mangroves found within the Project Corridor

1.	Name of Species observed	:	*Avicennia marina* and *Acanthus ilicifolius,S.apetala*
2.	Average height of standard	:	2.8m
3.	Average girth size	:	24cm
4.	Density	:	8 individuals/10m^2

iii. Mangrove as protected forest

The Mumbai High Court on October 6,2005 has ordered a total ban on the destruction and cutting of mangroves in the entire State and to stop all construction activity within 50 meters on all sides of all mangrove areas. The court has asked the state to declare all mangrove plots on government land as the 'protected forest' and mangroves on privately owned land as forest by June 1, 2006. August 24, 2006 was set for the State to hand over all government owned mangrove lands to the forest departments, which will be responsible for their protection, preservation and regenerations.

According to this High Court Order, cutting of mangroves in the project area is not permitted. Since the proposed metro rail project is an infrastructure project to be constructed in the public interest, the case shall be put to Maharashtra Coastal Zone Management Authority (MCZMA) to grant special permission to cut the mangroves in the area. Appropriate mitigation measures shall be taken for the rehabilitation of mangroves as per State rules.

iv. Coastal Regulation Zone

India has a coastal line of 7,500 km with many sprawling and still growing coastal sites. The coastal region is thus a place of human activity. Under the Environment (Protection) Act, 1986, the Coastal Regulation Zone Notification was issued in 1991.Through this notification, the Government of India directed the coastal States to prepare Coastal Zone Management Plans with High Tide Line, 500m-regulation line, other boundaries, etc. for approval of the Ministry of Environment and Forest (MoEF). By the said notification, the coastal areas were classified into four categories i.e. CRZ-I, CRZ-II, CRZ-III and CRZ-IV. The ecologically sensitive areas and areas of extraordinary natural beauty are included under CRZ-I, where no activity/construction is allowed. The coastal stretches of urban and developed areas are categorized under CRZ-II. In this category, buildings are permitted on the landward side of the existing structures. The areas, which do not come under CRZ-I and II are included in CRZ-

III where no construction is permitted up to 200m from the high tide line. The Lakshadweep, Andaman and Nicobar Islands and other small islands are categorised in CRZ-IV.

The passing of the alignment through mangrove areas i.e., Mahim Creek fall in the Coastal Regulatory Zone-I area. The construction shall be possible/permitted in this area after obtaining clearance from the State and Central Government under section 8.I(e) (construction of trans-harbour sea link) of CRZ-I classification given in the Coastal Regulation Zone Notification issued in 1991 and amended in 6th January,2011.The detail procedure for CRZ clearance is given in section 9.9.1 of this Chapter.

9.2 SOCIAL AND ECONOMIC ASSESSMENT

Development of proposed Mumbai Metro Line III (Coloba-Bandra-SEEPZ) involve acquisition of land for stations, running sections, TSS, Depot and for other facilities. For different components of this corridor, out of total 39.75 hectare requirement of land, 22.93 hectare private land and 16.82 hectare government land shall be acquired. The details of land requirement for different components of the project is given in Table 9.7. Acquisition of this private land may cause social disruption and economic loss for the project affected families/people. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimise any negative impacts. Considering the above, a sample Socio-Economic Survey (SES) was undertaken in order to assess the socio-economic condition of project-affected families/people and to examine the impacts of the proposed metro rail system on these conditions.

Table 9.7: Land Requirement

					Area in sq. m
Sl.No	**Particulars**	**Permanent Land Requirement**		**Temporary Land Requirement**	
		Government	**Private**	**Government**	**Private**
1	Depot	264070	-	-	-
2	Stations	14956	32260	18406	627
3	TSS	4000	2000	-	-
4	Construction Depot	-	-	109535	12370
Total		**4.03**	**283026**	**34260**	**127941**

A detail of structures, huts, families and persons likely to be affected is presented in **Table-9.8**.Out of total 105 buildings, about 42 buildings (254 families) would be affected permanently and 63 buildings (376 families) would be affected temporarily. Approximately 858 jhugies/ huts, and 32 kiosks would be affected. As some residential, commercial buildings, jhugies/ huts are coming along the alignment about 1520 families consisting 6840 persons are likely to be affected due to the proposed metro rail project.

Table 9.8: Details Of Structures, Jhugies & Families

S.No	**Description**	**No.**	**Details**
1.	No of Building Structures	105	Commercial, Residential, office buildings.
2.	No of Jugies/huts	858	Badhwar Park Station,Acharya Atray Chowk station,Sahar Road Station,Marol Naka Station
3.	No.of Families	1520[1]	As per S.No.1 & 2
4	No of Persons	6080	

1 The figure of the total PAFs is based on sample socio-economic survey conducted in September-October-2011 and likely to change in Census Social Survey.

9.2.1 Approach & Methodology

A Socio-Economic Survey (SES) was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed corridor on these conditions. On the basis of alignment drawings and field visits it was noted that approximately 1520 families would be affected as the plots of these families are touching the proposed metro rail corridor. During the social survey, it was observed that approximately 57% families are squatters which need relocation/compensation. The social survey in these affected areas was conducted by using random sampling method. About more than 10 %(152 families) of total affected families from major locations along the alignment which represent the whole stretch of proposed corridor were randomly selected for analysing their socio-economic conditions. The primary data for the study was collected through interviews with the project-affected people by using structured household questionnaire.

9.2.2 Demographic and Social Profile of the PAFs

i. Demographic & Social Profile

Demographic and social profile of project affected families and persons is presented in Table 9.9. Sex Ratio is very helpful indicator to know the participatory share of males and females in a region, which is also an important indicator for human development index. Among the surveyed population, it is observed that there are 327(53.4%) males and 285(46.6%) are females. There are 871 females against 1000 males. This shows that male slightly preponderate in the sample.

It is evident from the table that majority (44.9%) of family members belong to the age group of 15-35 years and 20.9 % belong to the age group to 36-60 years. Remaining 27.9% and 4.9%of family members belong to the age below 14 years and above 60 years respectively. The majority of the population are Hindus (61.2%), followed by those belonging to Muslims (32.2%), Christian (3.9%) and others like Sikh and Jain(2.7%). A look at the data regarding the caste heritage reveals that the majority of the people (37.5%) come from Other Backward Castes. But the second largest group of the people in project-affected areas belong to General Caste (32.2%), followed by those coming from Scheduled Caste (30.3%). It is observed that 24% persons has studied up to primary,18.1% studied up to Secondary,14.1% studied up to High School and 5.9% up to college. It is important to be noted that 37.9% of project affected people are illiterate. Illiteracy was found more in Jhugies/Jhupdi areas.

APPROACH OF SOCIAL ASSESSMENT

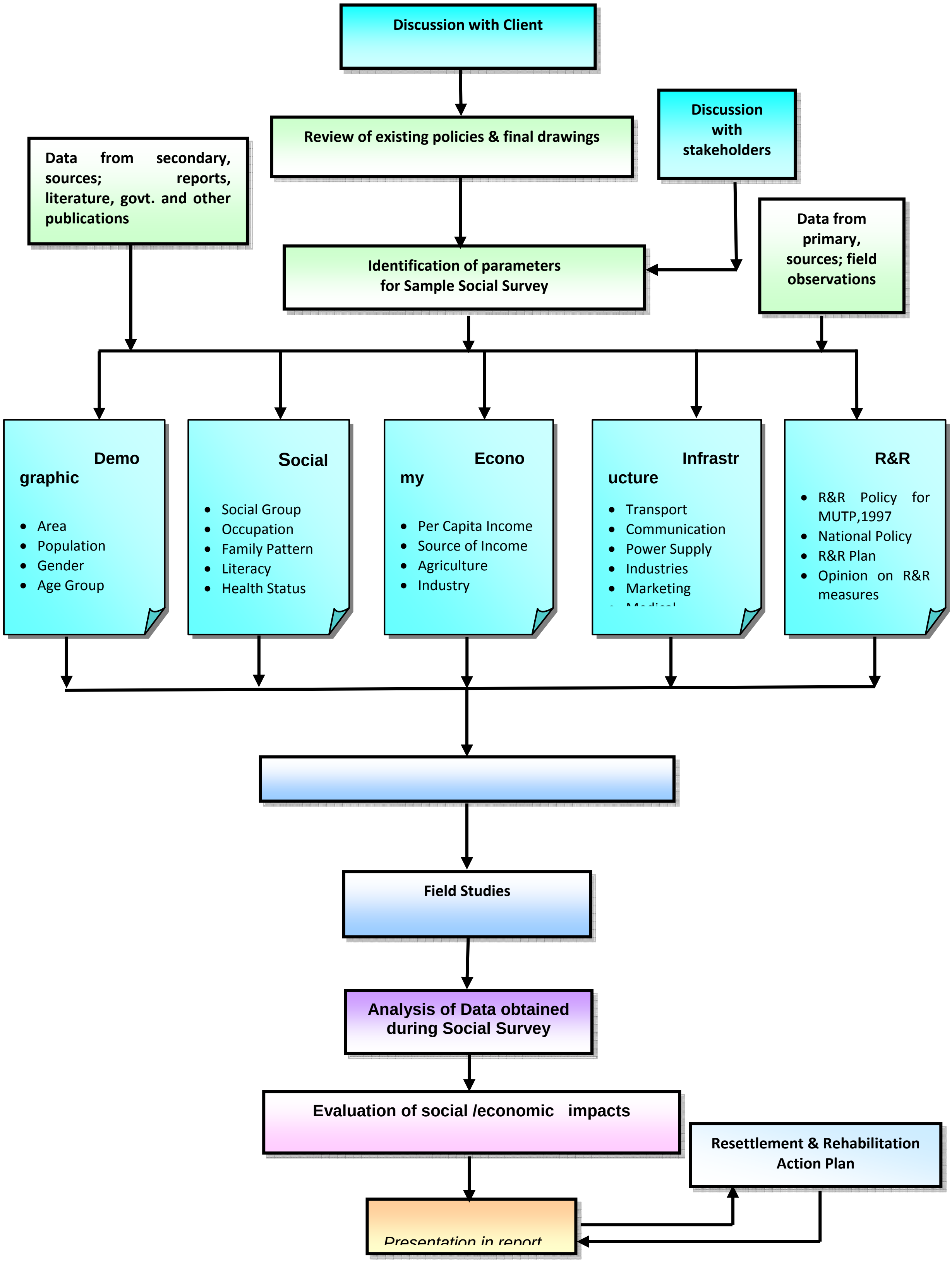


Table 9.9: Demographic and Social Profile of Pafs/Paps

S.No	Description	Frequency	Percentage (%)
1.	**Sex**		
1.1	Male	327	53.4
1.2	Female	285	46.6
2.	**Age Composition**		
2.1	0-14 yrs	171	27.9
2.2	15-35yrs	275	44.9
2.3	36-60yrs	128	20.9
2.4	>60	38	4.9
3.	**Religion**		
3.1	Hindu	93	61.2
3.2	Muslim	49	32.2
3.3	Christian	6	3.9
3.4	Others	4	2.7
4.	**Social Group**		
4.1	SC	46	30.3
4.2	ST	--	--
4.3	OBC/BC	57	37.5
4.4	General	49	32.2
5.	**Education**		
5.1	Illiterate	232	37.9
5.2	Primary	147	24.0
5.3	Secondary	111	18.1
5.4	High School	86	14.1
5.5	College	36	5.9

ii. Economic Conditions of PAFs

Main occupation of the head of household is business (55.9%) followed by labour (27%), service (9.2%),others (7.9%). About 27% of families have their income less than Rs. 25,000/, 42.1.6% of them have an income of Rs.25, 001-50,000/- per annum. About 17.8% of the families have an income range between Rs.50, 001 to 1, 00000 per annum. Remaining 13.2 % of the families have an income between Rs.1, 00,000 to 2, 00,000/- per annum. However, the average family income is Rs. 51233.9/- per annum.

Table 9.10: Economic Condition of PAFs

1.	**Occupation**	**Frequency**	**Percentage (%)**
1.1	Labour	41	27.0
1.2	Business	85	55.9
1.3	Service	14	9.2
1.4	Others	12	7.9
2.	**Family Income (Annual Rs.)**		
2.1	< 25,000	41	27.0
2.2	25,001-50,000	64	42.1
2.3	50,001-1,00000	27	17.8
2.4	1,00001-1,50000	13	8.6
2.5	1,50001-2,00000	7	4.6
2.6	Avg. Annual Income(Rs.)	51233.9/-	

iii. Family Pattern and its Size

The family particulars of PAPs/ PAFs are given in Table 9.11. Out of total PAFs majority (88.8%) are nuclear, 8.6% are joint. Family size has been classified into four categories i.e., individual, small (2-4), medium (5-7) and large (7 & above). Majority of the families (51.3%) are small, 37.5% are medium and 8.6% families are large. Average size of family is 4 persons.

So far as marital status of project affected family members are concerned, it is observed that out of 612 members, majority of them (53.8%) are unmarried and only 46.2% are married.

Table 9.11: Family Particulars

1	**Type of Family**	**Frequency**	**Percentage (%)**
1.1	Joint	13	8.6
1.2	Nuclear	135	88.8
1.3	Individual	4	2.6
2	**Size of Family**		
2.1	Individual	4	2.6
2.2	Small (2-4)	78	51.3
2.3	Medium (5-6)	57	37.5
2.4	Large (7 & above)	13	8.6
2.5	Avg. size of family	4 persons per family	
3	**Marital Status**		
3.1	Married	283	46.2
3.2	Unmarried	329	53.8

iv. Details of Structures

Based on the sample social survey it was observed that the project will affect 36.2% residential structures, 42.1% commercial structures,18.4% residential cum commercial structures and 3.3% other structures like water tank, municipal building, shed, office, store room etc. The sample survey identified three types of structures, based on construction material of the wall and floor/roof :(i) Type A is kaccha structures, which largely consist of mud/straw walls with tile roof. About 42.1% structures are kuccha. (ii) Type B structures are semi-pucca made of wooden walls with tin/roof. About 46.7% of the structures are semi-pucca. (iii) Type C structures are pucca. These are made of brick or concrete walls with concrete and/corrugated tin roof. About 11.2% of the structures are pucca. The study reveals that of the total affected structures, 11.2% are owners, 34.9% are tenants and 53.9% are squatters.

Table 9.12: Details of Structures

1.	**Details of Structure**	**Frequency**	**Percentage (%)**
1.1	Residential	55	36.2
1.2	Commercial	64	42.1
1.3	Residential+Commercial	28	18.4
1.4	Others	5	3.3
2.	**Type of Construction**		
2.1	Type-A: Kutcha	64	42.1

2.2	Type-B: Semi-Pucca	71	46.7
2.3	Type-C: Pucca	17	11.2
3.	**Ownership**		
3.1	Owners	17	11.2
3.2	Tenants	53	34.9
3.3	Squatters	82	53.9

9.3 POSITIVE ENVIRONMENTAL IMPACTS

The project is providing an alternative, which is less energy intensive and relatively environmental friendly. Based on project particulars and existing environmental conditions potential impacts have been identified that are likely to result for the proposed project. Based on project particulars and existing environmental conditions, potentials positive and negative impacts have been identified that are likely to result from the proposed metro rail corridor. The negative impacts are also analysed and presented. However, the positive impacts of the projects are given below:

9.3.1 Employment Opportunity

The proposed metro rail project is likely to be completed in a period of five years. Approximately 1800 persons are likely to work directly or indirectly for construction of the project. In post-construction phase, approximately 3200 people will be employed for operation and maintenance of metro rail. Thus, the project would provide substantial direct employment equal to the above number. In addition to these, more people would be indirectly employed for allied activities.

9.3.2 Benefits to Economy

In the present context, the project will streamline and facilitate easy movement of public in Mumbai city. The metro rail will yield tangible and non-tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of this metro rail project, Line III of Phase I in Mumbai city will result in the reduction in number of buses and usage of private vehicles. This, in turn will result in significant social and economic benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. This will facilitate people to move quickly towards urban centers and return there from. With the development of this corridor, it is likely that more people will be involved in trade commerce and allied services. This will facilitate passengers for the optimum use of this metro rail.

9.3.3 Reduction in the number of Vehicle Trips on the road

The number of vehicle trips in the years 2016, 2021, 2031 and 2041 with and without metro rail is projected in Table 9.13. After the introduction of metro rail system the reduction of vehicles for the years 2016, 2021, 2031 and 2041 is as indicated in **Table 9.14**. Similarly vehicle trip KMs and reduction in vehicle trip KMs are summarized in **Table 9.15** and **Table 9.16** respectively.

The basis of reduction of vehicle is shift of ridership from road vehicle to the proposed system. The reduction in number of vehicles gives benefits to economy by reduction in Vehicle Operating Cost (VOC), Fuel Consumption, Pollution Load, Accidents and Travel Time etc.

Table 9.13: Number of Vehicles Trips With and Without Colaba-Bandra-SEEPZ Metro Corridor (Avg. Daily)

MODE	No of Vehicle Trips without C-B-S Metro				No of Vehicles Trips with C-B-S Metro			
	2016	2021	2031	2041	2016	2021	2031	2041
Car + Taxi	4628346	5365521	6540541	7972882	4552876	5273172	6428421	7838339
2W	7239698	8392794	10230769	12471251	7060698	8173760	9964844	12152141
Bus	160988	186629	227500	277321	151680	175239	213672	260728
Auto	1510263	1750809	2352941	2868222	1400758	1616812	2190258	2673002
Total	13539295	15695754	19351751	23589676	13166012	15238983	18797195	22924209

Table 9.14: Reduction in Vehicle Trips With Colaba-Bandra-SEEPZ Metro Corridor (Avg. Daily)

MODE	Reduction of Vehicle Trips with C-B-S Metro			
	2016	2021	2031	2041
Car + Taxi	75470	92350	112120	134544
2W	179000	219034	265925	319110
Bus	9308	11390	13828	16594
Auto	109506	133998	162684	195220
Total	373283	456771	554556	665468

Table 9.15: Number of Vehicles Trip Kms With and Without Colaba-Bandra-Eepz Metro Corridor (Avg. Daily)

MODE	No of Vehicle Trip KMs without C-B-S Metro				No of Vehicles Trip KMs with C-B-S Metro			
	2016	2021	2031	2041	2016	2021	2031	2041
Car + Taxi	55540150	64386256	78486486	95674589	54634509	63278060	77141050	94060065
2W	108595469	125891912	153461538	187068759	105910475	122606396	149472663	182282109
Bus	1609880	1866292	2275000	2773212	1516800	1752394	2136719	2607275
Auto	12082107	14006474	18823529	22945777	11206062	12934493	17522061	21384015
Total	177827607	206150934	253046554	308462338	173267846	200571344	246272493	300333465

Table 9.16: Reduction in Vehicle Trip Kms with Colaba-Bandra-Seepz Metro Corridor (Avg. Daily)

S.NO.	MODE	Reduction of Vehicle Trip KMs with C-B-S Metro			
		2016	2021	2031	2041
1.	Car + Taxi	905641	1108196	1345437	1614524
2.	2W	2684994	3285516	3988875	4786650
3.	Bus	93080	113898	138281	165937
4.	Auto	876045	1071980	1301468	1561762
	Total	4559761	5579590	6774061	8128873

i. Less fuel Consumption Due to reduction in Vehicle:

There will be a reduction in number of vehicle trips on implementation of this project. Therefore, it is estimated that both petrol and diesel consumption will also get reduced. There is an inter-fuel substitution of petrol and diesel to electricity that could result in savings of foreign exchange and a reduction of air pollution. Fuel saved due to traffic diverted to the metro rail is estimated by the diverted traffic described above and the annual run and fuel consumption norms of different vehicles. **Table 9.17** provides information about the savings in fuel consumption due to reduction of vehicles in Mumbai for the years 2016, 2021, 2031 and 2041. These fuel savings are valued at 2011 prices (Rs.67.00/L for petrol and Rs.41.00/L for diesel) the corresponding fuel savings for buses, car+taxi and 2/3wheelers are as shown in **Table 9.18**.

Table 9.17: Savings in Fuel Consumption due to Reduction of Vehicles (Avg. Daily)

MODE	Reduction in Vehicle Trips KMs with CBS Metro				Fuel Consumption Norm (Km/L)	Reduction in Fuel Consumption (litres)			
	2016	2021	2031	2041		2016	2021	2031	2041
Bus (Diesel)	93080	113898	138281	165937	6	15513	18983	23047	27656
Car +Taxi(Petrol)	905641	1108196	1345437	1614524	14	64689	79157	96103	115323
2-3Wheeler (Petrol)	3561039	4357496	5290343	6348412	30	118701	145250	176345	211614

Table 9.18: Money Saving due to Reduction of Vehicles (Avg. Daily)

MODE	MONETARY VALUE(RS LAKH)			
	2016	**2021**	**2031**	**2041**
Bus (Diesel)	6.36	7.78	9.45	11.34
Car (Petrol)	43.34	53.04	64.39	77.27
2-3Wheeler (Petrol)	79.53	97.32	118.15	141.78

9.3.4 Reduction in Air Pollution

Reduction in traffic on Mumbai roads due to proposed metro rail could lead to reduce air pollution. Reduction in number of vehicles and the Emission factor of vehicles as per Euro-II norms given in **Table 9.19** and the reduction level of different pollutants like PM, NOx, HC, CO and CO2 for the years 2016, 2021 and 2031 and 2041 is given in **Table 9.20**.

Table 9.19: Emission Factor of Vehicles as per Euro-II Norms (G/Km)

MODE	PM	NOX	HC	CO
Bus	0.05	0.87	2.75	0.66
Car	0.03	0.2	0.25	1.98
2- Wheeler	0.075	0.3	0.7	2.2

Table 9.20: Reduction In Pollution Emission Due To Reduction Of Vehicles (Tonnes/Year)

MODE	Year			
	2016	2021	2031	2041
Emission reduction of Particulate Matter (PM)				
Bus	1.70	2.08	2.52	3.03
Car	9.92	12.13	14.73	17.68
2/3 Wheelers	97.48	119.29	144.82	173.79
Total	109.10	133.50	162.08	194.50
Emission reduction of Oxides of Nitrogen NOx				
Bus	29.56	36.17	43.91	52.69
Car	66.11	80.90	98.22	117.86
2/3 Wheelers	389.93	477.15	579.29	695.15
Total	485.60	594.21	721.42	865.70
Emission of reduction of Hydrocarbons HC				
Bus	93.43	114.33	138.80	166.56
Car	82.64	101.12	122.77	147.33
2/3 Wheelers	909.85	1113.34	1351.68	1622.02
Total	1085.91	1328.79	1613.25	1935.90
Emission reduction of Carbon Monoxide CO				
Bus	22.42	27.44	33.31	39.97
Car	654.51	800.89	972.35	1166.82
2/3 Wheelers	2859.51	3499.07	4248.15	5097.77
Total	3536.44	4327.40	5253.80	6304.57
Emission reduction of Carbon Dioxide CO_2				
Bus	35.24	43.12	52.35	62.82
Car	1028.51	1258.55	1527.97	1833.57
2/3 Wheelers	4493.52	5498.54	6675.66	8010.79
Total	5557.27	6800.20	8255.98	9907.17

9.3.5 Carbon-di-Oxide Reduction

Carbon di-oxide is one of the major greenhouse gases, which directly deplete the ozone layer. To reduce the overall greenhouse gas emissions International Emission Trading (IET) Mechanism has been followed under Kyoto Protocol. Under IET mechanism, countries can trade in the international carbon credit market. Countries with surplus credits can sell the same to countries with quantified emission limitation and reduction commitments under the Kyoto Protocol. Caron credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one ton of carbon dioxide reduction. Therefore, 5557.27, 6800.20, 8255.98 and 9907.17 Carbon credits per year will be achieved through this project in the 2016, 2021, 2031 and 2041 respectively. In economic terms it will valued as Rs. 23.01 lakh (5557.27 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.), Rs. 28.15 lakh (6800.20 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.), Rs. 34.18 lakh (8255.98 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.) and Rs. 41.02 lakh (9907.17 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.) for year 2016, 2021, 2031 and 2041 respectively.

9.4 NEGATIVE ENVIRONMENTAL IMPACTS

Based on project particulars and existing environmental conditions, potential negative impacts likely to result from the proposed development have been identified. Negative impacts have been listed under the following headings:

- Impacts due to project location
- Impacts due to construction works, and
- Impacts due to project operation.

9.4.1 Impacts Due to Project Location

i. Acquisition of Land

About 39.75 ha of land (Government land-16.82 ha & Private land-22.93 ha) will be required for the proposed metro rail project. The details of land required for the project is given in **Table-9.21**.

Table 9.21: Acquisition Of Land

S.No.	Land Requirement	Area (in ha.)	
1	Govt. land	**16.82**	42.3
2	Private land	**22.93**	57.7
	Total	**39.75**	100

ii. Displacement of People

Rehabilitation and Resettlement (R&R) of displaced families is most important social issue addressed in this section. About 1520 families constitute 6074 persons are likely to be affected due to the acquisition of land[2].

iii. Loss of Trees

Tree survey was carried out along the proposed alignment. The project is in urban area, hence no forest land exists along the project alignment or its corridor. The main species are Gulmohar, Peepal, Coconut, Palms, Dhodkher, kodumar, and Neem. No rare or endangered species of trees have been noticed during field studies. Most of the trees contain the average girth size of about 30-100cm. Since the proposed alignment is underground, no impacts on trees are anticipated except at stations to be constructed by Cut and Cover Method. Approximately 638 trees have been observed at station locations and these are likely to be lost due to construction of proposed metro station. Two alternative depot locations have been evaluated 1. Kalina University and 2. Aarey Milk Colony, out of which Aarey Milk Colony is the selected option. 100 Nos of trees are anticipated at Aarey Milk Colony whereas Kalina University is open area. With removal of these trees the process of CO_2 absorption, O_2 production and the income from forest products will get affected and the losses are reported below.

[2] This figure of affected families is based on sample social survey. However, the exact number of affected families will be considered after census social survey.

S.No.	Description		Quantity
1.	Total no. of Trees	:	2638
2.	Increase in CO_2 @ 21.8 Kg/year/ tree	:	57508 kg
3.	Decrease in Oxygen production @ 49 Kg/year/ tree	:	129262 kg

Table 9.22: Loss of Trees

Description	
Total loss of Trees (Nos.)	2638
Average cost of one tree (Rs.)	15000
Total Loss (Rs. Lakh)	**396.00**

According to Clean Development Mechanism one tonne of CO2 increase will yield one Carbon credit and 6 Euros (1Euro = Rs.69.00) is earned by one carbon credit. Total loss of carbon credit is 57.51 per year due to cutting of 2638 trees. Therefore, 57508 kg of increase in CO2 absorption is estimated as a loss of Rs.23809 per year. For five years of construction period of the project it is estimated as a loss of Rs.1.19 lakh.

Around 11564 kg of Oxygen production will be reduced because of this trees loss and this will lead to a loss of Rs.71.81 lakh(129262 (kg of O2)X55.55(Rs./Kg of O2). Therefore, total loss with the removal of trees will be Rs. 72.05 lakh. The average consumption of oxygen for a person is about 182 Kg/year. It means these trees will meet the requirement of about 710 people round the year.

iv. Loss of Mangroves

Total value of mangroves likely to be affected due to the construction of proposed underground metro corridor is **Rs.1.50 lakh**.

Table 9.23: Loss of Mangroves

Loss of Mangrove Trees	Cost
Total loss of Mangrove Trees *(Nos.)*	30
Average cost of one tree *(Rs.)*	5000
Total loss *(Rs. lakhs)*	**1.50**

v. Loss of Historical and Cultural Monuments:

The proposed metro rail project will affect residential and commercial structures at some of the metro stations where construction be made by cut and cover method. No cultural and monuments are likely to be affected.

vi. Impacts on Water Bodies

The proposed alignment is underground at about 15 m depth, hence no surface water body would be affected. Hence, no impact on aquatic life is anticipated.

vii. Utility/Drainage problems

There will have no impact on utility and on drainage of the area due to proposed underground metro rail. But construction of metro station by cut and cover method, will affect utilities and drainage of the area. The sub-surface, surface and overhead utility services may be sewer, water mains, storm water drains, telephone cables, electric pipes, etc. These utilities services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance.

9.4.2 Impacts Due to Project Construction

i. Soil Erosion

Though the project may not have significant impact on soil erosion, however, minor impact on soil erosion due to runoff from unprotected excavated areas may result in soil erosion, especially when erodibility of soil is high. Mitigation measures include careful planning, timing of cut-and-fill operations and re-vegetation. Problems could arise from dumping of construction soils (concrete, bricks), waste materials (from contractor's camp) etc. causing surface and ground water pollution. Hence, it is proposed to have Ready Mix Concrete (RMC) directly from batching plant for use at site. Batching plants should be located away from the site preferably**,** away from the human settlements. The site of filling of excavated earth/debries/muck & dumping of released construction materials would be identified suitably prior to start of the construction work.

ii. Health Risk at Construction Site

Health risks during construction activity include disease hazards to workers due to lack of sanitary facilities like safe disposal of human waste and garbage clearance and disposal facility. In order to avoid such a situation, proper mitigation measures should be incorporated, which should include proper water supply, sanitation, drainage, healthcare and human waste disposal facilities in labour camps. In addition reduced contaminated water spillage and adoption of disease control measures should be adopted to reduce the health risks.

iii. Impact on Water Quality

Construction activities may have impact on water bodies due to disposal of waste. The waste could be due to the spillage of construction materials, dumping of used water from the stone crusher, oils and greases, and labour camp. But the quantities of such spills are very negligible. Care, however, needs to be taken to provide adequate sanitary facilities and drainage in the temporary colonies of the construction workers. Provision of adequate washing and toilet facilities with septic tanks and appropriate refuse collection and disposal system should be made obligatory. Contamination of ground water can take place, if the dump containing above substances gets leached and percolate into the ground water table. This is not the case with the present project, as the activity does not involve usage of any harmful ingredients. Moreover, activities are of short duration and major construction activities are underground. Hence, in overall, the impact on either ground or surface water quality is anticipated as minimal due to the present project.

iv. Impact on Drainage especially in flood-prone areas

The flood-prone area through which alignment of metro rail corridor passes is area nearby Mithi river. The metro rail has been proposed underground, hence no obstruction to water courses are anticipated.

v. Impact of proposed road improvement works

The proposed metro rail alignment passes through areas where some projects are already under construction and some projects have been proposed for construction in future. During construction of the proposed metro rail project it is required for proper integration with other on-going and future projects. Area wise details of project under construction and future projects are given in **Table 9.24**.

Table 9.24: On-Going and Future Projects

Area	Project under construction	Future Projects
Dharavi		Redevelopment plan
BKC-ITO		Metro Line-II
Kalina	Widening of Sharad devi Raod	
Domestic Airport		Construction of terminals/facilities as per Airport Master Plan
Sahar Road	IA Project Raod	Construction of terminals/facilities as per Airport Master Plan
International Terminal	IA Project Raod	Construction of terminals/facilities as per Airport Master Plan
Marol Naka	Metro Line-I	
Aarey Milk Colony		Monorail Alignment on JVLR with integration station a Aarey Milk Colony(only if present metro gets termina and mono rail comes)

Schedule of construction of other road improvement works may be carefully seen prior to taking up of the construction of proposed metro corridor. EIA reports of the ongoing and future road improvement works should be collected by the developer for review to integrate the project activities of the proposed metro rail project. On the basis of review of impacts due to various activities of ongoing and future projects on the environment, suitable changes in the project schedule may be suggested during construction of the project. The above points will be taken care of by environmental engineer/Environmental expert of project developer.

9.4.3 Impacts due to Project Operation

i. Noise

The main sources of noise from the operation of trains include: engine noise, cooling fan noise, wheel-rail interaction, electric generator and miscellaneous noise like passenger's chatting. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. The maximum noise level is estimated as 64 dB(A). Being the underground metro corridor, only commuters and staffs working will get affected. However, reduction of vehicular traffic in anticipated due to diversion of traffic to metro, hence road traffic noise will come down.

ii. Accidental Hazards

In view of the hazards potential involved due to failure of system and accident the on-site and off- site emergency measures need to be formulated and shall be implemented by the construction agency during construction and operational phases.

iii. Water Supply

CPHEEO (Central Public Health Environmental Engineering Organisation) has recommended 45-litres/day, water supply to persons working at railway stations. Water requirement at all stations has various components, viz. Personal use of Staff, Fire demand, Make up water for air conditioning and ventilation, and wastage. The water demand at each station would be about 50 m3 per day. Platform cleaning requirement has been worked out at the rate of 0.250 lit per sqm.

iv. Railway Station Refuse

Due to non-availability of solid waste data, it is assumed that about 64 gm per person per day of solid waste will be generated. The total refuse, generated will be insignificant since it is due to staff working at station only. Passengers will not be allowed for littering of the area.

v. Visual Impacts

The construction of proposed metro rail corridor will not have any visual impacts being it constructed underground.. An architecturally well-designed structure, which could be aesthetically pleasing will be incorporated for the construction of proposed corridor.

vi. Solid and Liquid Waste

During maintenance of the locomotives/coaches in the carshed proposed either at Aarey Milk Colony or Kalina University, solid and liquid waste will be generated which may cause pollution to the environment by polluting the surface/ground water sources. Solid waste may cause soil pollution when it would be disposed in unscientific manner.

vii. Checklist of Impacts

A typical checklist identifying anticipated environmental impacts is shown in **Table 9.25.**

Table 9.25: Evaluation of Environmental Impacts

Proposed activity	Potential impact	Nature of potential impact	Rating of impact		
		Beneficial or adverse	Direct or indirect	Significance of impact	Magnitude of impact
Construction of Metro Rail Corridor	Demand/ Supply Infrastructure Employment	Beneficial Beneficial Beneficial	Direct Indirect Direct	Medium Medium Medium	Medium Medium Low
Raw Materials Consumption	Stone	Adverse	Indirect	Medium	Low
Water consumption	Surface Water Ground Water	Adverse Adverse	Direct Direct	Medium Low	Low Low
Transportation of materials	Ambient noise Public health and safety	Adverse Adverse	Direct Indirect	Low High	Low Low
Atmospheric emission	Ambient air quality Ambient odor	Adverse Adverse	Direct Direct	Medium Medium	Low Low
Waste water discharge	Land/Water	Adverse	Direct	Low	Insignificant
Solid Waste disposal	Ground water Soil quality	Adverse Adverse	Indirect Indirect	Medium Low	Insignificant Insignificant
Noise generation	Ambient noise	Adverse	Direct	Low	Inignificant
Vibration	Public health	Adverse	Direct	Medium	Insignificant
Construction spoils disposal	Land Water	Adverse Adverse	Direct Direct	Low Medium	Low Low

Note: (Impact) High – Irreversible; Medium – Mitigated through measures; Low – Mitigation required

9.5 ENVIRONMENTAL MANAGEMENT PLAN

Based on environmental baseline conditions, planned project activities and its impacts assessed, the set of measures to be taken during implementation and operation to avoid or offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which needs to be taken to implement them are enumerated in this section.

Mitigation Measures: Based on project description, Environmental Baseline Data and Environmental Impacts, it is proposed to prepare the Environmental Management Plan for the following:

a) Compensation for Loss of Trees,
b) Compensation for loss of Mangroves

c) Compensatory Afforestation and Fencing,
d) Water Supply & Sanitation,
e) Noise Control
f) Vibration Control

9.5.1 Compensation for Loss of Trees

Approximately 2638 trees have been observed at the location of metro stations and depot sites which are likely to be cut due to construction of proposed project. The compensation for loss of these trees works out to **Rs. 395.70 lakh.**

9.5.2 Compensation for loss of Mangroves

There are approximately 30 mangroves likely to get affected at Bandra Metro stations. Total value of mangroves likely to be affected due to the construction of proposed metro corridor is **Rs. 1.50 lakh**

9.5.3 Compensatory Afforestation and Fencing

According to the survey, about 2638 trees are likely to be lost due to the project. Two times the number of trees are to be planted as per the Department of Forests, Maharastra Government. Hence, about 5276 trees are required to be planted. The total area required for afforestation of these tress comes to about 7 ha. It is presumed that government land will be provided for afforestation; hence no land cost will be involved. Land for plantation of trees will be identified by the project proponent in consultation with Forest Department of State Government. Compensatory afforestation cost (excluding fencing) for 7 ha will be about Rs. 14.00 lakhs @ about Rs.200000 per ha. Fencing shall be provided in order to save the saplings from the animals. The cost towards fencing is estimated to be about Rs.6.00 lakh. Thus, the total cost of compensatory afforstation and fencing works out to Rs. 20.00 lakhs. The recommended plant species for afforstation includes gulmohar, pipal, neem, poplar etc.

9.5.4 Water Supply & Sanitation

The public health facilities, such as water supply and sanitation are much needed at project location. Water should be treated before use upto WHO/ Indian drinking water standards. In addition, water will be required for contractor's camps during construction, for which additional arrangements have to be made in consultation with the Mumbai Municipal Corporation & Mumbai Development Authority. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage solves the excreta disposal problems. The sewerage disposal system would be adopted for sewage disposal as the project site is situated in Mumbai urban/suburban areas. Mobile toilet facilities would be made available to workers and staffs working in the project which will be connected to nearest sewerage system with permission of Mumbai Municipal Corporation. Total cost of mobile toilet having 10 seats is estimated as **Rs 54.00 Lakhs** (27 Toilets @ Rs 200,000 per toilet). Collection of solid waste is required for labour and office staff by providing the bin at selected location. The abou 108 bins (27 stations x 4 bins) of 50-120 litres capacity will be required which can be accommodated at different stations. The total cost for bins works out to **be Rs. 2.70 lakhs** (108 bins x Rs.2500). Solid waste collected will be disposed at Mumbai Municipal Corporation's collection bin.

9.5.5 Noise Control

There may be an increase in noise level in ambient air due to construction and operation of this corridor. However, noise levels in the core city will go down significantly due to operation of metro rail through underground tunnel and reduction in traffic on road. However, noise may increase slightly during construction due to transportation of muck and construction material. Proper operation and maintenance of the construction vehicles and equipment would keep them within noise limits. However the exposure of workers to high noise levels especially, near the engine, vent shaft etc. need to be minimized. This can be achieved by job rotation, automation, protective devices, noise barriers, and soundproof compartments, control rooms etc.

The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices i.e. ear plugs. Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds. Ballast-less track would be supported on two layers of rubber pads to reduce track noise and ground vibrations.

9.5.6 Vibration Control

Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

While designing track structure for metro rail system, all the above points have been taken into consideration in the following ways:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 60-kg/m, 90 UTS, supported at every 60-cm. has been proposed. Further, rail grinding at regular intervals by Metro rail grinding machine and also lubrication of rail by vehicle-mounted lubricator have been contemplated.
- Metro rail will be continuously welded and also will be laid to fine tolerances, so that any noise/vibration on account of irregular track geometry could be reduced.
- The vibration generated from rail-wheel interaction will be greatly absorbed by the elastic fastening system proposed to be used.

In sensitive areas, track on floating slab can be provided so as to avoid propagation of noise/vibration to adjacent structures. Additional screening of noise/vibration can be arranged by providing parabolic noise/vibration reflecting walls on each sides of the track.

9.5.7 Soil Disposal

Construction of underground metro rail corridor from Colaba to SEEPZ is a specialised and complex task. Owing to paucity of space in the busy cities and for safety reasons, elaborate measures need to be adopted for collection, transfer and disposal of excavated soil. Soil collection, transportation, disposal and its treatment need to be carried out in a systematic manner. Soil collection should be in containers with the help of conveyor belt from the construction sites. These containers should be such that soil should not spill during transportation to disposal site. The sites for dumping muck/soil is identified at sites proposed for the construction of Western Coastal Road and also for the construction of Jetties 100 km away from the construction site. Transportation of muck would be through barges to the Jetty sites.

9.5.8 Occupational health hazards and control

Exposure to air pollutants and higher noise levels, increased levels of heat & humidity at work place may lead to occupational health disorder and diseases. It is therefore necessary to provide safe and clean working environment for the control/prevention of such health hazards. Care shall be taken to provide good working conditions during operation of proposed metro corridor. Provision of conditions in contract and good construction practices will take care of any occupational health hazard issues and provide environmentally safe work areas. However, a provision of **Rs. 100.00 Lakhs** have been proposed for health related issues and its control for this project

9.5.9 Disaster Management

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which pose unexpected danger to the structural integrity of tunnel and rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

9.5.10 Solid and Liquid Waste Management of Carshed

Solid waste generated in carshed will be segregated in two parts i.e. organic and inorganic. Inorganic waste (non-recyclable) will be dumped at a suitable location with impervious layer of bed so that leachate would not penetrate in to the ground water table. Recycle waste will be sold for reuse. Organic waste may be disposed off by composting method.

Effluent coming from carshed will be given a pre-treatment by providing oil and grease trap followed by degrit chamber. The pre-treated effluent will be brought into an aeration tank to degrade the organic matter to the acceptable level as prescribed by local authority. From the aeration tank, effluent come into sedimentation tank for suspended solid removal. The treated effluent will be put into the nearby municipal sewer line for their disposal. A Provision of **Rs. 70 Lakhs** for construction of effluent treatment plant has been proposed at construction car shed site.

9.6 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring will be required for the construction and operational phases. The parameters need to be monitored are: Water Quality, Air quality and Noise levels etc.

9.6.1 Water Quality

Though it is expected that, no impact on water quality is anticipated, monitoring of water quality may be required to assess the impact of the project before and after construction. Water quality parameters shall be monitored one year before the construction, during the construction phase and also for at least three years after the completion of the project (total 9 years). Monitoring shall be carried out at least three times a year to cover seasonal variations. The parameters for monitoring would be: pH, Dissolved Oxygen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids, Chlorides, Nitrates, Sulphates, Total Nitrogen, Total Phosphates, oils and grease etc (about ten parameters as essential depending on the site conditions). The main monitoring stations could be about four locations. The cost for water quality analysis works out to be **Rs. 10.80 lakhs** (Once in a season (1) X 3 season in a year X 4 locations X 9 years X cost =1X3X4X9X10000).

9.6.2 Air Quality and Noise Levels

Ambient air quality and Noise levels should be monitored one year before the construction, during the construction phase and for at least three years after the completion of the project. It is proposed to have the monitoring programme at four locations. The cost for Ambient air quality and Noise levels Monitoring works out to be **Rs. 228.96 lakhs** as per the break up given in **Table 9.26**.

Table 9.26: Cost of Air And Noise Monitoring

S.No	Description of monitoring	Frequency	Cost
1.	Air quality monitoring	Seasonal	Twice (2) in a week x Four (4) weeks in a season x Three (3) seasons in a year x Seven (9) years x Four (4) locations x Rs. 25000/- per monitoring per location for all parameters = 2x4x3x9x4 x 20000 = **Rs. 172.80 Lakhs**.
2.	Noise monitoring	Seasonal	Once (1) in a season x Three (3) seasons in a year x seven (9) years x Four (4) locations x Rs. 2000/- per monitoring per location = 1x3x9x4x2000 =Rs. **2.16 Lakhs**
3.	Vibration monitoring	Seasonal	Once (1) in a season x Three (3) seasons in a year x seven (9) years x Four (4) locations x Rs. 2000/- per monitoring per location = 1x3x9x4x50000 =Rs**. 54 Lakhs**
		Total	**Rs. 228.96 Lakhs**

9.6.3 Environmental Management System

The Environmental Management System (EMS) constitutes provision of an Environmental Division, which should be staffed by an Environmental Engineer/Officer, an Environmental Assistant and two other assistants (miscellaneous works). The task assigned should include supervision and co-ordination of studies, monitoring and implementation of environmental mitigation measures. An Environmental Advisor shall review progress of the division every year. Cost of such an establishment has been estimated as **Rs. 85.00 lakhs**.

9.7 RESETTLEMENT ACTION PLAN

This chapter presents an overview of the budget and cost estimates. The cost estimates for land and structures are based on present market value. At the this stage of the proposed project this budget is just indicative. However, the compensation amount for the land acquisition and structures will be determined by the competent authority appointed under Land Acquisition Act after census socio-economic survey.

9.7.1 Resettlement Policy and Legal Frame work

i. Resettlement Policy

Government of Maharashtra (GOM) has already adopted an R & R Policy for MUTP.A copy of Resettlement and Rehabilitation Policy for MUTP,1997(as amended in December 2000) is given in **Annexure 9.1**. The objectives of R&R as enunciated in the policy are;

- To minimize the resettlement by exploring all viable alternative project designs,
- Where displacement is unavoidable, to develop and execute resettlement plans in such a manner that displaced persons are compensated for their losses at replacement cost prior to the actual move,
- To accord formal housing rights to the PAHs at the resettlement site by establishing the cooperative housing societies of the PAHs,
- To develop and implement the details of the resettlement program through active community participation,
- To make efforts to retain existing community network in the resettlement area and to minimize the adverse impact, if any, on the host community; and
- To improve environmental health and hygiene of the PAHs at the site of resettlement and to educate, motivate and organise the community to manage its environment at the resettlement location.

ii. Legal framework

The R & R Policy and the Resettlement Action Plan (RAP) and the site specific Resettlement Implementation Plan (RIP) are developed and executed under the following legal framework;

- Land Acquisition Act 1894: for compulsory acquisition of land for public purposes.

- Maharashtra Regional and Town Planning Act, 1966: for preparation of Development Plans (Master Plans) that designate land for public purposes, which can then be acquired under the Land Acquisition Act; and to formulate Development Control Regulations.
- Development Control Regulations for Greater Mumbai 1991: These regulations offer an alternative to acquisition under LA Act 1894 by way of Transfer of Development Rights (TDR).
- The amended DC Regulations provide incentives for rehabilitation (including resettlement of slum dwellers). For landowners prepared to provide 225 sq.ft. dwelling units free of cost to slum dwellers, the incentive is in the form of right to build and sell floor space equivalent to that required for slum rehabilitation
- The DC Regulations also set out the standards for building design and construction and provision of services like water supply, sewerage, site drainage, access roads, elevators, fire fighting etc
- The Maharashtra Co-operative Societies Act 1960: provides for establishing, registering and administering the co-operative societies. The land and building is owned by the co-operative and its members have occupancy rights of apartment occupied by them. Sale and purchase of such units can take place only with the consent of the society. This is a common form of tenure in Mumbai's apartment buildings and is widely understood.

iii. Definition of Project Affected Households (PAH)

Project Affected Households includes households, business units including their workers and owners of assets like land and buildings affected by MUTP and may include; non-resident land owners (including farmers and horticulturist); non-resident lessees; resident landlord (including farmers and horticulturists); resident lessees, tenants or sub-tenants of buildings; squatters (non-resident structure owners, resident structure owners, tenants); pavement dwellers. Household for this purpose means all the males/females, their family members and relatives staying in a house/tenement/hut.Since, the above R&R policy for MUTP does not specify the compensation cost, National Policy for Rehabilitation and Resettlement-2007 and market survey data have been taken wherever found appropriate. Since the Option-II of the proposed metro rail corridor has been finalised, the budget and cost estimate of the same is presented here.

iv. Entitlements for R&R

Every eligible household losing a dwelling place shall be allotted a dwelling unit of minimum of 25 sq.m. at an alternate site. Similarly every PAH losing a commercial structure shall be eligible for an alternate place for commercial use of equivalent area.

v. Access to training, employment, and credit

There are a number of training programs offered by government for skill upgrading for promoting self-employment. Similarly there are government programs of extending financial assistance to the poor for self-employment. During the preparation of site specific Resettlement Implementation Plan, the communities will be informed of such programs. In addition, local savings and loan associations will also be promoted through NGOs.

vi. Selection of Resettlement Site

As per the R&R Policy of MUTP, the site for resettlement shall be selected out of the feasible options in consultation with the affected community as a part of the RAP preparation. The principal criteria for site selection shall include access to employment opportunities, infrastructure and social services. Environmental Assessment of the resettlement site shall be carried out as part of the preparation of CEMP. MMRDA has about five rehabilitation sites in Mumbai.These are (i)District Centre Oshiwara,(ii) Goregaon(W),(III) Nahar Railway Station(W),(IV) Kanjur Marg(W) and (v) Punam Nagar,Andheri(E). However, finalization for selection of resettlement site would be taken in consultation of PAFs, MMRDA officers and other concerned Departments during census (detailed) socio-economic survey.

vii. Grievance Redressal Mechanism

The Project Implementation Authority will designate a senior officer at the local level to consider any grievance of PAFs in consultation with the concerned NGO. If the aggrieved PAF is not satisfied with this decision, final appeal could be made to the Grievance Redressal Committee (GRC) appointed by the Project Management Unit comprising its officials and the representatives of NGOs in accordance with the R & R Policy.

viii. Institutional Arrangement

A Project Management Unit (PMU), headed by a Project Director, should be created by project executing and implementing agency for planning and implementing R & R component. The PMU is also responsible for overall coordination with all the implementing agencies and monitoring the progress of MUTP. The Project Director-PIU will recruit and appoint the NGOs for information and community construction programme and other socio-cultural/health measures related to resettlement activities. There will be a Social Management Unit (SMU) and Project Director is the head of this unit. The SMU will be headed by Social Development Officer who will be responsible for day to day activities related to social, resettlement & rehabilitation, land related issues with the help of local NGO hired for the purpose. Each construction management unit will have a Resettlement and Rehabilitation Officer (RRO) in the rank of Assistant Engineer. The RRO will report to the Social Development Officer and Project Director on the day-to-day activities of resettlement implementation. The Project Director through the RRO and the field offices will monitor the progress of the work and ensure coordination between the relevant departments and RP implementation committees.

The PD-PIU will be responsible to carry the following task concerning resettlement of the project:

- Overall responsibility of implementation of R&R activities.
- Responsible for land acquisition and R&R activities in the field,
- Ensure availability of budget for R&R activities,
- Liaison with local administration for support for land acquisition and implementation of R&R; and Participate in the district level committee.

9.7.2 R&R Benefits

i. Compensation for Land & Structure

The rate for private land plus building has been considered different areas/locations wise and is based on market value. The tabular statement for detailed acquisition of land and loss of structure is given in Ground Survey and Alignment Report. An additional 30% has been taken as solatium over and above the compensation in consideration of compulsory
nature of acquisition. About 12% as interest rate has also been considered. The total cost of private land plus building for compensation has been given in DPR.

ii. Replacement Cost for Shelter

The project affected squatters who opt for township option, shall be entitled to a monetary supplement that represents the replacement cost of their shelter. For calculating such monetary supplement, Municipal Corporation of Greater Mumbai and the Public Works Department shall finally determine for various types of construction, a unit cost of replacement based on the rate schedules used by them for construction activities undertaken by them.

Each squatter will be provided a fully developed plot of 25sq.m. Replacement cost @Rs.8500 per sq.m for a total plot of 25 sq.m for construction of shelter. Total replacement cost for construction of shelters work out to **Rs.3119.50**.

iii. Shifting Allowance

Each displaced family will be provided shifting allowance of Rs.10000/- as transportation cost for shifting of building materials, belongings and cattle etc. A provision of **Rs.152 lakh** has made under this head.

iv. Training Allowance

Training would be provided to squatters, commercial owners/tenants, and wage earners for upgradation of skills. For calculating training allowance following heads have been considered:

- Amount to be paid to the master trainer
- Cost towards travel, stay and food of trainees
- Hiring of training venue
- Raw material to be used during training.

A provision of **Rs. 52.15**/-lakhs for PAFs has been made under this head.

v. Economic Rehabilitation Grant

Economic Rehabilitation Grant is grant given to a PAP belonging to a vulnerable family losing livelihood viz; loss of commercial unit (owner as well as helping hands); loss of land including title holder, daily labourer, etc. ERG will be given to those members who are dependent on the affected property (land or shop etc.). ERG for vulnerable people has been calculated based on BPL cut off line of the state. The yearly figure will be converted into monthly amount. An addition of 25% over and above the cut off line will ensure that inflation rate is also taken care of therefore, ERG amount is Rs.25,000/-.There are 1326 PAFs belonging to vulnerable family will be losing property because of the project. The provision made under this sub-head is **Rs. 121.50/- lakh**.

vi. Religious Structure

About eight religious structures located in Government and railway land will be affected due to the proposed project. A lum sum amount of **Rs.8.00/- lakh** has been estimated for relocation of temple which includes beautification by way of plantation.

vii. Amenities for Township

In addition to the developed plot of 25 sq.m, recreational open space @ 15% of the plot area, water supply @ of 135 liters per capita per day, one balwadi of 20.9 sq.m for every

100dwelling units and minimum width of pathway is 1.5m has been considered according to the Development Control Regulations (DCRs) for Greater Mumbai1991. The provision made under this sub-head is **Rs. 3667.22 lakh**.

9.8 COST ESTIMATE

The cost for environment and resettlement and rehabilitation is given in **Table-9.27**.The total cost for environmental and social management plan is **Rs. 90.97 crore**.

Table 9.27: Cost For Environmental And Social Plan

S. NO.	ITEM	RS. (in lakh)
A. Environmental Cost		
1	Compensation for loss of trees	395.70
2	Loss of Mangroves	1.50
3	Compensatory Afforestation	20.00
4	Water Supply and sanitation	56.70
5	Occupational health hazards & control	100.00
6	Muck disposal (Environmental Management)	100.00
7	Water Quality Monitoring	10.80
8	Air,Noise and Vibration Monitoring	228.96
9	Environment Management System	85.00
10	Solid and Liquid Waste Management in Carshed	70.00
	Total A	***1068.66***

B. Social Cost		
	Compensation for loss of land & Structures	See DPR
10	Replacement cost @ 8500 per sq.m for total 25sq.m. per PAF	3119
11	Shifting Allowance @ 10000	152.00
12	Training for skill improvement @ Rs.5000 for one member of a family	52.15
13	Economic Rehabilitation grant for Vulnerable families @ 25000/- per family	121.50
14	Religious Structures (Lumsum)	8.00
15	Amenities for township	
a.	Plot of 25sq.m for 516 PAFs[3]	1835
b.	Recreational open space @ 15% of the plot area	275.25
c.	Water Supply (Lum sum)[2]	40.00
d.	Sanitation (Lum sum)[3]	70.00
e.	Balwadi 20.9sq.m for every 100dwelling(lum sum)	15.67
f.	Road(minimum width of pathway is 1.5m[5]	1431.3
16	NGO Cost (lum sum)	45.00
17	Independent Evaluation (lum sum)	20.00
	Total B	***7185.37***
	Total A + B	8254.03
	Miscellaneous items @10% of sub total	825.40
	TOTAL	**9097.43**

The Environment Management Plan should be implemented in phases, so that optimum benefit could be achieved and it should be synchronised with the construction schedules.

9.9 ENVIRONMENTAL CLEARANCES REQUIRED

Prior to start of construction work, CRZ clearance and permission for tree cutting is required. The procedures to get the clearance are described as below:

9.9.1 Procedure for CRZ clearance

The project proponent shall submit the proposal to the Maharashtra Coastal Zone Management Authority (MCZMA) along with following documents/reports for CRZ clearance-

(i) Form-1(Annexure IV of the Notification);
(ii) Rapid Environment Impact Assessment (EIA) Report including marine and terrestrial EIA.
(iii) Disaster Management Report and Risk Management Report;
(iv) CRZ map indicating HTL and LTL demarcated by an authorized agency(1:4000 scale);
(v) Project layout superimposed on the above mentioned map;
(vi) The CRZ map shall normally indicate a 7 km radius around the project site;

[3] Rs.3000/- has been considered per sq.m of land in rehabilitation sites of MMRDA.
2. Water supply includes area of 500 sq.m, filtration and disinfection.
3. Sanitation includes sewage and STP has been taken.
4. Minimum 30% of total dwelling and construction @ Rs.8000/- per sq.m is taken.

(vii) The CRZ map shall indicate the CRZ-I,II,III and IV areas;
(viii) No Objection Certificate from concerned Pollution Control Boards or Committees for the projects which envisage discharge of effluents, solid wastes, sewage etc.

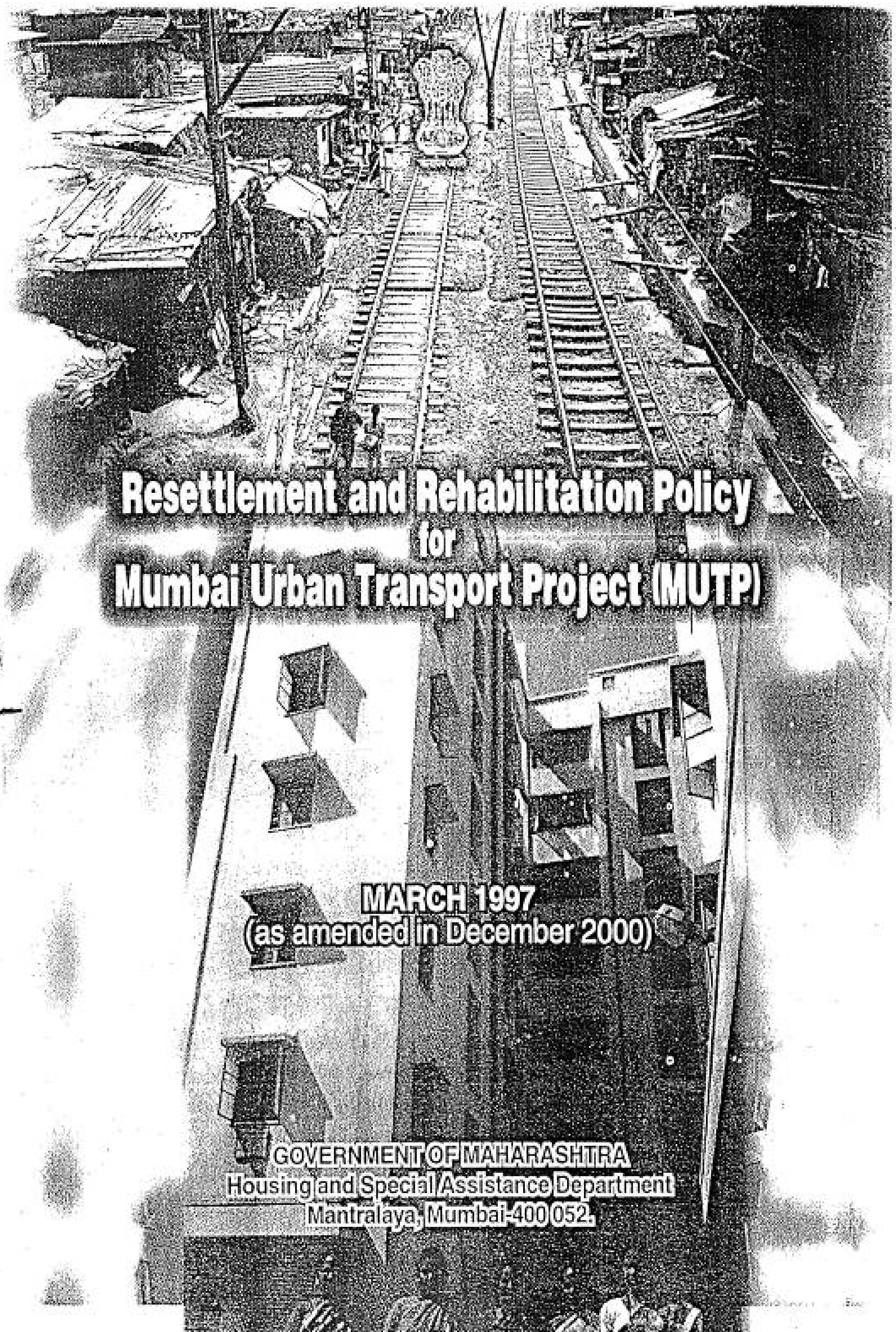
The Maharashtra Coastal Zone Management Authority (MCZMA) shall examine the above documents in accordance with the approved CZMP and CRZ Notification and make recommendations within a period of sixty days from the date of receipt of above documents to Ministry of Environment and Forest (MoEF) or State Government. MoEF or State Government shall consider the proposed project based on recommendations of MCZMA within a period of sixty days.

9.9.2 Procedures for Removal of Trees

The project proponent shall apply in writing to the Tree Authority, Municipal Corporation of Greater Mumbai, Dr.Ambedkar Road Byculla(East),Mumbai, for removal of trees coming in the work of proposed elevated rail corridor project. The application shall be accompanied by a site plan, indicating the position of tree required to be felled and the reasons therefor. On receipt of such application, the Tree Authority shall cause the Tree Officer to personally inspect the tree and hold enquiry and submit a report to the Tree Authority within a period of thirty days from the date of receipt of such application. Adequate public notice shall be given by the Tree Officer by advertising in local newspapers as well as by affixing a notice on a conspicuous part of the tree that is required to be fell. Thereafter, the Tree Authority may give permission with or without conditions or refuse it, within a period of sixty days from the date of receipt of the application.

Annexure -1

Resettlement and Rehabilitation Policy
Of Govt. Of Maharashtra
for
Mumbai Urban Transport Project (MUTP)


Resettlement and Rehabilitation Policy
for
Mumbai Urban Transport Project (MUTP)
MARCH 1997
(as amended in December 2000)
GOVERNMENT OF MAHARASHTRA
Housing and Special Assistance Department
Mantralaya, Mumbai-400 052.

Policy for Resettlement and Rehabilitation of persons affected by Mumbai Urban Transport Project.

GOVERNMENT OF MAHARASHTRA

Housing and Special Assistance Department
Resolution No. Prakalpa 1700/CR 31/Slum 2,
Mantralaya, Mumbai 400 032
Dated the 12th December, 2000

Read : Government Resolution, Housing and Special Assistance Department, No. MIS 1094/CR 558/Slum 2, dated 12th March 1997.

1. Resolution :

Government of Maharashtra has decided to take up "Mumbai Urban Transport Project" (MUTP) with a view to bringing about improvements in traffic and transportation situation in the Mumbai Metropolitan Region (MMR). Efforts are being made to obtain financial assistance for this project from the World Bank. The schemes under MUTP include roads, Road Over Bridges (ROBs), traffic management schemes as well as various rail projects. The various schemes under MUTP would affect a substantial number of households, business activities and structures, which will have to be relocated. Resettlement of project affected persons, according to the World Bank operational directives, is required to be an integral part of World Bank financed projects. Preliminary estimate indicates that approximately 25,000 to 30,000 families will have to be relocated due to MUTP. Government of Maharashtra appointed a Task Force, in February, 1995 under the Chairmanship of Shri D. M. Sukthankar, former Chief Secretary, to prepare a framework for Resettlement and Rehabilitation (R & R) Policy and to assist the Government in determining the institutional arrangements and implementation strategies for R & R. The Task Force submitted its report to the Government after a detailed study of the households, business activites and structures likely to be affected by MUTP. Based on the recommendations of the Task Force, orders prevailing for R & R of persons affected by the projects in rural areas, the legal provisions and a series of discussions with the World Bank missions a revised R & R Policy was submitted to the Government for approval. Accordingly the following Resettlemant & Rehabilitation Policy has been formulated.

2. Applicability of the Policy :

The following R & R policy shall be applicable to all the sub-projects described in the Borrower's Project Implementation Plan (BPIP) for the MUTP and also the sub-projects identified for inclusion in the subsequent phases of MUTP. Resettlement Action Plans (RAP) and Community Environmental Management Plans (CEMP) will be prepared for each subproject involving resettlers in accordance with this Policy.

3. Objectives :

(a) To minimise the resettlement by exploring all viable alternative project designs, and to prioritise various elements of the project by treating this as one of the important considerations,

(b) Where displacement is unavoidable, to develop and execute resettlement plans in such a manner that displaced persons are compensated for their losses at replacement cost just prior to the actual move, displaced persons are assisted in their move and supported during the transition period in the resettlement site and displaced persons are assisted in improving or at least restoring their former living standards, income earning capacity and production levels; and to pay particular attention to the needs of poor resettlers in this regard,

(c) To accord formal housing rights to the PAPs at the resettlement site. Such rights shall be in the form of leasehold rights of the land to the co-operative society of the PAPs and occupancy rights of built floor space to the members of the society. The membership of the co-operative society and the occupancy rights will be jointly awarded to the spouses of the PAP household. The documents in this respect will be the leasehold agreement with the co-operative society, which will include a list of its members and description of dwelling unit allotted to each member. The members of the co-operative society will receive a share certificate signifying the membership of the society.

(d) To develop and implement the details of the resettlement programme through active community participation by establishing links with the community based organisations; and

(e) To make efforts to retain existing community network in the resettlement area, wherever this is not feasible to make efforts to integrate the resettled population with the host community, and to minimise the adverse impact, if any, on the host community.

4. Categories of Project Affected Structures :

Project affected structures shall be categorised by referring to ownership, land use and type of construction.

Ownership :

- Land and building owned by the same person,
- Land owned by one person and building owned by the lessees,
- Land and building both leased to lessee,
- Land and building occupied by statutory tenants with owner occupant or where owner is a absentee
- Land occupied by squatters without any legal title. Category of squatters includes - non-resident structure owners, resident structure owners and tenants.

Land use :

- Land used for farming, horticulture etc.
- Land used for open uses such as storage, vehicle repairing etc.
- Structure used for residential purposes
- Structure used for shop-cum-residence
- Structure used for shop
- Structure used for workshop, factory etc.
- Structure used for schools, balwadis, community activities, religious purposes, medical and health facilities, gymnasium etc.

Type of structures :

- Multi-storeyed RCC structures,
- RCC or Steel frame structures in slum,
- Ground storeyed structures with RCC slab or tile or AC sheet or GI sheet roof,
- Ground storeyed structures/hutment in slums.

5. Definition of Project Affected Persons (PAP) :

Project Affected Person includes households, business units including their workers and owners of assets like land and buildings affected by MUTP shall be considered as PAPs and may include; non-resident land owners (including farmers and horticulturist); non-resident lessees; resident landlord (including farmers and horticulturists); resident lesseeresident lessees, tenants or sub-tenants of buildings; squatters (non-resident structure owners, resident structure owners, tenants); pavement dwellers. Household for this purpose means all the males/ females, their family members and relatives staying in a house/tenement/hut.

6. Eligibility of Project Affected Persons (PAPs) for R & R :

(a) All legitimate occupants of land and building affected by MUTP up to the time of actual resettlement will be eligible for the benefit of R & R Policy. However, PAPs who are squatters and not the legitimate occupants of land or buildings shall be eligible for R & R only if enumerated during the baseline survey. The date of completion of baseline survey shall, therefore, be the cut-off date. While preparing the Resettlement Action Plan (RAP) the baseline survey will be updated if the gap between the baseline survey and the RAP is more than one year. Any new unauthorised structures or additions to existing structures carried out after the cut-off date and their occupants will not be eligible for R & R.

Similarly, the occupants of a structure except legal heir who have acquired the structures after the cut off date shall not be eligible for the benefits of Resettlement and Rehabilitation. However, member added to the eligible households by way of birth and marriage after the cut-off date will be considered eligible for R & R. For this purpose, the baseline survey will create a detailed data base available with both the R & R Agency and the affected community. The significance of the cut-off date will also be explained to the community.

(b) PAPs who do not wish to participate in the RAP prepared in the manner as laid down in this policy will not be eligible for rehabilitation and will have to vacate the occupied space on their own.

(c) Aerial photographs if available and visual documentation carried out during baseline surveys will help identify squatters entering the area after the baseline surveys. These squatters shall not be entitled for any R & R benefits. Motivating and strengthening of Community Based Organisations (CBOs) during the baseline survey will be attempted to help prevent further encroachment after baseline survey. R & R activities and MUTP project execution schedule shall be closely co-ordinated to minimise the time between site clearance and commencements of civil works so as to prevent further encroachment. Implementing agencies shall protect the cleared sites by appointing watch and ward staff. Even with these measures, if encroachment takes place, eviction will be resorted to.

7. Selection of Resettlement Site :

The site for resettlement shall be selected out of the feasible options in consultation with the affected community as a part of the RAP preparation. The principal criteria for site selection shall include access to employment opportunities, infrastructure and social services. Environmental assessment of he resettlement site shall be carried out as part of the preparation of CEMP.

8. Land acquisition :

(a) For acquisition of land for the project, landowners and lessees shall be compensated as per the provisions of the Land Acquisition Act, 1894 (LA Act). The facility of Transferable Development Rights (TDRs) will be available as an alternative to compensation under the LA Act, in accordance with the Development Control Regulations (DCRs) for Greater Mumbai 1991 as amended from time to time and being in force.

(b) TDRs will also be available to developers who agree to build and hand over free of cost dwelling units for R & R according to the approved RAP, in accordance with the DCRs more particularly the Urban Development Department Notification datd the 15th October 1997.[1] FSI of 2.5 shall a be allowed for construction of tenements, under the above schemes, on the lands reserved for resettlement of PAPs by making appropriate changes in the reservation in the Development Plan. To provide incentive to landowners in residential zones to build dwelling units to the PAPs, an additional FSI of 1.5 may be permitted. 0.75 of this additional. FSI shall be used for rehabilitating PAPs free of cost, and the balance FSI of 0.75 may be allowed for free sale.[2]

9. Resettlement Options :

While preparing RAP following two options may be explored with the community;

(a) Township option : This will be in the form of a sites and services project developed by the R & R agency (or other public agency) on a green-field site owned by the agency. A fully developed plot of 25 sq. meters shall be allotted one year in advance of the target date of relocation. The agency can use some land for high income housing of non-PAPs and for commercial activities. The agency can sell plots for commercial activities and high-income housing at market price to recover the project cost.

[1] Transfer of Development Right is available as an alternative to compensation under the LA Act 1894. If the landowner whose land is reserved for a public purpose is prepared to surrender such land to free of cost and free of encumbrances to BMC he can opt for receiving TDR equivalent to floor space which he could have constructed had his land not been reserved. In Suburbs where most of the land acquisition is required to be carried out for MUTP such floor space (and therefore the TDR will be reckoned at the Floor Space Index (FSI) of 1. These TDRs are saleable in the market and can be used in areas specified in the DCRs. In addition to the TDR given for the land, TDR equivalent to the floor space constructed for the slum dwellers and handed over free of cost for can also be granted. Such floor space is restricted to FSI of 2.5 and consequently TDR available for constructed dwelling units is also restricted to 2.5.

[2] More particularly as provided for in Urban Development Department Notification dated the 15th October 1997.

(b) Tenements under Slum Redevelopment (SRD)/Public Housing (PH)/Housing the Dishoused (HD) : A tenement of 20.91 sq.m. in muti-storeyed buildings.

(c) The entitlement of PAPs in terms of floor space / plot at the resettlement site for the options described in section 9 above will be as stated in Apendix. I

10. Other Amenities :

(a) For township / sites and services option :

In addition to the developed plot of 25 sq.m., water supply at 90 lpcd, pedestrian pathways according to DCRs, on plot toilet seat and water tap, community facilities like primary school, dispensary, playground, fair price shop as may be required, and site for religious places that existed in the old community.

(b) For PH / HD and SRD options :

PH / HD and SRD are a part of the Development Plan of Greater Mumbai. The standards of off-site amenities will therefore be according to the Development Plan. The on-site amenities like the recreational open space, Balwadis, water supply, sanitation, pathways and access streets etc. shall be provided according to the standards prescribed in DCR's. [3]

11. Monetary Supplement to Squatters :

The Project Affected Squatters who opt for Township option, shall be entitled to a monetary supplement that represents the replacement cost of their shelter at the time of baseline survey. For calculating such monetary supplement, Municipal Corporation of Greater Mumbai and the Public Works Department shall determine for various types of construction, a unit cost of replacement based on the rate schedules used by them for construction activities undertaken by them. The monetary supplement shall be disbursed in suitable instalments related to the progress of work of building the structure on the serviced site. However, PAPs that opt for fully built dwelling unit will not be eligible for such monetary supplement.

[3] Some of the standards prescribed by the DCRs at present are; recreational open space @ of 15% of the plot area, water supply @ of 135 litres per capita per day, one balwadi of 20.9 sq.m. for every 100 dwelling units and minimum width of patway is 1.5 m.

12. Compensation for Economic Losses :

Every effort shall be made to relocate the affected households to nearby site and thus avoid cutting access to existing employment and income earning sources.

(a) If the relocation of workers / employees results in an increase in travel distance to reach the original place of work or new place of work, a lump sum compensation not exceeding twelve quarterly season tickets for such excess distance by suburban railway at the time of resettlement shall be paid to such workers / employees subject to actual verification of extra expenditure incurred.

(b) If it turns out to be impossible to continue present occupation or where workers / employees / entrepreneurs permanently lose their source of livelihood, because of displacement, a lump sum compensation equivalent to one year's income be given to such workers / employees / entrepreneurs at the rates to be determined by the R & R implementing agency. A valuation committee comprising the representatives of the R & R Agency and the NGO shall assist the R & R Agency in determining the annual income of PAPs.

(c) Vulnerable households such as women headed households, handicapped and the aged will be extended an additional package of rehabilitation services to help them overcome the difficulties on account of resettlement. This will include preference in allotment of dwelling units on the ground floor for the handicapped and preference in sanctioning of loans from the fund mentioned below. Any further assistance required for vulnerable PAPs will be determined during RAP preparation.

(d) For those who permanently lose their jobs, the rehabilitation package shall include access to employment information through employment exchange and training facilities. Moreover, community operated fund will be created to provide seed capital and other loans. Community operated fund could be linked with community saving programmes. The fund could be controlled and monitored by the community with the assistance of Non-Governmental Organisation (NGO).

13. Other Benefits :

In addition to the shelter-related rehabilitation described in the Appendix I, cost of shifting will be paid to the PAPs or free transport arrangements be made available to the PAPs for moving to the resettlement site.

14. Planning and Implementation Procedure :

(a) Based on the baseline survey carried out through close participation of NGOs and CBOs, a list of eligible project affected structures, households,lands, shops and business activities shall be prepared and announced for community endorsement to avoid conflict over subsequent entrants in the project area.

(b) RAP preparation shall be undertaken with active participation of eligible PAPs. Draft RAP shall include, a statement of objective and policies, an executive summary, and provision for the following :

- organizational responsibilities,
- community participation and integration with host populations,
- socioeconomic survey,
- legal framework,
- alternative sites and selection,
- valuation of and compensation for lost assets,
- land tenure, acquisition, and transfer,
- access to training, employment, and credit,
- shelter, infrastructure, and social services,
- environmental protection and management; and
- implementation schedule, monitoring, and evaluation.

Cost estimates should be prepared for these activities, and they should be budgeted and scheduled in coordination with the physical works of the main investment project.

(b) Draft RAP shall be shared with the PAPs, NGOs, CBOs and general public in the area through community meetings and other appropriate media. The views of PAPs will be taken into account in finalising the RAP.[4]

[4] In case indigenous people are affected by MUTP a separate Indigenous People Development Plan (IPDP) will be prepared along with the RAP in accordance with the World Bank's Operational Directive 4.20.

(c) In addition, general dissemination of information on R & R policy, specific RAPs and environmental management plan related to MUTP shall also be undertaken in a planned manner. These activities may include organising seminars, bringing out the news items in newspapers, T.V, radio, technical and academic journals.

(d) The RAP prepared in this manner shall be implemented by the agency identified for the purpose.

(e) "A two-stage resettlement process will be adopted only under emergency circumstances and only if the affected community agrees to move to the transit housing prior to shifting to permanent houses. Prior to shifting people to transit houses the following need to be ensured -

  (i) the type of accommodation and basic amenities to be provided in the transit camps and a time table for moving to permanent sites are discussed and agreed with the PAPs and

  (ii) the world Bank will verify the feasibility of the schedules in the time table, particularly whether acquiring permanent sites can be completed within at most two years and that permanent housing can be available before the end of the third year."

15. Redressal of Grievances :

R & R Agency shall designate a senior officer at the local level to consider any grievance of PAPs in consultation with the concerned NGO and give his decision in writing, within a stipulated time period, and also keep a record of such decisions. If the aggrieved PAP is not satisfied with this decision, final appeal, could be made to the Grievance Redressal Committee appointed by the R & R Agency comprising its officials and the representatives of NGOs.

16. Completion of Resettlement Prior to Commencement of Civil Works :

The agreed resettlement activities in transit structures in the case of two stage implementation procedure and in permanent settlements in other cases shall be generally completed prior to commencement of the relevant section of the civil work of the transport project. On completion of resettlement, the site shall be turned over to the concerned transport project-implementing agency.

17. Indirectly Affected PAPs :

The relocation of affected communities and persons may have adverse impact on the community linkages at the old site. In order to minimise such adverse impact appropriate and careful measures need be planned. For this purpose, the affected community be identified based on the social and economic linkages and not purely on the basis of right of way required for the project. If the social and economic linkages are substantially affected[5], the remaining people, whose proportion should not exceed 20% of the directly affected PAPs. If they desire should be resettled along with the PAPs. However, if the remaining people do not desire to shift, efforts shall be made to provide earlier social and economic facilities at the old site.

18. Host Community :

The relocation of PAPs at the new site may impact two types of host communities. One, resident of the relocation site and the other living in the vicinity of the resettlement site. Resettlement of PAPs will displace the first type of host community and increase the burden on the infrastructure services available to the second type of the host community. The host community that is resident of the relocation site shall be treated as eligible PAPs and shall be extended all the benefits of this policy. In case of the host community in the vicinity of the relocation site, the increased demand of services on account of resettled community, may reduce the quality of life of the host community. In order to avoid or minimise such impacts the RAP will propose augmentation of available services. Such augmentation will be carried out as part of RAP implementation.

19. Modification of Development Plan :

Urban Development Department shall decide, on case to case basis, about the changes to be carried out in the reservation in the Development Plan for lands

[5] The social and economic linkages shall be considered to be substantially affected when almost all the residents of the affected area had shifted together to the area from the same area of origin, or; some common infrastructure facilities such as, school, dispensary etc. were shared by all the residents, which need to be demolished to clear the site for the project and providing these facilities for the remaining families is not feasible, or; the number of the remaining families is so small that it is not possible for them to stay as a community.

to be acquired and utilised for R & R of PAPs according to the procedure laid down in the Maharashtra Regional and Town Planning Act 1966 (MR & TP Act). *

20. Institutional Arrangements :

Institutional arrangements, including interdepartmental oversight committees, the hiring of experts in housing, engineering, social development, land acquisition, legal, environment, PR and other relevant areas and monitoring mechanisms, will be set forth in a separate notification to be issued on institutional arrangements.

21. Restrictions on Transfer / Disposal of Tenements Allotted to the PAPs :

No PAPs shall transfer / dispose of the tenement allotted to him without prior permission of the Government. The procedure followed by Slum Rehabilitation Authority for transfer / disposal of tenements under Slum Rehabilitation Schemes shall mutatis-mutandis be applied in case of transfer / disposal of tenements allotted to the PAPs under this policy.

These orders are issued after obtaining concurrence of the Urban Development Department vide informal reference No. 594 Dated 22/11/2000.

This Government Resolution shall supersede all the previous Government Resolutions on this subject.

By order and in the name of the Governor of Maharashtra,

Sd/-
(R. B. Budhiraja)
Principal Secretary to Government of Maharashtra,

*** The procedure for modifying the Development Plan reservation is prescribed in Section 37 of the MR & TP Act 1966. This requires publication of proposed modification for inviting public suggestions and objections, hearing the suggestions and objections and then taking a final decision.**

Copy to :

1. Secretary to Hon. Governor,
2. Secretary to Chief Minister,
3. Chief Secretary,
4. Chairman, Railway Board, Rail Bhavan, New Delhi.
5. Private Secretaries to all Ministers and State Ministers,
6. Additional Secretary, Urban Development Department, Government of India. New Delhi.
7. General Manager, Western Railway, Churchgate, Mumbai
8. General Manager, Central Railway, CST, Mumbai.
9. Managing Director, M.R.V.C. 2nd floor, Churchgate Station Building, Mumbai 400 020.
10. Metropolitan Commissioner, MMRDA, Bandra Kurla Complex, Mumbai.
11. Secretary to All Department, Mantralaya, Mumbai.
12. Vice President and Chief Executive Officer, MHADA, Mumbai 400 051.
13. Chief Executive Officer, S.R.A., Bandra (East) Mumbai 400 051.
14. Divisional Railway Manager, Western Railway, Mumbai Central, Mumbai.
15. Divisional Railway Manager, Central Railway, CST, Mumbai.
16. Additional Police Commissioner, Traffic Police, Worli, Mumbai.
17. Commissioner, Gr. Mumbai Municipal Corporation, Mumbai.
18. Commissioner, Thane Municipal Corporation.
19. Collector, Mumbai
20. Collector, Mumbai Suburban District, Mumbai.
21. Additional Collector (ENC), Mumbai.
22. Controller, Encroachment, Mumbai.
23. All Officers, Housing and Special Assistance Department, Mantralaya, Mumbai.
24. Select File.

Appendix - I

SUMMARY OF REHABILITATION MEASURES

Sr. No.	Category of RAP	Legal Compensation	Rehabilitation		
			Monetary Supplement	Type of Shelter related Rehabilitation	Price to be Charged
1.	Non-resident land Owners (Including farmers and horticulturists	Market value of land and building, according to LA Act.	Nil	Nil	
	Non-resident lessees	Apportionment of compensation for the unexpired period of lease according to LA Act.	Nil	Nil	
2.	Resident landlord (land and building) (including farmers and horticulturists)	As in 1 above,	Nil	Cash supplement equivalent to cost of construction of floor space (subject to a max. of 20.91 sq.m) occupied prior to resettlement. OR Floor space equal to self occupied floor area, subject to maximum of 70 sq.m., irrespective of use of floor space	First 20.91 sq.m. of floor space free of cost and at actual cost for the area in excess thereof
	Resident lessee of land and building	Apportionment of compensation for the unexpired period of lease according to LA Act.	Nil	Floor space equal to self occupied floor area, subject to maximum of 70 sq.m., irrespective of use of floor space	First 20.91 sq.m. of floor space free of cost and at actual cost for area in excess thereof.
3.	Resident lessees, tenants or sub-tenants of buildings	Shifting charges according to LA Act.	Nil	Floor space equal to self occupied floor area, subject to a maximum of 70 sq., irrespective of use of floor space.	Free of cost on owenership basis up to 20.91 sq.m. of floor space and at actual cost for area in excess thereof

4.	Squatters				
	Non-Resident structure owners (The status to be established by documentary evidence in	Nil	Replacement cost of lost structure	Nil	
	Resident structure owners	Nil	Replacement cost of lost structure	Township option Plot of 25 sq.m.	Free of cost
				Plot in excess of 25 sq.m.	At cost of excess area.
			Nil	**PH/HD/SRD Option :** Residential : floor space of 20.91 sq.m.	Free of cost.
				Shops & business Area equivalent to existing area with a maximum of 70 sq.m. Out of which 20.91 sq.m.	Free of cost
				Area in excess of 20.91 sq.m.	At cost for the excess area
	Tenants	Nil	Nil	**Township option** Plot of 25 sq.m.	Free of cost.
				Plot in excess of 25 sq.m.	At cost for the excess area.
				PH/HD/SRD Option : Residential : floor space of 20.91 sq.m.	Free of cost
				For shops & business Area equivalent to existing area witha maximum of 70 sq.m. out of which 20.91 sq.m.	Free of cost
				Area in excess of 20.91 sq.m.	At cost for the excess area

10. COST ESTIMATES

10.1 CAPITAL COST ESTIMATE

10.1.1 Introduction

Cost estimate for Mumbai Metro Corridor from Colaba to SPEEZ via Bandra has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. at September, 2011 price level.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) route km length of alignment, (ii) number of units of that item and (iii) item being an independent entity. All items related with alignment, construction, permanent way, Power Rails, Signaling & telecommunication, whether in main lines or in maintenance depot, have been estimated at rate per route km/km basis.

Cost of all underground station structures includes lift, escalators, VAC and other electrical services at these stations. The automatic fare collection (AFC) installations at all stations have been assessed in terms of each station as a unit. Similarly, for items like Rolling stock costs have been estimated in terms of number of units required for each item. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed on the basis of each item, taken as an independent entity.

The basis of the rate adopted is for DPRs of DMRC Phase – III projects which was at Jan ’2011 price level. These rates have been enhanced by 10% to arrive at Sept’2011 price level due to the difficult working conditions and also to account for different subsoil conditions of Mumbai.

The element of customs duty, excise duty and VAT has been excluded for working out the base project cost. However, these details are tabulated separately for use in financial appraisal of project. Rates of these central and state taxes and duties have been adopted similar as of assessed in Mahim – Kanjur Marg report.

Base capital project cost at September, 2011 price level works out to be **Rs. 149701 Million** excluding land cost and **Rs. 165566 Million** including land cost. This base cost does not include central taxes and duties, insurance and octroi. Central and state taxes and duties (customs, Excise and VAT) have been worked out to **Rs. 25467 Million** and given in **Table 10.4**. The component towards octroi and insurance has been worked out as **Rs. 2951.50 Million.**The abstract capital cost estimates are shown at **Table 10.1** and **10.2.**

Table 10.1: Abstract of Cost Estimate

S. No.	Item	Amount (Rs. in Millions) Without taxes
1.0	Land	15864.77
2.0	Alignment and Formation	42412.09
3.0	Station Buildings	59472.54
4.0	Aarey Milk Colony Depot	2442.00
5.0	P-Way	2435.52
6.0	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators	4788.76
7.0	Signaling and Telecom.	6148.78
8.0	R & R incl. Hutments etc.	907.83
9.0	Misc. Utilities, road works, other civil works such as median stn. signages Environmental protection and traffic management	2172.44
10	Rolling Stock	17640.00
11.0	Total of all items except Land	138419.95
12.0	General Charges incl. Design charges @ 5 % on all items except land	6921.00
13.0	Total of all items including G. Charges	145340.95
14.0	Contingencies @ 3 % on all items except land	4360.23
15.0	Gross Total	149701.18
Gross Total including Contingencies (excluding Land Cost)		149701
Gross Total including Contingencies (including Land Cost)		165566

Table 10.2: Capital Cost Estimate

Colaba – Bandra - SPEEZ
Total length =34.000 km UG
Total Station = 27 No.s Station by NATM Method = 11 No.s, By Cut & Cover method = 16 No.s,

Sep 2011, Price Level

S. No.	Item	Unit	Rate (Rs. in Millions)	Qty.	Amount (Rs. in Millions)
				Without taxes	
1.0	**Land**				
a	**Pvt. Land**				4637.23
b	**Govt. Land**				10562.86
c	**Contingencies @ 3 % on (a and b)**				456.00
d	**Stamp Duty payable on the lease of Pvt. land 5% of 90% of its Value**	4637.23	Millions		208.68
	Sub Total (1)				**15864.77**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (300m each)	R. Km.	1587.41	24.828	39412.22
2.2	Underground section by cut & cover for X-overs	R. Km.	1112.76	1.072	1192.88
2.3	Tunnel Ventilation and air conditioning	R. Km.	8.50	34.000	289.00
2.7	Additional charges for crossing the Rly Tracks	LS	200.00	1.000	200.00
2.8	Crossing of Mithi River	Each	200.00	1.000	200.00
2.9	Provision for construction of under pass and subways	LS			800.00
2.10	Construction of flyover at Aarey Milk Colony due	LS			300.00

S. No.	Item	Unit	Rate (Rs. in Millions)	Qty.	Amount (Rs. in Millions)
				Without taxes	
	to entry to Depot				
2.10	For providing entry to Depot				
	a) At grade portion	R. Km.	60.00	0.300	18.00
	Sub Total (2)				**42412.09**
3.0	**Station Buildings**				
3.1	**Underground Station(300 m length) incl. EM works, lifts, escalators, VAC etc. by Cut & Cover**				
a	Underground Station- Civil works	Each	1328.25	16.000	21252.00
b	Underground Station- EM works etc.	Each	566.83	16.000	9069.28
3.2	**Underground Station(300 m length) incl. EM works, lifts, escalators, VAC etc. by NATM**				
a	Underground Station- Civil works	Each	1992.38	11.000	21916.13
b	Underground Station- EM works etc.	Each	566.83	11.000	6235.13
3.3	**Metro Bhawan & OCC bldg.**				
a	Metro Bhawan & OCC bldg.-civil works	LS			800.00
b	Metro Bhawan & OCC bldg.-EM works etc	LS			200.00
	Sub Total (3)				**59472.54**
4.0	**Maintenance Depot**				
a	Civil works for depot	LS			1691.50
b	EM works etc for depot	LS			750.50
	Sub Total (4)				**2442.00**
5.0	**P-Way**				
5.1	Ballastless track for underground Section	R. Km.	71.28	34.000	2423.52
5.3	Ballastless track for entry to Depot	R. Km.	40.00	0.300	12.00
	Sub Total (5)				**2435.52**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	UG Section	R. Km.	140.14	34.000	4764.76
6.2	For entry to Depot at grade	R. Km.	80.00	0.300	24.00
	Sub Total (6)				**4788.76**
7.0	**Signaling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	154.99	34.000	5269.66
7.2	Automatic fare collection	Per station	32.56	27.000	879.12
	Sub Total (7)				**6148.78**
8.0	**R & R incl. Hutments etc.**				
a	Environmental Cost	LS			106.80
b	Social Cost	LS			718.50
c	Misc. items @ 10% of (a & b)				82.53
	Sub Total (8)				**907.83**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection, and traffic management**				
a	Civil works + EM works	R. Km.	34.65	25.900	897.44
b	Traffic improvement, management & infrastructures	LS			1005.00
c	Cost towards security arrangements at stations	Per station	10.00	27.000	270.00
	Sub Total (9)				**2172.44**
10.0	**Rolling Stock**	Each	84.00	210.000	17640.00
	Sub Total (10)				**17640.00**
11.0	**Total of all items except Land**				**138419.95**
12.0	**General Charges incl. Design charges @ 5 % on**				**6921.00**

S. No.	Item	Unit	Rate (Rs. in Millions)	Qty.	Amount (Rs. in Millions)
				Without taxes	
	all items except land				
13.0	**Total of all items including G. Charges**				**145340.95**
14.0	**Contingencies @ 3 % on all items except land**				**4360.23**
15.0	**Gross Total**				**149701.18**
	Gross Total including Contingencies (excluding Land Cost)			=	**149701**
	Gross Total including Contingencies (with Land Cost)			=	**165566**
16.0	**Octroi**				
a	Octroi on OHE @ 5.5% of	4788.76	Millions		263.38
b	Octroi on Sig. & Tele. & AFC @ 5.5% of	6148.78	Millions		338.18
c	Octroi on Rolling stock @5.5% of	17640.00	Millions		970.20
d	Octroi on other materials @ 0.5% of balance project cost of	109842.41	Millions		549.21
	Sub Total (16)				**2120.98**
17.0	**Insurance 0.6% of Capital cost of**	138419.95	Millions		**830.52**
	Gross total with octroi and insurance			=	**168517.45**
				Say	**168517**

10.1.2 Civil Engineering Works

i. Land Requirements

Acquisition of land in Mumbai Suburban area is not only difficult but impractical. Therefore, land requirements have been kept to the barest minimum and worked out on area basis.

a) For underground alignment, practically no land is proposed to be acquired permanently, except areas for locating entry/exit structures, traffic integration, Chiller Plant, TSS and RSS etc.

b) Total permanent land requirement has been worked out to be 31.72 Ha including land for Depot.
- Govt. Land = 1.89 Ha
- Private Land = 3.43 Ha
- Depot Land = 26.40 Ha (Govt. land Aarey Milk Colony)

c)Cost of private land has been worked out area wise, based on prevailing rates for Commercial/Residential properties as per Ready Reckoner published by Architects Publishing Corp. of India Mumbai (2011 edition). Over & above these rates, provision for 30% solatium & 12% interest has been made.

d) For Govt/Municipal land, rates adopted are as per Ready Reckoner published by Architects Publishing Corp. of India Mumbai (2011 edition). In case, the government land is made available on Govt. rates/free transfer basis, the cost would get reduced to that extant.

e) In addition to land required permanently, 14.09 Ha land will be required temporarily for cut & cover of construction of stations, and temporary construction depots. For temporary land, ground rent of 3 years @ 6% per year as the cost of the land has been provided for.

f) The additional cost of temporary land requirement during construction of station by NATM is covered in the construction cost of NATM station.

g) Land acquisition in Airport area has not been proposed as it will be made available by MIAL free of cost for providing the underground station utilities.

Table 10.5 to **10.11** gives the details of land requirements for the proposed corridor. The total cost of Land works out to be **Rs. 15864.77 Millions** with contingencies and stamp duty on private land**.**

ii. Formation & Alignment

Underground construction

a) The underground section is proposed by T.B.M and NATM/ Cut and Cover method as per actual methodology to be decided at detailed design stage. The rates adopted are based on the rates adopted by DMRC for their DPR phase – III projects.

b) The cost of Tunneling and other underground construction includes cost of initial building survey, monitoring and also repairs, if required. This work is to be carried out after award of work by respective contractors.

c) Emergency cross-overs at Bandra Metro (Mid Terminal) and alignment in Mumbai University, Kalina are proposed by cut and cover method and the rates adopted are also based on DMRC phase – III projects. These rates cover all works of Civil Engineering including utility diversions, etc; but exclude cost of Permanent way, as well as electrical works, which are covered under separate items.

iii. Station Buildings

Underground stations

a) Civil works covers the cost of 300 m alignment length for each station and all other civil works, utility diversions, protection arrangements, etc., but excludes cost of Permanent way. Rate for stations by cut & cover method are based on DMRC rates for their project estimates. As rates of stations by NATM are not readily available thus these rates have been enchased by 50% due to difficult site conditions, adoption of more sophisticated construction and monitoring equipment/machinery and also to provide for additional time period required for construction of station by NATM methodology..

b) Separate provision has been made towards cost of all E & M works, including lifts, escalators V.A.C., etc. but excludes O.H.E. These are based on DMRC project estimates.

iv. Permanent Way

For underground sections, ballastless track has been proposed. For ballastless track, the rates adopted are also based on DMRC phase – III projects.

v. Depot at Aarey Milk Colony

For the Project, a depot is proposed in Aarey Milk Colony, where about 26.40 ha. land would be acquired. The land presently is vacant. Market valuation of this land has been done and included in the cost estimates. In case, the land for depot is made available on Govt. rates/free transfer basis, the cost would get reduced to that extant.

Cost has been worked out based on the rates of various DPR projects of Delhi Metro. The detailed analysis for working out the cost of Depot is given **Table 10.3**.

Table 10.3: Detailed Cost Estimate for Aarey Milk Colony Depot

S. NO.	DESCRIPTION	QTY	RATE (in Rs. Millions)	Amount (in Rs. Millions)	REMARKS
A)	**Civil works**				
1	EARTHWORK (in cum) (Avg filling height 2.00m)	520000	0.00025	130.00	Rs. 250 per cum
2	Drainage & Minor Bridges	LS		50.00	
3	Roads, Pavements etc. (in km)	2.5	20	50.00	
4	Boundary Wall (in km)	2.1	11.5	24.15	
5	SHEDS (in sqm) - For area, refer Annexure – II of Chapter – 7 (Maintenance depot)	30600	0.015	459.00	Rs. 15000 per sqm
6	BUILDINGS (In sqm) - For area, refer Annexure – II of Chapter – 7 (Maintenance depot)	17107	0.0255	436.23	Rs. 25500 per sqm
7	Track including OHE (in Km)	13.8	22.6	311.88	
8	Provisions of Points & Crossings	44	0.97	42.68	
9	General electric works			77.48	5% over shed & 12.50% over civil work for buildings = 3.8+4.9=8.70
10	Residential Quarters	20 units + common hall	30 lakhs per unit	60.00	
11	Misc items like water supply arrangement, sanitary, fire fighting etc			50.00	
	Sub-total of Civil work & general electrical work (1 to 11)			**1691.42**	

B) Machinery & Plant

S. No.	Equipment	Qty	Unit	Unit Rate (In Millions)	Amount (in Millions)
1	Travelling O/H EOT crane for Workshop 25/5 T	2	Nos.	20.00	40.00
2	Travelling O/H EOT crane for Inspection bay 1.5T	2	Nos.	6.00	12.00
3	Travelling O/H EOT crane for ETU shed 5 T	1	Nos.	7.50	7.50
4	Synchronized pit jacks system for car lifting	2	Nos.	50.00	100.00
5	Battery powered Locomotive	2	Nos.	35.00	70.00
6	OHE Inspection car	2	Nos.	35.00	70.00
7	Other Material Handling Equipments (Mobile crane, Trucks, Fork lift trucks, Hyd. Trolleys etc.)			20.00	20.00
8	Machines for wheel shop - 500T wheel press, Vertical boring m/c (Turret Lathe), Multipurpose Wheel Lathe/surface Wheel Lathe, Axle turning lathe/Axle journal turning and burnishing lathe, Axle UST inspection machine etc.)			50.00	50.00
9	Bogie static load testing m/c, Bogie wash/cleaning plant, Other Testing Machines for bogie etc			50.00	50.00
10	Baking oven, Dynamic balancing m/c, TM test console etc			20.00	20.00
11	Under floor Pit wheel lathe with Chip crusher and conveyor	1	Nos.	75.00	75.00
12	Automatic Washing plant for Metro cars.	1	Nos.	30.00	30.00
13	Turn table for one car	1	Nos.	10.00	10.00
14	Turntable for bogies	4	Nos.	1.50	6.00
15	Driving cab simulator	1	Nos.	35.00	35.00
16	Painting booth for separate parts	1	Nos.	20.00	20.00
17	Compressor 500 CFM for shop air supply	1	Nos.	5.00	5.00
18	DG set 320 KVA	3	Nos.	5.00	15.00
19	Machines for machine shop - Lathe, Grinders, Drill m/cs etc.			20.00	20.00
20	Special jigs & Fixtures, Test Benches (Inverter, Brake, Speedometer, Door, RMPU, MCB etc.)			20.00	20.00
21	Vertical carousel storage system	1	Set	15.00	15.00
22	Computer MMIS for the Depot	1	L.S.	15.00	15.00
23	Storage Racks, Industrial furniture, Work benches etc.			10.00	10.00
24	Elec. & Pneu. Tools, Measuring and testing equipment (including Oscilloscope, Tan Delta etc), Tool kits etc.			5.00	5.00
25	Other misc. M&P			30.00	30.00
	TOTAL COST OF M & P				**750.50**

10.1.3 Utility Diversions

Main Sewers / Water pipe lines are generally running across/along the existing Corridor. These are, therefore, need to be diverted on actual need basis.

In the underground section, work is proposed by T.B.M, to avoid interference/damage to sewer/water lines. However, in the station lengths, these will need protection/support during construction, provision for the same have been covered in station costs.

Along the existing Corridor, electrical/signal cables may need diversion/provision of new cables. To avoid interruption to the existing system new cables will have to be laid. Provision for the same has been made. Other important utility works required include road diversion/traffic diversions.

Provision for all other utility works has been made on route km basis, based on experience of Delhi Metro.

10.1.4 Environmental Impact Assessment

Provision for environmental impacts of this Metro corridor has been made to cover various protection works, additional compensatory measures, compensation for loss of trees, compensatory a forestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division.

10.1.5 Rehabilitation & Resettlement

Private Structures- Provision towards compensation/rehabilitation of these on private land, likely to be affected has been assessed after site inspection. Sufficient provision is kept in the estimate to cover the cost of shifting of hutments and other structures.

10.1.6 Traction & Power Supply

Provisions have been made to cover following subheads:

- OHE (Flexible).
- Receiving-cum-Traction Sub-stations including cables.
- ASS for underground stations.
- Service connection charges for Receiving Sub-stations.
- SCADA augmentation.
- Catenary's maintenance vehicle.
- Miscellaneous items e.g. illumination, lifting T&P, etc.

For underground section, rates are based on rates of DMRC projects.

10.1.7 Electrical Services at Stations

These are included in estimated costs of stations on underground alignment section. Cost for underground stations cover all electrical works like V.A.C escalators and lifts etc., but does not include O.H.E.

10.1.8 Signaling & Telecommunication Works

The rates adopted are based on Delhi Metro. The detailed calculations for working out the rates are given in chapter 3.

10.1.9 Automatic Fare Collection

The rates adopted are based on Delhi Metro. The detailed calculations for working out the rates are given in chapter 3.

10.1.10 Rolling Stock

These rates are also based on DPR for Delhi Metro phase – III projects.

10.1.11 Taxes and Duties

Estimate for taxes and duties for the corridor is given in **Table 10.4**. It is estimated that the taxes and duties for full corridor will amount to Rs **25467 Millions.**

Table 10.4: Details of Taxes and Duties

S. No.	Description	Total cost without Taxes & duties (in Millions)	Taxes and duties			Total taxes & duties (in Millions)
			custom duty (in Millions)	excise duty (in Millions)	VAT (in Millions)	
1	**Alignment & Formation**					
	Underground	41005.09	2357.79	3444.43	1435.18	**7237.40**
	Underground -EM	289.00	0.00	34.39	22.54	**56.93**
	Entry to Depot & flyovers	1118.00	0.00	80.50	107.90	**188.39**
2	**Station Buildings**					
	a) Underground station-civil works	43168.13	2482.17	3172.86	1510.88	**7165.91**
	b) Underground station-EM works	15304.41	1760.01	910.61	596.87	**3267.49**
	c) Metro Bhawan & OCC bldg-civil works	800.00	0.00	57.60	77.20	**134.80**
	d) Metro Bhawan & OCC bldg-EM works	200.00	8.40	14.40	19.30	**42.10**
3	**Depot**					
	Civil works	1691.50	106.56	88.80	118.41	**313.77**
	EM works	750.50	31.52	54.04	57.41	**142.97**
4	**P-Way**	2435.52	407.95	48.71	66.98	**523.64**
5	**Traction & power supply**					
	a) Traction and power supply	4788.76	402.26	251.41	335.21	**988.88**
6	**S & T Works**					
	a) S & T	5269.66	882.67	105.39	145.00	**1133.06**
	b) AFC	879.12	137.99	21.98	30.77	**190.74**
7	**R & R hutments**	907.83	0.00	0.00	113.48	**113.48**
8	**Misc.**					
	Civil works	1629.33	0.00	117.31	157.23	**274.54**
	EM works	543.11	0.00	47.25	63.82	**111.07**
9	**Rolling Stock**	17640.00	3263.40	141.86	176.40	**3581.66**
	Total	**138419.95**	**11840.72**	**8591.53**	**5034.57**	**25466.83**
	Total taxes & Duties					**25467**

Table 10.5: Details of Land permanently required for Stations (Colaba – Mahim)

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
1	ST-1A	Cuffe Parade Station	BMC Park	Govt	665		209000	138.99	49, 1/2	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
2	ST-1B	Cuffe Parade Station	BMC Park	Govt	162		209000	33.86	49, 1/2	Ventilation Shaft
3	ST-1C	Cuffe Parade Station	BMC Park	Govt	30		209000	6.27	49, 1/2	Entry/Exit
4	ST-1D	Cuffe Parade Station	BMC Park	Govt	94		209000	19.65	49, 1/2	Entry/Exit & Escalator,
5	ST-1E	Cuffe Parade Station	BMC Park	Govt	162		209000	33.86	49, 1/2	Ventilation Shaft
6	ST-1F	Cuffe Parade Station	BMC Park	Govt	35		209000	7.32	49, 1/2	Entry/Exit & lift etc,
7	ST-1G	Cuffe Parade Station	footpath, BMC	Govt	56		0	0.00		Escalator
8	ST-1H	Cuffe Parade Station	footpath, BMC	Govt	70		0	0.00		Entry/Exit
9	ST-1I	Cuffe Parade Station	footpath, BMC	Govt	70		0	0.00		Entry/Exit & Escalator,
		Cuffe Parade Station	Open	Pvt	24		209000	5.02	49, 1/2	
10	ST-1J	Cuffe Parade Station	footpath, BMC	Govt	24		0	0.00		Entry/Exit & Escalator,
		Cuffe Parade Station	Open	Pvt	70		209000	14.63	49, 1/2	
11	ST-2A	Badhwar Park Station	Open, BMC	Govt	162		164600	26.67	49, 1/2	Ventilation Shaft
12	ST-2B	Badhwar Park Station	Open, BMC	Govt	30		164600	4.94	49, 1/5	Entry/Exit
13	ST-2C	Badhwar Park Station	footpath, BMC	Govt	30		0	0.00	49, 1/5	Entry/Exit
		Badhwar Park Station	Open	RLY	40		164600	6.58	49, 1/5	
14	ST-2D	Badhwar Park Station	footpath, BMC	Govt	45		0	0.00	49, 1/5	Escalator
		Badhwar Park Station	Open	Pvt	11		164600	1.81	49, 1/5	

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
15	ST-2E	Badhwar Park Station	BMC Park	Govt	94		164600	15.47	49, 1/5	Entry/Exit & Escalator,
16	ST-2F	Badhwar Park Station	BMC Park	Govt	665		164600	109.46	49, 1/5	Chillar Plant, Water Tank, Fuel Tank& DG Set etc
17	ST-2G	Badhwar Park Station	BMC Park	Govt	30		164600	4.94	49, 1/5	Entry/Exit
18	ST-2H	Badhwar Park Station	Open, BMC	Govt	56		164600	9.22	49, 1/5	Escalator
19	ST-2I	Badhwar Park Station	footpath, BMC	Govt	70		0	0.00	49, 1/5	Entry/Exit
20	ST-2J	Badhwar Park Station	BMC Park	Govt	162		164600	26.67	49, 1/5	Ventilation Shaft
21	ST-3A	Vidhan Bhawan Station	Bhimalaya Party office	Govt	162	10 S/S Tiled	134200	21.74	52, 2/7	Ventilation Shaft
22	ST-3B	Vidhan Bhawan Station	footpath, BMC	Govt	20		0	0.00	52, 2/7	Entry/Exit & Escalator.
		Vidhan Bhawan Station	Treasury office	Govt	74	36 sqm Tiled Bldg	371600	27.50	52, 2/7	
23	ST-3C	Vidhan Bhawan Station	Treasury office	Govt	665	S/S Tiled	371600	247.11	52, 2/7	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
24	ST-3D	Vidhan Bhawan Station	Treasury office compound	Govt	30		134200	4.03	52, 2/7	Entry/Exit
25	ST-3E	Vidhan Bhawan Station	footpath, BMC	Govt	30		0	0.00	52, 2/7	Entry/Exit & Escalator
		Vidhan Bhawan Station	Pvt Open	Pvt	64		134200	8.59	52, 2/7	
26	ST-3F	Vidhan Bhawan Station	footpath, BMC	Govt	94		0	0.00	52, 2/7	Entry/Exit & Escalator
27	ST-3G	Vidhan Bhawan Station	footpath, BMC	Govt	70		0	0.00	52, 2/7	Entry/Exit
28	ST-3H	Vidhan Bhawan Station	Open, BMC	Govt	162		134200	21.74	52, 2/7	Ventilation Shaft
29	ST-4A	Churchgate Metro Station	footpath, BMC	Govt	162		0	0.00	54, 2/29	Ventilation Shaft
30	ST-4B	Churchgate Metro Station	footpath, BMC	Govt	70		0	0.00	54, 2/29	Entry/Exit
31	ST-4C	Churchgate Metro Station	footpath, BMC	Govt	30		0	0.00	54, 2/29	Entry/Exit & Escalator.
		Churchgate Metro Station	open	Pvt	64		136100	8.71	54, 2/29	
32	ST-4D	Churchgate Metro Station	footpath, BMC	Govt	30		0	0.00	54, 2/29	Entry/Exit
33	ST-4E	Churchgate Metro Station	footpath, BMC	Govt	56		0	0.00	54, 2/29	Escalator
34	ST-4F	Churchgate Metro Station	footpath, BMC	Govt	40		0	0.00	54, 2/29	Entry/Exit &

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
		Churchgate Metro Station	open	Pvt	54		136100	7.35	54, 2/29	Escalator
35	ST-4G	Churchgate Metro Station	Perol Pump, BMC	Govt	162	S/S Garage & Shed	452700	73.34	54, 2/29	Ventilation Shaft
36	ST-4H	Churchgate Metro Station	Perol Pump, BMC	Govt	94		136100	12.79	54, 2/29	Entry/Exit & Escalator
37	ST-4I	Churchgate Metro Station	footpath, BMC	Govt	35		0	0.00	54, 2/29	Entry/Exit & lift etc,
38	ST-4J	Churchgate Metro Station	open, Play ground	Pvt	665		136100	90.51	54, 2/29	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
39	ST-5A	Hutatma Chowk Station	footpath, BMC	Govt	30		0	0.00	52, 2/14	Entry/Exit
40	ST-5B	Hutatma Chowk Station	BMC Park	Govt	665		93500	62.18	52, 2/14	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
41	ST-5C	Hutatma Chowk Station	BMC Park	Govt	162		93500	15.15	52, 2/14	Ventilation Shaft
42	ST-5D	Hutatma Chowk Station	footpath, BMC	Govt	56		0	0.00	52, 2/14	Escalator
43	ST-5E	Hutatma Chowk Station	footpath, BMC	Govt	35		0	0.00	52, 2/14	Entry/Exit
44	ST-5F	Hutatma Chowk Station	open Pvt	Pvt	35		93500	3.27	52, 2/14	Entry/Exit
45	ST-5G	Hutatma Chowk Station	footpath, BMC	Govt	56		0	0.00	52, 2/14	Escalator
46	ST-5H	Hutatma Chowk Station	open Pvt	Pvt	80		93500	7.48	52, 2/14	Entry/Exit & Escalator
		Hutatma Chowk Station	footpath, BMC	Govt	14		0	0.00	52, 2/14	
47	ST-5I	Hutatma Chowk Station	open Pvt	Pvt	70		93500	6.55	52, 2/14	Entry/Exit
48	ST-5J	Hutatma Chowk Station	footpath, BMC	Govt	10		0	0.00	52, 2/14	Entry/Exit & lift etc,
		Hutatma Chowk Station	Builtup	Pvt	25	G+0, Bldg.	172800	4.32	52, 2/14	
49	ST-5K	Hutatma Chowk Station	open Pvt	Pvt	30		93500	2.81	52, 2/14	Entry/Exit
		Hutatma Chowk Station	footpath, BMC	Govt	40		0	0.00	52, 2/14	
50	ST-5L	Hutatma Chowk Station	open Pvt	Pvt	56		93500	5.24	52, 2/14	Escalator
51	ST-6A	CST Metro Station	Footpath Green	Govt	162		0	0.00	54, 2/27	Ventilation Shaft
52	ST-6B	CST Metro Station	footpath, BMC	Govt	30		0	0.00	54, 2/27	Entry/Exit
53	ST-6C	CST Metro Station	Open BMC	Govt	94		106700	10.03	54, 2/27	Entry/Exit & Escalator

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54	ST-6D	CST Metro Station	Open BMC	Govt	665		106700	70.96	54, 2/27	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
55	ST-6E	CST Metro Station	Open BMC	Govt	94		106700	10.03	54, 2/27	Entry/Exit & Escalator
56	ST-6F	CST Metro Station	footpath, BMC	Govt	30		0	0.00	54, 2/27	Entry/Exit & Escalator
57	ST-6G	CST Metro Station	Open BMC	Govt	64		106700	6.83	54, 2/27	Entry/Exit & Escalator
58	ST-6H	CST Metro Station	footpath, BMC	Govt	94		0	0.00	54, 2/27	Entry/Exit & Escalator
59	ST-6I	CST Metro Station	footpath, BMC	Govt	35		0	0.00	54, 2/27	Entry/Exit & lift etc,
60	ST-7A	Kalbadevi Station	Builtup, Parsi Temple	Pvt Comm	665	G+0 Tiled Bldg 215 sqm	128600	85.52	61, 5/44	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
61	ST-7B	Kalbadevi Station	Builtup	Pvt Comm	120	G+5 Bldg	771600	92.59	61, 5/44	Ventilation Shaft
		Kalbadevi Station	footpath, BMC	Govt	42		0	0.00	61, 5/44	
62	ST-7C	Kalbadevi Station	footpath, BMC	Govt	10		0	0.00	61, 5/44	Entry / Exit
		Kalbadevi Station	Builtup, Parsi Temple	Pvt Comm	20	G+0 Bldg	128600	2.57	61, 5/44	
63	ST-7D	Kalbadevi Station	Builtup	Pvt Comm	94	G+3, Bldg	514400	48.35	61, 5/44	Entry/Exit & Escalator
64	ST-7E	Kalbadevi Station	Builtup	Pvt Comm	94	G+0, Bldg	128600	12.09	61, 5/44	Entry/Exit & Escalator
65	ST-7F	Kalbadevi Station	Builtup	Pvt Comm	94	G+1, Bldg	257200	24.18	61, 5/44	Entry/Exit & Escalator
66	ST-7G	Kalbadevi Station	Builtup	Pvt Comm	94	G+2, Bldg	385800	36.27	61, 5/44	Entry/Exit & Escalator
67	ST-7H	Kalbadevi Station	Builtup	Pvt Comm	35	G+3, Bldg	514400	18.00	61, 5/44	Entry/Exit & lift etc,
68	ST-7I	Kalbadevi Station	Builtup	Pvt Comm	80	G+2, Bldg	385800	30.86	61, 5/44	Ventilation Shaft
		Kalbadevi Station	Builtup	Pvt Comm	82	G+4, Bldg	643000	52.73	61, 5/44	

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69	ST-8A	Girgaon Station	Builtup	Pvt Comm	82	G+4, Bldg	648500	53.18	63, 6/54	Ventilation Shaft
		Girgaon Station	Builtup	Pvt Comm	80	G+0, Bldg	129700	10.38	63, 6/54	
70	ST-8B	Girgaon Station	Builtup	Pvt Comm	35	G+0, Bldg	129700	4.54	63, 6/54	Entry/Exit & lift etc,
71	ST-8C	Girgaon Station	Builtup	Pvt Comm	94	G+4, Bldg	648500	60.96	63, 6/54	Entry/Exit & Escalator
72	ST-8D	Girgaon Station	Builtup	Pvt Comm	70	G+0, Bldg	129700	9.08	63, 6/54	Entry/Exit
73	ST-8E	Girgaon Station	Builtup	Pvt Comm	56	G+0, Bldg	129700	7.26	63, 6/54	Escalator
74	ST-8F	Girgaon Station	Builtup	Pvt Comm	94	G+4, Bldg	648500	60.96	63, 6/54	Entry/Exit & Escalator
75	ST-8G	Girgaon Station	Builtup	Pvt Comm	94	35 sqm G+6, Bldg	7129700	670.19	63, 6/54	Entry/Exit & Escalator
76	ST-8H	Girgaon Station	footpath, BMC	Govt	20		0	0.00	63, 6/54	Entry/Exit & lift etc,
		Girgaon Station	Builtup	Pvt Comm	15	G+2 Bldg	389100	5.84	63, 6/54	
77	ST-8I	Girgaon Station	Builtup	Pvt Comm	162	G+2 Bldg	389100	63.03	63, 6/54	Ventilation Shaft
78	ST-8J	Girgaon Station	Builtup	Pvt.	665	G+0 Bldg	128600	85.52	63, 6/55	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
79	ST-9A	Grant Road Metro Station	footpath, BMC	Govt	56	Temp shops	5000	0.28	71, 8/68A	Escalator
80	ST-9B	Grant Road Metro Station	footpath, BMC	Govt	70		0	0.00	71, 8/68A	Entry/Exit
81	ST-9C	Grant Road Metro Station	footpath, BMC	Govt	35		0	0.00	71, 8/68A	Entry / Exit , Lift
82	ST-9D	Grant Road Metro Station	footpath, BMC	Govt	47		0	0.00	71, 8/68A	Entry/Exit & Escalator
		Grant Road Metro Station	Open BMC	Govt	47		65500	3.08	71, 8/68A	
83	ST-9E	Grant Road Metro Station	Open BMC	Govt	162		65500	10.61	71, 8/68A	Ventilation Shaft
84	ST-9F	Grant Road Metro Station	Open BMC	Govt	665		65500	43.56	71, 8/68A	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
85	ST-9G	Grant Road Metro Station	Open	Pvt	94		65500	6.16	71, 8/68A	Entry/Exit & Escalator
86	ST-9H	Grant Road Metro Station	footpath, BMC	Govt	20		0	0.00	71, 8/68A	Entry/Exit
		Grant Road Metro Station	builtup	Pvt	50		363000	18.15	71, 8/68A	
87	ST-9I	Grant Road Metro Station	footpath, BMC	Govt	28		0	0.00	73, 8/70A	Escalator

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
		Grant Road Metro Station	footpath, BMC	Govt	28		0	0.00	73, 8/70A	
88	ST-9J	Grant Road Metro Station	footpath, BMC	Govt	10		0	0.00	73, 8/70A	Entry / Exit , Lift
		Grant Road Metro Station	builtup	Pvt	25		181500	4.54	73, 8/70A	
89	ST-9K	Grant Road Metro Station	builtup	Pvt	162		181500	29.40	73, 8/70A	Ventilation Shaft
90	ST-10A	Mumbai Central Metro Station	Open	Rly	94		96500	9.07	73, 8/70A	Entry/Exit & Escalator
91	ST-10B	Mumbai Central Metro Station	Open	Rly	162		96900	15.70	73, 8/70A	Ventilation Shaft
92	ST-10C	Mumbai Central Metro Station	Open	Rly	665		96900	64.44	73, 8/70A	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
93	ST-10D	Mumbai Central Metro Station	footpath, BMC	Govt	35		0	0.00	73, 8/70A	Entry / Exit , Lift
94	ST-10E	Mumbai Central Metro Station	footpath, BMC	Govt	94		0	0.00	73, 8/70A	Entry/Exit & Escalator
95	ST-10F	Mumbai Central Metro Station	footpath, BMC	Govt	94		0	0.00	73, 8/70A	Entry/Exit & Escalator
96	ST-10G	Mumbai Central Metro Station	footpath, BMC	Govt	35		0	0.00	73, 8/70A	Entry / Exit , Lift
97	ST-10H	Mumbai Central Metro Station	footpath, BMC	Govt	30		0	0.00	73, 8/70A	Entry/Exit & Escalator
		Mumbai Central Metro Station	Open , BMC	Govt	64		96900	6.20	73, 8/70A	
98	ST-10I	Mumbai Central Metro Station	Open , BMC	Govt	162		96900	15.70	73, 8/70A	Entry/Exit & Escalator
99	ST-11A	Mahalaxmi Metro Station	Green footpath, BMC	Govt	485		0	0.00	74, 9/74A	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
		Mahalaxmi Metro Station	open	Pvt	180		69000	12.42	74, 9/74A	

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
100	ST-11B	Mahalaxmi Metro Station	Green footpath, BMC	Govt	92		0	0.00	74, 9/74A	Ventilation Shaft
101	ST-11C	Mahalaxmi Metro Station	open	Pvt	70		69000	4.83	74, 9/74A	Ventilation Shaft
102	ST-11D	Mahalaxmi Metro Station	open	Pvt	84		69000	5.80	74, 9/74A	Entry/Exit & Escalator
		Mahalaxmi Metro Station	footpath, BMC	Govt	10		0	0.00	74, 9/74A	
103	ST-11E	Mahalaxmi Metro Station	open	Pvt	35		69000	2.42	74, 9/74A	Entry / Exit , Lift
104	ST-11F	Mahalaxmi Metro Station	open	Pvt	94		69000	6.49	74, 9/74A	Entry/Exit & Escalator
105	ST-11G	Mahalaxmi Metro Station	footpath, BMC	Govt	40		0	0.00	74, 9/74A	Entry/Exit & Escalator
		Mahalaxmi Metro Station	open	Pvt	54		69000	3.73	74, 9/74A	
106	ST-11H	Mahalaxmi Metro Station	Open , BMC	Govt	35		69000	2.42	74, 9/74A	Entry / Exit , Lift
107	ST-11I	Mahalaxmi Metro Station	footpath, BMC	Govt	56		0	0.00	74, 9/74A	Escalator
108	ST-11J	Mahalaxmi Metro Station	footpath, BMC	Govt	70		0	0.00	74, 9/74A	Entry Exit
109	ST-11K	Mahalaxmi Metro Station	Park , BMC	Govt	162		69000	11.18	74, 9/74A	Ventilation Shaft
110	ST-12A	Science Museum Station	footpath, BMC	Govt	50		0	0.00	85, 12/92	Ventilation Shaft
		Science Museum Station	open	Pvt	112		74600	8.36	85, 12/92	
111	ST-12B	Science Museum Station	footpath, BMC	Govt	25		0	0.00	85, 12/92	Entry / Exit , Lift
		Science Museum Station	open	Pvt	10		74600	0.75	85, 12/92	
112	ST-12C	Science Museum Station	footpath, BMC	Govt	40		0	0.00	85, 12/92	Entry/Exit & Escalator
		Science Museum Station	open, Race Cource	Govt	54		74600	4.03	85, 12/92	
113	ST-12D	Science Museum Station	footpath, BMC	Govt	40		0	0.00	85, 12/92	Entry/Exit & Escalator
		Science Museum Station	open	Pvt	54		74600	4.03	85, 12/92	
114	ST-12E	Science Museum Station	footpath, BMC	Govt	30		0	0.00	85, 12/92	Entry/Exit & Escalator
		Science Museum Station	open, Race Cource	Govt	64		74600	4.77	85, 12/92	
115	ST-12F	Science Museum Station	open	Pvt	665		74600	49.61	85, 12/92	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
116	ST-12G	Science Museum Station	footpath, BMC	Govt	35		0	0.00	85, 12/92	Entry / Exit , Lift
117	ST-12H	Science Museum Station	footpath, BMC	Govt	40		0	0.00	85, 12/92	Entry/Exit & Escalator
		Science Museum Station	open	Pvt	54		74600	4.03	85, 12/92	

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
118	ST-12I	Science Museum Station	footpath, BMC	Govt	30		0	0.00	85, 12/92	Ventilation Shaft
		Science Museum Station	open	Pvt	132		74600	9.85	85, 12/92	
119	ST-13A	Acharya Atrey Chowk Station	Built up	Pvt	665	G+0 Bldg and shed	150400	100.02	84, 12/91B	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
120	ST-13B	Acharya Atrey Chowk Station	Open	Govt	162		81400	13.19	84, 12/91B	Ventilation Shaft
121	ST-13C	Acharya Atrey Chowk Station	Footpath BMC	Govt	35		0	0.00	84, 12/91B	Entry/Exit & lift etc,
122	ST-13D	Acharya Atrey Chowk Station	Built up	Pvt	94	G+0 Bldg	225600	21.21	84, 12/91B	Entry/Exit & Escalator,
123	ST-13E	Acharya Atrey Chowk Station	Petro Pump	Govt	162		225600	36.55	84, 12/91B	Ventilation Shaft
124	ST-13F	Acharya Atrey Chowk Station	Petro Pump	Govt	35		225600	7.90	84, 12/91B	Entry/Exit & lift etc,
125	ST-13G	Acharya Atrey Chowk Station	Petro Pump	Govt	94		225600	21.21	84, 12/91B	Entry/Exit & Escalator,
126	ST-13H	Acharya Atrey Chowk Station	Built up	Pvt	94	G+1 Bldg	451200	42.41	84, 12/91B	Entry/Exit & Escalator,
127	ST-13I	Acharya Atrey Chowk Station	Temp builtup	BMC	94		150400	14.14	84, 12/91B	Entry/Exit & Escalator,
128	ST-14A	Worli Station	Open Institute	Govt	665		110900	73.75	83, 12/88	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
129	ST-14B	Worli Station	Open Institute	Govt	162		110900	17.97	83, 12/88	Ventilation Shaft
130	ST-14C	Worli Station	Open	Pvt	35		110900	3.88	83, 12/88	Entry/Exit & lift etc,
131	ST-14D	Worli Station	Open	Pvt	70		110900	7.76	83, 12/88	Entry/Exit
132	ST-14E	Worli Station	Open	Pvt	162		110900	17.97	83, 12/88	Ventilation Shaft
133	ST-14F	Worli Station	Open	Pvt	35		110900	3.88	83, 12/88	Entry/Exit & lift etc,
134	ST-14G	Worli Station	Open	Pvt	56		110900	6.21	83, 12/88	Escalator

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135	ST-14H	Worli Station	Open	Pvt	94		110900	10.42	83, 12/88	Entry/Exit & Escalator,
136	ST-14I	Worli Station	Open	Pvt	94		110900	10.42	83, 12/88	Entry/Exit & Escalator,
137	ST-14J	Worli Station	Open	Pvt	94		110900	10.42	83, 12/88	Entry/Exit & Escalator,
138	ST-15A	Siddhi Vinayak Station	Open Playground	Govt	665		151500	100.75	83, 12/88	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
139	ST-15B	Siddhi Vinayak Station	Open Playground	Govt	162		151500	24.54	83, 12/88	Ventilation Shaft
140	ST-15C	Siddhi Vinayak Station	Open Playground	Govt	35		151500	5.30	83, 12/88	Entry/Exit & lift etc,
141	ST-15D	Siddhi Vinayak Station	Open Playground	Govt	94		151500	14.24	83, 12/88	Entry/Exit & Escalator,
142	ST-15E	Siddhi Vinayak Station	Open Playground	Govt	162		151500	24.54	83, 12/88	Ventilation Shaft
143	ST-15F	Siddhi Vinayak Station	Open Playground	Govt	35		151500	5.30	83, 12/88	Entry/Exit & lift etc,
144	ST-15G	Siddhi Vinayak Station	Open Playground	Govt	94		151500	14.24	83, 12/88	Entry/Exit & Escalator,
145	ST-15H	Siddhi Vinayak Station	Open Playground	Govt	94		151500	14.24	83, 12/88	Entry/Exit & Escalator,
146	ST-15I	Siddhi Vinayak Station	Open Playground	Govt	94		151500	14.24	83, 12/88	Entry/Exit & Escalator,
147	ST-16A	Dadar Metro Station	Open	Pvt	665		84400	56.13	95, 17/111	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
148	ST-16B	Dadar Metro Station	Open	Pvt	162		84400	13.67	95, 17/111	Ventilation Shaft
149	ST-16C	Dadar Metro Station	BMC footpath	Govt	35		0	0.00	95, 17/111	Entry/Exit & lift etc,
150	ST-16D	Dadar Metro Station	BMC footpath	Govt	94		0	0.00	95, 17/111	Entry/Exit & Escalator,

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of storey(ies) of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
151	ST-16E	Dadar Metro Station	Petrol Pump	Govt	162		243400	39.43	95, 17/111	Ventilation Shaft
152	ST-16F	Dadar Metro Station	BMC footpath	Govt	35		0	0.00	95, 17/111	Entry/Exit & lift etc,
153	ST-16G	Dadar Metro Station	BMC footpath	Govt	56		0	0.00	95, 17/111	Escalator
154	ST-16H	Dadar Metro Station	BMC footpath	Govt	56		0	0.00	95, 17/111	Escalator
155	ST-16I	Dadar Metro Station	BMC footpath	Govt	70		0	0.00	95, 17/111	Entry/Exit
156	ST-16J	Dadar Metro Station	BMC footpath	Govt	70		0	0.00	95, 17/111	Entry/Exit
157	ST-16K	Dadar Metro Station	BMC footpath	Govt	94		0	0.00	95, 17/111	Entry/Exit & Escalator,
158	ST-16L	Dadar Metro Station	BMC footpath	Govt	94		0	0.00	95, 17/111	Entry/Exit & Escalator,
159	ST-17A	Shitla Devi temple Station	Petrol Pump	Govt	665		172800	114.91	95, 17/116	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
160	ST-17B	Shitla Devi temple Station	Petrol Pump	Govt	162		172800	27.99	95, 17/116	Ventilation Shaft
161	ST-17C	Shitla Devi temple Station	Petrol Pump	Govt	162		172800	27.99	95, 17/116	Ventilation Shaft
162	ST-17D	Shitla Devi temple Station	Footpath BMC	Govt	56		0	0.00	95, 17/116	Escalator
163	ST-17E	Shitla Devi temple Station	Footpath BMC	Govt	56		0	0.00	95, 17/116	Escalator
164	ST-17F	Shitla Devi temple Station	Footpath BMC	Govt	56		0	0.00	95, 17/116	Escalator
165	ST-17G	Shitla Devi temple Station	Footpath BMC	Govt	56		0	0.00	95, 17/116	Escalator
166	ST-17H	Shitla Devi temple Station	Footpath BMC	Govt	70		0	0.00	95, 17/116	Entry/Exit
167	ST-17I	Shitla Devi temple Station	Footpath BMC	Govt	70		0	0.00	95, 17/116	Entry/Exit
168	ST-17J	Shitla Devi temple Station	Footpath BMC	Govt	70		0	0.00	95, 17/116	Entry/Exit
169	ST-17K	Shitla Devi temple Station	Footpath BMC	Govt	70		0	0.00	95, 17/116	Entry/Exit
				Total land	**24478**		**Total Cost**	**3906.05**		

Cost of Govt. Land	**=**	**1830.78 Millions**
Cost of Pvt. Land	**=**	**2075.31 Millions**
Add 42% Solatium & interest on Pvt. Land	**=**	**871.63 Millions**
Total Cost	**=**	**4777.72 Millions**

Table 10.6: Details of Land permanently required for Stations (Mahim - SEEPZ)

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of story of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
1	ST-18A	Dharavi Station	Temp Builtup	Pvt	665		47900	31.85	99, 122B	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
2	ST-18B	Dharavi Station	Temp Builtup	Pvt	162		47900	7.76	99, 122B	Ventilation Shaft
3	ST-18C	Dharavi Station	Open BMC	Govt	35		23300	0.82	99, 122B	Entry/Exit
4	ST-18D	Dharavi Station	Open BMC	Govt	94		23300	2.19	99, 122B	Entry/Exit & Escalator,
5	ST-18E	Dharavi Station	Open & Drain	Govt	162		23300	3.77	99, 122B	Ventilation Shaft
6	ST-18F	Dharavi Station	Drain	Govt	35		23300	0.82	99, 122B	Entry/Exit & lift etc,
7	ST-18G	Dharavi Station	Open BMC	Govt	94		23300	2.19	99, 122B	Entry/Exit & Escalator,
8	ST-18H	Dharavi Station	Temp Builtup	Pvt	94		23300	2.19	99, 122B	Entry/Exit & Escalator,
9	ST-18I	Dharavi Station	Open	Pvt	94		23300	2.19	99, 122B	Entry/Exit & Escalator,
10	ST-18J	Dharavi Station	Open	Govt	94		23300	2.19	99, 122B	Entry/Exit & Escalator,
11	ST-19A	Bandra Station	Pvt Open	Pvt	665		71200	47.35	111, 29,167	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
12	ST-19B	Bandra Station	Open	Govt	162		71200	11.53	111, 29,167	Ventilation Shaft
13	ST-19C	Bandra Station	Open	Govt	35		71200	2.49	111, 29,167	Entry/Exit
14	ST-19D	Bandra Station	Open	Govt	94		71200	6.69	111, 29,167	Entry/Exit & Escalator,
15	ST-19E	Bandra Station	Open	Govt	162		71200	11.53	111, 29,167	Ventilation Shaft
16	ST-19F	Bandra Station	footpath	Govt	35		0	0.00	111, 29,167	Entry/Exit & lift etc,
17	ST-19G	Bandra Station	Open	Govt	94		71200	6.69	111, 29,167	Entry/Exit & Escalator,
18	ST-19H	Bandra Station	footpath	Govt	94		0	0.00	111, 29,167	Entry/Exit & Escalator,
19	ST-20A	Mumbai University, Kalina Station	Open area of university	Govt	665		89200	59.32	113, 31/173	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
20	ST-20B	Mumbai University, Kalina Station	Open area of university	Govt	162		89200	14.45	113, 31/173	Ventilation Shaft
21	ST-20C	Mumbai University, Kalina Station	Open area of university	Govt	35		89200	3.12	113, 31/173	Entry/Exit
22	ST-20D	Mumbai University, Kalina Station	Open area of university	Govt	94		89200	8.38	113, 31/173	Entry/Exit & Escalator,
23	ST-20E	Mumbai University, Kalina Station	Open area of university	Govt	162		89200	14.45	113, 31/173	Ventilation Shaft
24	ST-20F	Mumbai University, Kalina Station	Open area of university	Govt	35		89200	3.12	113, 31/173	Entry/Exit & lift etc,

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of story of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
25	ST-20G	Mumbai University, Kalina Station	Open area of university	Govt	94		89200	8.38	113, 31/173	Entry/Exit & Escalator,
26	ST-20H	Mumbai University, Kalina Station	Open area of university	Govt	94		89200	8.38	113, 31/173	Entry/Exit & Escalator,
27	ST-20I	Mumbai University, Kalina Station	Open area of university	Govt	94		89200	8.38	111, 28/164	Entry/Exit & Escalator,
28	ST-21A	Santacruz Station	Temp Builtup	Pvt	94	G+1 Bldg	238800	22.45	111, 28/164	Entry/Exit & Escalator,
29	ST-21B	Santacruz Station	Footpath BMC	Govt	94		0	0.00	111, 28/164	Entry/Exit & Escalator,
30	ST-21C	Santacruz Station	Footpath BMC	Govt	94		0	0.00	111, 28/164	Entry/Exit & Escalator,
31	ST-21D	Santacruz Station	Footpath BMC	Govt	94	Polce Station	16000	1.50	111, 28/164	Entry/Exit & Escalator,
32	ST-21E	Santacruz Station			1978	G+1 Bldg	238800	472.35	111, 28/164	Permanently requires for Cut and Cover for Chillar Plant, Water Tank, Fuel Tank & DG Set, Ventilation Shaft and emergency Entry Exit etc
33	ST-25A	Marol Naka Station	Temp Builtup	Govt	8886		37300	331.45	129, 43/217	Entry/ Exit 2 no's, Chillar Plant, Water Tank, Fuel Tank & DG Set & Shaft & station facilities
							37300	0.00	129, 43/217	Area 8886 sqm, Compensation for loss of structures
34	ST-25B	Marol Naka Station	Temp Builtup Govt	Govt	162		37300	6.04	129, 43/217	Ventilation Shaft
35	ST-25C	Marol Naka Station	Temp Builtup Govt	Govt	162		37300	6.04	129, 43/217	Ventilation Shaft
36	ST-25D	Marol Naka Station	Footpath BMC	Govt	56		0	0.00	129, 43/217	Escalator
37	ST-25E	Marol Naka Station	Footpath BMC	Govt	70		0	0.00	129, 43/217	Entry/Exit
38	ST-26A	MIDC Station	Temp House	Pvt. Res	2501		85500	213.84	119, 43/219A	Chillar Plant, Water Tank, Fuel Tank & DG Set etc , Ventilation shaft and entry/exit
39	ST-26B	MIDC Station	Police Colony	Govt. res.	1712		85500	146.38	119, 43/219A	
40	ST-26C	MIDC Station	Temp House	Pvt. Res.	212		85500	18.13	119,	

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	No of story of building	Rate (in Rs.)	Amount (In Millions)	Ready Reconer No	Purpose
									43/219A	
41	ST-26D	MIDC Station	Pump House, Employee Estate Insurance Co.	Govt.	893		51500	45.99	119, 43/219A	Entry/exit and escalator, and Ventilation shaft
42	ST-27A	SEEPZ Station	Built up	Govt	665	150 sqm Govt Toilet	83500	55.53	129, 45/221A	Chillar Plant, Water Tank, Fuel Tank & DG Set etc
43	ST-27B	SEEPZ Station	Open BEST	Govt	162		50100	8.12	129, 45/221A	Ventilation Shaft
44	ST-27C	SEEPZ Station	Footpath BMC	Govt	35		0	0.00	129, 45/221A	Entry/Exit
45	ST-27D	SEEPZ Station	Open SEEPZ	Pvt	94		0	0.00	129, 45/221A	Entry/Exit & Escalator,
46	ST-27E	SEEPZ Station	Open , Power Grid Corporation	Govt	162		50100	8.12	129, 45/221A	Ventilation Shaft
47	ST-27F	SEEPZ Station	Open SEEPZ	Pvt	35		50100	1.75	129, 45/221A	Entry/Exit & lift etc,
48	ST-27G	SEEPZ Station	Open SEEPZ	Pvt	94		50100	4.71	129, 45/221A	Entry/Exit & Escalator,
49	ST-27H	SEEPZ Station	Open , Power Grid Corporation	Govt	94		50100	4.71	129, 45/221A	Entry/Exit & Escalator,
50	ST-27I	SEEPZ Station	Open BEST	Govt	94		50100	4.71	129, 45/221A	Entry/Exit & Escalator,
				Total land	**22748**		**Total Cost**	**1622.07**		

Cost of Govt. Land	**=**	**797.51 Millions**
Cost of Pvt. Land	**=**	**824.56 Millions**
Add 42% Solatium & interest on Pvt. Land	**=**	**346.32 Millions**
Total Cost	**=**	**1968.39 Millions**

Table 10.7: Detail of Land Required Permanently for Traction Sub Station

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Rate (In Rs)	Amount (In Millions)	Ready Reconer No
1	TSS-1	Cuffe Parade Station to Badhwar Park	Open BMC	Govt	2000	209000	418.00	49, 1/2
2	TSS-2	Science Museum Station to Acharya Atre Chowk Station	Stables, Builtup	Pvt.	2000	165200	330.40	85, 12/92
3	TSS-3	Between Dharavi & Bandra Metro	Hut & Marble Store	Govt	2000	23300	46.60	P79, 18/122B
				Total Land	**6000**	**Total Cost**	**795.00**	

Cost of Govt. Land = 464.60 Millions
Cost of Pvt. Land = 330.40 Millions
Add 42% Solatium & interest on Pvt. Land = 138.77 Millions
Total Cost = 933.77 Millions

Table 10.8: Detail of Land Required Permanently for Depot

S No	Location	Details	Land Ownership	Area In Sqm	Rate (In Rs.)	Amount (In Millions)	Ready Reconer No
1	Aarey Milk Colony	Open Land	Govt. Open	260000	19600	5096	113, 31/173
2	Entry to Depot	Open Land	Govt. Open	4070	19600	79.772	113, 31/173
					Total	**5175.772**	

Table 10.9: Detail of Land Required For Construction Depot

S No	Plot No	Station	Details	Land Ownership	Area In Sqm	Rate (In Sqm.)	Amount (In Millions)	Ready Reconer No	Remarks
1	CD-1	Before Cuffe Parade Station	Open Land, MIDC	Govt.	9861	209000	370.97	49, 1/2	Land for construction depot will be higher on 6% of basic land rate for three year
2	CD-2	Before Cuffe Parade Station Near World Trade Centre	Open Land, Matralaya	Govt.	9890	209000	372.06	49, 1/2	
3	CD-3	Between Badhwar Park and Vidhan Bhawan	Open Land, BMC	Govt.	3918	164600	116.08	49, 1/2	
4	CD-4	Between Mumbai Central and Mahalaxmi	Open Land, BMC	Govt.	12725	69000	158.04	47, 9/74A	
5	CD-5	Between Science Museum and Achray Atrey Nagar	Open Land Race Course	Govt.	3904	74600	52.42	85, 12/92	
6	CD-6	Dharavi to Bandra Metro	Open land drive in theatre, BMC	Govt.	23508	74600	315.67	111, 29/167	
7	CD-7	Dharavi to Bandra Metro	BMC Open	Govt.	30729	74601	412.63		
8	CD-8	CSIA (International)	Casting yard, Airport Authority of India	Govt.	15000	31500	85.05	P95, 33/175	
9	CD-9	Between SEEPZ and Aarey Milk Colony	Open	Pvt	12370	19600	43.64	44/220	
				Total Land	**121905**	**Total Cost**	**1926.57**		

Cost of Govt. Land	=	**1882.93 Millions**
Cost of Pvt. Land	=	**43.64 Millions**
Total Cost	=	**1926.57 Millions**

Table 10.10: Detail of Temporarily Land requirement

S No	Plot No	Station/Location	Details	Land Ownership	Area In Sqm	Rate (In Rs.)	Amount (In Millions)	Ready Reconer No	Remark
1	Temp-1	Cuffe Parade Road	BMC Park	Govt	5999	209000	225.68	49, 1/2	For Cut and Cover of station block
2	Temp-2	Bandra Metro	Mangroves, Maharastra Govt.	Govt	2672	71200	34.24	111, 29/167	For Cut and Cover of station block
3	Temp-3	Bandra Metro	Open Land Yashshree Appt.	Pvt	31	71200	0.40	111, 29/167	For Cut and Cover of station block
4	Temp-4	Bandra Metro	Temp colony, Sant Dynashwar Nagar	Pvt	203	71200	2.60	111, 29/167	For Cut and Cover of station block
5	Temp-5	Mumbai University, Kalina	Open & Road, state Govt	Govt	9029	89200	144.97	113, 31/173	For Cut and Cover of station block
6	Temp-6	MIDC	Open Land IDBI and Mumbai Bazar	Pvt	235	51500	2.18	119, 43/219A	For Cut and Cover of station block
7	Temp-7	SEEPZ	Open	Pvt	158	50100	1.43	129, 45/221A	For Cut and Cover of station block
8	Temp-8	SEEPZ	Open, Western Power Grid	Govt	330	50100	2.98	129, 45/221A	For Cut and Cover of station block
9	Temp-9	SEEPZ	Open, SEEPZ	Govt	376	50100	3.39	129, 45/221A	For Cut and Cover of station block
				Total Land	**19033**	**Total Cost**	**417.86**		

Cost of Govt. Land = 411.26 Millions

Cost of Pvt. Land = 6.60 Millions

Total Cost = 417.86 Millions

Table 10.11: Summary of Land Cost in Millions

	Stations		TSS		Construction Depot		Temp. Land		Depot	Total
	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ		
Pvt Land	2946.94	1170.88	469.17	0.00	0.00	43.64	0.00	6.60	0.00	**4637.23**
Govt Land	1830.78	797.51	418.00	46.60	1069.58	813.35	225.68	185.58	5175.77	**10562.86**
Total	4777.72	1968.39	887.17	46.60	1069.58	856.99	225.68	192.19	5175.77	**15200.09**
									Say	**15200.09 Millions**

Note : It is assumed that all land & property in airport area except the land required for temporary construction depot identified in CSIA (International) area for which provision of payment of lease charges are kept, will be made available free of cost by MIAL and hence cost has not been taken in estimate.

10.2 OPERATION AND MAINTENANCE COST

The Operation and Maintenance costs are worked under three major heads:

- Staff costs
- Maintenance cost which includes expenditure towards upkeep and maintenance of the system and consumables and
- Energy costs

For the estimation of above three heads, two costs i.e. Replacement and Additional Rolling Stock, Minor depot cost are considered and worked out for the subsequent years.

i. Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided for Mumbai Metro, it is expected that only 10% of the equipment comprising Electrical, P-Way and Signalling & Telecom would require replacement after 20 years. Further, 25% of the project cost comprising Rolling Stock and traction is expected to have a life of 30 years after which it shall be required to be replaced. These costs have been provided duly escalated @ of 5% per annum.

ii. Additional Investment

The total investment on additional Rolling Stock of Rs. 9851.55 Million in 2024-25 and Rs. 8382.24 Million in 2030-31 has been provided, considering an escalation factor of 5% p.a. These costs have been provided to take care of increased requirement of Rolling Stock and related equipments to take care of the increased traffic as the existing rolling stock would not be sufficient to carry the projected traffic. Consequently, provision has been made for setting up of a minor depot in the year 2024-25 to cater to the maintenance requirement for increased holding of Rolling Stock.

10.2.1 Staff Cost

The staff is provided @ 45 persons per kilometer and the annual cost on this account in the year 2016 is estimated at Rs. 1505.75 Million. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries. The distribution of staff, their wages and average cost per year are shown in **Table 10.12**.

Table 10.12: Human Resource Requirement

Staff Hierarchy	No. of Persons assumed	Salary Rs. Per month	Total Amount
Top Management	1	202,740	202,740
Middle Management	9	136,250	1,226,250
Lower Management	25	88,290	2,207,250
Supervisors	470	64,200	30,174,000
Staff	1003	47,600	47,742,800
Total Staff Required for 33.508 km of Corridor Length	**1508**		**81,553,040 per month**
			81.55Million per month
			978.64 Million per year in 2011
			1505.75 Million in 2016 with 9% growth per annum

10.2.2 Maintenance Expenses

Maintenance expenses are taken as a percentage of Fixed Assets. The maintenance cost as percentage of capital cost have been fixed in consultation with MMRDA officials. For the first year of operation i.e. 2016-2017, it is estimated to be Rs. 1333.45 Million, duly escalated @ of 5% per annum. **Table 10.13** shows the basis for working out the maintenance cost.

Table 10.13: Maintenance Cost

Fixed Assests	Cost (2011) Million Rs	Maintenance %	Maintenance Cost(2011) Million Rs
Alignment and Formation	42412.09	0.5%	212.06
Station buildings	59472.54	0.5%	297.36
Depot	2442.00	2%	48.84
P-Way	2435.52	1%	24.36
Rolling Stock	17640	2%	352.80
Traction and Power Supply	4788.76	1%	47.89
Signalling and Telecom	6148.78	1%	61.49
		Total Maintenance Cost in 2011	1044.79
		Maintenance Cost in 2016 with 5% Escalation	**1333.45**

In 2024-25 with the additional investment of Rs. 12389.93 Million on Rolling Stock and Minor Depot, total operation and maintenance cost estimates to be Rs. 19266 Million. Similarly, in 2030-31 with additional investment of Rs. 8382.24 Million on Rolling Stock, O&M cost works out to be Rs. 19342 Million.

10.2.3 Energy Charges

The cost of electricity is estimated to be a significant part of O&M charges, constituting about 25% of total annual working cost (providing an escalation of 5% per annum). The annual energy consumption is assessed to be about 260 million units in the first year of operation (2016) **(Table 10.14)**. The power tariff in Mumbai (2010) is Rs. 4.50 per unit which is escalated @ 5% for the first year of operation and later it is escalated @ 5% for every second year of operation. By assuming so, energy is costing about Rs. 1567.80 Million in 2016, Rs. 2565.50 Million in 2025 (with additional 72 cars) and Rs. 3650.70 Million in 2031 (with additional 48 cars).

Table 10.14: Power Requirement and Energy Charges

Year	Unit Rate	Power Required (Million Units)	Cost in Rs. Millions
2016-2017	6.03	260	1567.80
2017-2018	6.03	260	1567.80
2018-2019	6.33	260	1645.80
2019-2020	6.33	260	1645.80
2020-2021	6.65	260	1729.00
2021-2022	6.65	260	1729.00
2022-2023	6.98	260	1814.80
2023-2024	6.98	260	1814.80
2024-2025	7.33	260	1905.80

Year	Unit Rate	Power Required (Million Units)	Cost in Rs. Millions
2025-2026	**7.33**	**350**	**2565.50**
2026-2027	7.7	350	2695.00
2027-2028	7.7	350	2695.00
2028-2029	8.08	350	2828.00
2029-2030	8.08	350	2828.00
2030-2031	8.49	350	2971.50
2031-2032	**8.49**	**430**	**3650.70**
2032-2033	8.91	430	3831.30
2033-2034	8.91	430	3831.30
2034-2035	9.36	430	4024.80
2035-2036	9.36	430	4024.80
2036-2037	9.82	430	4222.60
2037-2038	9.82	430	4222.60
2038-2039	10.31	430	4433.30
2039-2040	10.31	430	4433.30
2040-2041	10.83	430	4656.90
2041-2042	**10.83**	**430**	**4656.90**
2042-2043	11.37	430	4889.10
2043-2044	11.37	430	4889.10
2044-2045	11.94	430	5134.20
2045-2046	11.94	430	5134.20
2046-2047	12.54	430	5392.20

Therefore, the total Operation and Maintenance cost in the years 2016-17, 2025-26, 2031-32 and 2041-42 is estimated at about Rs. 4407 Million, Rs. 8152 Million, Rs. 12407 Million and Rs. 22971 Million respectively. (**Table 10.15**).

Table 10.15: Operation and Maintenance Costs

Year	Staff Cost (A)	Maintenance Expenses (B)	Energy Charges (C.)	Addition/ Replacement Cost(D)	Total (A+B+C+D)	Total O&M Cost
2016-2017	**1,505.75**	**1,333.45**	**1567.80**		**4,407.00**	**4,407**
2017-2018	1,641.27	1,400.12	1567.80		4,609.19	4,609
2018-2019	1,788.99	1,470.13	1645.80		4,904.92	4,905
2019-2020	1,949.99	1,543.64	1645.80		5,139.43	5,139
2020-2021	2,125.49	1,620.82	1729.00		5,475.31	5,475
2021-2022	2,316.79	1,701.86	1729.00		5,747.65	5,748
2022-2023	2,525.30	1,786.95	1814.80		6,127.05	6,127
2023-2024	2,752.58	1,876.30	1814.80		6,443.68	6,444
2024-2025	3,000.31	1,970.11	1905.80	**12389.93***	19,266.15	19,266
2025-2026	**3,270.34**	**2,316.42**	**2565.50**	*Addition of 72 coaches & Minor Depot	**8,152.25**	**8,152**
2026-2027	3,564.67	2,432.24	2695.00		8,691.91	8,692

	Staff Cost	Maintenance Expenses	Energy Charges		Total (A+B+C+D)	Total O&M Cost
2027-2028	3,885.49	2,553.85	2695.00		9,134.34	9,134
2028-2029	4,235.18	2,681.54	2828.00		9,744.72	9,745
2029-2030	4,616.35	2,815.62	2828.00		10,259.97	10,260
2030-2031	5,031.82	2,956.40	2971.50	**8382.24***	19,341.96	19,342
2031-2032	**5,484.68**	**3,271.87**	**3650.70**	*Addition of 48 coaches	**12,407.25**	**12,407**
2032-2033	5,978.30	3,435.46	3831.30		13,245.06	13,245
2033-2034	6,516.35	3,607.23	3831.30		13,954.88	13,955
2034-2035	7,102.82	3,787.60	4024.80		14,915.22	14,915
2035-2036	7,742.07	3,976.98	4024.80		15,743.85	15,744
2036-2037	8,438.86	4,175.82	4222.60	**3,733.90***	20,571.18	20,571
2037-2038	9,198.36	4,384.62	4222.60	*Replacement of Elec., Pway, S&T	17,805.57	17,806
2038-2039	10,026.21	4,603.85	4433.30		19,063.36	19,063
2039-2040	10,928.57	4,834.04	4433.30		20,195.91	20,196
2040-2041	11,912.14	5,075.74	4656.90		21,644.78	21,645
2041-2042	**12,984.23**	**5,329.53**	**4656.90**		**22,970.66**	**22,971**
2042-2043	14,152.82	5,596.00	4889.10		24,637.92	24,638
2043-2044	15,426.57	5,875.80	4889.10		26,191.47	26,191
2044-2045	16,814.96	6,169.59	5134.20		28,118.75	28,119
2045-2046	18,328.31	6,478.07	5134.20	**30,929.35***	60,869.93	60,870
2046-2047	19,977.85	6,801.98	5392.20	*Replacement of RS, PS	32,172.03	32,172

11. ECONOMIC ANALYSIS

11.1 APPROACH

11.1.1 The economic appraisal of Colaba – Bandra – SEEPZ MRT Corridor in Mumbai has been carried out within the broad framework of Social Cost –Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices. This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 34 years to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR.

11.1.2 The Economic Internal Rate of Return (EIRR) for the project has then been arrived using Discounted Cash Flow technique to the net benefit stream at economic prices.

11.2 EVALUATION ASSUMPTIONS

The key evaluation assumptions used in the economic evaluation are listed in **Table 11.1**

Table 11.1 Key Evaluation Assumptions

PARAMETER	ASSUMPTION
Price Level	September’2011
First year of operation of Phase I	2017-18
Construction period Phase I	5 years, 2012-13, 2016-17
Daily to annual factor	340

11.3 ESTIMATION OF COSTS

11.3.1 The project cost comprises capital cost and operation & maintenance cost. The Cost components considered for the purpose of this exercise include:

- Capital cost of infrastructure (civil engineering, land, track, power supply, traction system, signaling and telecommunications, etc.) and rolling stock.
- Operating cost of MRTS
- Maintenance and Replacement costs

Table 11.2 summarizes the estimated cost to economy for Colaba – Bandra – SEEPZ Corridor of Mumbai MRTS. The cost at September ‘2011 prices is estimated at Rs 165,566 Million Including Rs 15,865 million of land cost. The completion cost is estimated at Rs 190,277 Million. The taxes being the transfer payments are not considered in the project costs.

Table 11.2: Estimated Cost to Economy for Colaba – BANDRA – SEEPZ MRT Corridor

System	Cost	Rs. In Million
2016-17	Cost at Sept'11	209,269
	Completion Cost	190,277
	Operating Cost	4,609

11.4 ESTIMATION OF BENEFITS

11.4.1 The Colaba – Bandra – SEEPZ MRTS corridor will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. The Introduction of MRTS will result in reduction in number of buses, usage of private vehicles, air pollution and increase the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general.

11.4.2 The benefit stream that has been quantified includes:

- Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing bus system and private vehicles in case MRTS project is not taken up.

- Savings in operating costs of all buses and other vehicles due to de-congestion including those that would continue to use the existing transport network even after the MRTS is introduced.

- Savings in time of commuters using the MRTS over the existing transport modes because of faster speed of MRTS.

- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.

- Savings on account of prevention of accidents and pollution with introduction of MRTS.

- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case MRTS is not introduced.

- Savings in fuel consumption on account of less number of vehicles on road and decongestion effect with introduction of MRTS are included in those of vehicle operating cost.

The values used for various parameters in the analysis are given in Appendix –1.

11.4.3 The Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area.
- Improving the image of the city.

11.5 TRANSPORT DEMAND ON MRT CORRIDOR

11.5.1 At present the corridor is served by bus system and IPT modes in addition to private vehicles. The total transport demand and demand estimated on this MRTS corridor for various years is given in **Table 11.3.**

Table 11.3: Transport Demand Forecast on Colaba – Bandra – SEEPZ Corridor of Mumbai MRTS

I T E M	2017	2025	2031
Daily Total Trips (Lakh)	270.00	340.00	385.00
Daily Trips on (C-B-Z) MRT Corridor (Lakh)	10.38	13.87	17.00
Daily Trips by other modes (Lakh)	259.62	326.13	368.00

11.5.2 The traffic on MRTS will come due to shifting of traffic from buses, IPT and private modes once a more efficient system is available. The major shifting of traffic would be from buses. It has been estimated that 465 buses will decrease with the introduction of this MRT corridor. This will save Rs. 1871 Million in the year 2017 towards capital and operating cost of bus system. The saving in respect of private vehicles will be approx. Rs. 15766 Million.

11.6 SAVINGS IN TRAFFIC CONGESTION

11.6.1 MRT will contribute towards reducing the congestion and journey time on roads because of diversion of some traffic to MRTS. Reduction in traffic congestion will save the necessary capital investment and vehicle operating cost as well as increase in time saved per vehicle. With the implementation of this MRTS corridor, the savings from operating costs due to decongestion effect has been estimated to be Rs 3195 Million in the year 2017.

11.7 SAVINGS IN FUEL CONSUMPTION

11.7.1 Savings in fuel consumption with the introduction of Colaba – Bandra – SEEPZ MRTS have already been included in savings of vehicle operating cost. The effect of MRTS on fuel savings alone has been calculated separately as follows. The main fuels used in vehicles are CNG and petrol. The saving because of fuel alone from the savings in vehicle operating costs and savings due to decongestion effect for the year 2017 works out to Rs 6391 Million as shown in **Table 11.4.**

Table 11.4: Savings in Fuel Alone With the Project Scenario in Year 2017-18

(Rs. in Million)

Parameters	Savings
Savings in CNG/Diesel due to - Less number of vehicles - Decongestion effect	 419.7 1.8
Savings in Petrol due to - Less number of vehicles - Decongestion effect	 4870.8 1098.9
TOTAL	6391.20

11.8 PASSENGER TIME SAVING

11.8.1 With the introduction of Colaba – Bandra – SEEPZ MRTS, there will be reduction in traffic congestion on the roads and correspondingly, there will be saving in time of commuters travelling by various modes of road transport. Similarly, MRTS System itself being faster than conventional road transport modes will also lead to considerable saving in time of commuters traveling on MRTS. With the implementation of the project, the passenger time savings are estimated at Rs. 7263.50 Million for the year 2017-18.

11.9 SAFETY

11.9.1 The reduction in traffic volumes on roads brought about by modal transfer to Colaba – Bandra – SEEPZ MRTS is expected to reduce number of accidents. Any reduction in number of accidents will involve savings from damage to vehicles and savings towards medical and insurance expenses to persons involved in accidents. The benefits because of accidents prevented with the introduction of this MRTS corridor works out to Rs.17.40 Million in the year 2017-18.

11.10 REDUCED AIR POLLUTION

The benefits because of saving in cost of prevention of vehicular pollution, with the implementation of Colaba – Bandra – SEEPZ Corridor of Mumbai MRTS in the year 2016-17 are expected to be Rs 1114.02 Million.

11.11 SAVINGS IN ROAD INFRASTRUCTURE

The proposed MRT corridor will also bring savings in investment in road infrastructure because shifting of passengers to MRT and withdrawal of vehicles in the project area. Since no local data is available concerning the road infrastructure investment on this account, this saving has not been incorporated into economic evaluation.

11.12 SHADOW PRICING

The value of Project cost and benefits have been expressed in terms of market prices. These prices, however, do not reflect the real resource cost and value of benefits derived from the project to the economy. The market prices are distorted due to variety of factors. These factors could be controlled/administered prices of inputs, monopolistic market of inputs, tax structure etc. The factors used for converting project inputs and output to economic costs are given in following **Table 11.5**

Table 11.5: Factors used for Converting Project Inputs and Output to Economic Costs

S.No	Item	Factor
1	CAPITAL COST	0.85
2	OPERATIONS & MAINTENANCE COST	0.80
3	SAVINGS IN CAPITAL & OPERATING COST OF BUSES	0.89
4	SAVINGS IN CAPITAL & OPERATING COST OF PRIVATE VEHICLES	0.8
5	SAVINGS IN PASSENGER TIME	1.0
6	SAVINGS IN VOC	1.1
7	SAVINGS IN ACCIDENT COSTS	1.0
8	SAVINGS IN POLLUTION COSTS	1.0

11.13 RESULT OF ECONOMIC ANALYSIS

11.13.1 The cost and benefit streams for 44-year period in the economic prices have been worked out and presented in **Tables 11.6** for Colaba – Bandra – SEEPZ corridor of Mumbai MRTS. The residual value of MRTS facilities (e.g. Metro and Rail corridors, equipment for power supply and tele-communication, rolling stock, etc.) in last year has not been taken into account as benefit in these tables. The total cost worked out on the above basis is then subtracted from the total benefits to estimate the net benefit of the project. This flow is then subjected to the process of discounting to work out the internal rate of return on the project, to examine the viability of the Project in Economic terms. Thereafter, the Project EIRR in economic terms has been arrived by using shadow prices.

11.13.2 The EIRR in economic terms works out to **17.93 %** for Colaba – Bandra – SEEPZ corridor of Mumbai MRTS.

11.14 SENSITIVITY ANALYSIS

11.14.1 A sensitivity analysis of the EIRR with 10% cost overrun and 10% reduction in traffic materialization (separately) has been carried out. The EIRRs under these scenarios are given in **Table 11.7.**

Table 11.7: EIRRs - Sensitivity Analysis

Sensitivity Parameter	EIRR (%)
Basic EIRR	17.93
With increase in cost by 10%	17.06
With reduction in traffic materialization by 10%	17.59
With 10% reduction in traffic and increase in cost by 10%	16.73
With increase in cost by 20%	16.07

11.14.2 It can be seen from the above table that 10% increase in cost affects economic viability more than it does in case of reduction in traffic for the project. Accordingly, it is recommended that controls should be exercised to keep the cost of construction under control.

Table 11.6: Cost Benefit Stream For Colaba – Bandra – SEEPZ MRTS: Economic Prices

Cost and Benefit Stream for Mumbai MRTS: Economic Prices

Units: Rs in Million

Year	Capital Cost	Running Expense Of MRTS	Total Costs	Savings Buses	From Others Vehicles	Savings From TIME	Savings From VOC	Savings From ACC/POL	Total Savings	Net Cash Flow
2012-13	20103	0	20103	0	0	0	0	0	0	-20103
2013-14	34800	0	34800	0	0	0	0	0	0	-34800
2014-15	44191	0	44191	0	0	0	0	0	0	-44191
2015-16	46400	0	46400	0	0	0	0	0	0	-46400
2016-17	16240	0	16240	0	0	0	0	0	0	-16240
2017-18	0	3687	3687	2125	16098	9270	4498	1644	33635	29947
2018-19	0	3924	3924	2286	17317	9972	4838	1768	36181	32257
2019-20	0	4112	4112	2459	18627	10727	5205	1902	38920	34809
2020-21	0	4380	4380	2645	20038	11539	5599	2046	41867	37486
2021-22	0	4598	4598	2770	19886	11036	3754	2019	39465	34867
2022-23	0	4902	4902	2980	21391	11872	4038	2172	42453	37551
2023-24	0	15067	15067	3230	22080	12867	4376	2354	44907	29840
2024-25	0	5501	5501	3500	22791	13945	4743	2551	47531	42030
2025-26	0	6522	6522	3794	23525	15114	5141	2765	50338	43816
2026-27	0	6954	6954	4112	24282	16381	5572	2997	53343	46389
2027-28	0	7307	7307	4456	25064	17754	6039	3248	56560	49253
2028-29	0	7796	7796	4830	25871	19241	6545	3520	60007	52211
2029-30	0	14914	14914	5235	26704	20854	7093	3815	63701	48787
2030-31	0	8768	8768	5673	27564	22602	7688	4135	67661	58893
2031-32	0	9926	9926	6964	33466	31027	10359	3894	85711	75785
2032-33	0	10596	10596	7103	34136	31647	10567	3972	87425	76829
2033-34	0	11164	11164	7245	34818	32280	10778	4052	89174	78010
2034-35	0	11932	11932	7390	35515	32926	10993	4133	90957	79025
2035-36	0	15582	15582	7538	36225	33585	11213	4215	92776	77194
2036-37	0	13470	13470	7689	36949	34256	11438	4300	94632	81162
2037-38	0	14244	14244	7842	37688	34941	11666	4386	96524	82280
2038-39	0	15251	15251	7999	38442	35640	11900	4473	98455	83204
2039-40	0	16157	16157	8159	39211	36353	12138	4563	100424	84267
2040-41	0	17316	17316	8322	39995	37080	12380	4654	102432	85117
2041-42	0	18377	18377	8489	40795	37822	12628	4747	104481	86105

Cost and Benefit Stream for Mumbai MRTS: Economic Prices

Units: Rs in Million

Year	Capital Cost	Running Expense	Total Costs	Savings Buses	From Others	Savings From			Total Savings	Net Cash Flow
						TIME	VOC	ACC/POL		
2042-43	0	19710	19710	8659	41611	38578	12881	4842	106571	86860
2043-44	0	20953	20953	8832	42443	39350	13138	4939	108702	87749
2044-45	0	47238	47238	9008	43292	40137	13401	5038	110876	63638
2045-46	0	23952	23952	9189	44158	40939	13669	5139	113094	89141
2046-47	0	25738	25738	9372	45041	41758	13942	5241	115356	89618
2047-48	0	27509	27509	9560	45942	42593	14221	5346	117663	90154
2048-49	0	29402	29402	9751	46861	43445	14506	5453	120016	90614
2049-50	0	31425	31425	9946	47798	44314	14796	5562	122416	90991
2050-51	0	33588	33588	10145	48754	45200	15092	5673	124865	91277
2051-52	0	35899	35899	10348	49729	46104	15393	5787	127362	91463
2052-53	0	38369	38369	10555	50724	47026	15701	5903	129909	91540
2053-54	0	41010	41010	10766	51738	47967	16015	6021	132507	91498
2054-55	0	43832	43832	10981	52773	48926	16336	6141	135157	91326
2055-56	0	46848	46848	11201	53828	49905	16662	6264	137861	91013
									IRR %	**17.93**

APPENDIX I

Assumption made in carrying out Economic Analysis

Various assumptions have been made, while assessing the economic benefits to the society on account of various factors after introduction of MRTS system. Following are the assumptions made for each of the factors:

Assumption for Inflation Rate

The prices for various calculations made are at Sept 2011 level. The inflation rate calculated for each year has been calculated from wholesale price index for various years as given in Economic Survey2002-2003. The years for which WPI figures not available, inflation rate are from inter net have been obtained.

Year	WPI	Growth
2005-06	104.47	1.052
2006-07	111.35	1.049
2007-08	116.63	1.047
2008-2009	126.02	1.08
2009-2010	130.81	1.04
2010-2011	143.32	1.09
Average Annual Growth Rate during 2005-2011=1.05411		
*** Office of Economic Advisor to Govt of India, Ministry of Commerce and Industry*		

Assumption For Modal Characteristics

1. Mode	Average speed (Km.)		Daily vehicle utilisation (Km.)	Occupancy/ Vehicle	Trips/ Day	SHARE IN SHIFT OF TRIPS TO MRTS (%)
	Without MRTS	With MRTS				
Bus	10	12	211	50	-	60
Car	15	20	30	3	2	6
2 Wheeler	15	25	30	1.35	2	9
3 Wheeler	13	17	100	1.7	15	9
TAXI	15	20	100	3	15	6
TRAIN						10

Mode	Avg. lead	VOC/ Km.* (Rs.)	VOC/hour** (Rs.)	Value of Time (Passenger)/***Hour (Rs.)
Bus	12	56	841.5	27.5
Car+ Taxi	15	17	247.5	66
2 Wheeler	10	6	82.5	44
3 Wheeler	8	8	115.5	49.5
MRTS	8.22			27.5

Source:* Detailed feasibility study under SMART project by TWET, DE-Consult and CES

** Assumes average speed of 15 Km/ Hr in Mumbai

*** CES report on Mumbai Urban Infrastructure Project (MUIP)

Values brought to current price level using escalation factor of 5%

Assumptions For Fuel Consumption & Emission*

Mode	Fuel consumption (Litre/Km.)	Reduction in fuel consumption due to decongestion effect (Lt./Km.)	Pollution Emission (Kg./1000 Litres)
Bus	0.279	0.0682	61.04
Car	0.077	0.0287	219.68
2 Wheelers	0.029	0.0096	231.76
3 Wheelers	-	0.0192	215.51

**Paper by CPCB Scientists obtained from Inter net*

- Damage cost of Pollution Rs. 55.30/- per Kg.

- Price of Fuel
  - Petrol Rs71.92/- per litre
  - CNG Rs. 31.47/- per litre

Assumptions for Bus characteristics

- Fleet Utilization 90%
- Load Factor 90%
- Carrying Capacity 50 passengers
- Daily Utilisation 211 km.

Source: Best Statistics

435919
33861

Assumptions for Road Accidents

- Cost of a Fatal Accident Rs 9,61,661*
- Cost of an Injury Accident Rs. 2,34,890*

**Source: Road Cost Evaluation study conducted by M/S Tata Consultancy Services'1999.* Values brought to current price level using escalation factor of 5%

- **Cost of damage to Vehicles due to an Accident.***

CARS	Rs 29,093
USES	Rs 84,585
TRUCKS	Rs 87,458
SC/MC	Rs 7,363

**Source: : Road Cost Evaluation study conducted by M/S Tata Consultancy Services'1999.* Values have been brought to current price level using escalation factor of 5%.

Data on number of accidents has been obtained from Additional Director General of Police (Traffic).

12. FINANCIAL ANALYSIS

12.1 CAPITAL COST ESTIMATES

The basic Project cost of the metro corridor at September 2011 prices is estimated at Rs 149,701 Million. The cost of land is estimated at Rs.15,865 Million. Of the total land cost, Rs 4,985 Million is cost of private land and the cost of government land is estimated at Rs 10,880 Million. The total cost of project including land cost, is estimated at Rs 165,566 Million.

The Central and State taxes and duties (Customs, Excise and VAT) amount to Rs 25,467 Million. Of the total taxes and duties, Rs 20,432 Million are central taxes (Customs and Excise duty) and Rs 5035 Million are state taxes (Value Added Tax). The component towards Octroi and insurance works out to be Rs. 2121 Million and Rs. 831 Million respectively. The details of the cost components at September 2011 prices are given in **Table 12.1**

Table 12.1 Costs of Colaba- Bandra- Seepz Metro System (Sept'2011 Prices)

Cost Component	**Rs in Mn**
Construction Cost	149701
Total Construction Cost	**149701**
Land Cost	15865
Govt Land	10880
Private land	4985
Total Cost With Land	**165566**
Taxes	28419
Central Taxes	20432
State Taxes	5035
Octoroi & Insurance	2952
Total Cost with Taxes w/o Land	**178120**
Total Cost With Taxes & Land	**193984**

12.1.1 Completion Cost

With escalation factor of 5% p.a. the Completion Cost of the project including land and taxes is estimated to be Rs. 223,386 Million. For the purpose of financial analysis, only the cost of private land, (being a cash payout) has been added to the project cost as the government land is expected to be available on transfer basis. Further, JICA is expected to part fund the project through soft loan. As per the policy decision taken by Department of Economic Affairs, JICA will not fund the IDC and the same has been added to project cost. The private land cost is not escalated since land acquisition would be completed in the initial two years. It is proposed to start land acquisition and construction work prior to June 2012 and commission the system by Mar-2017. Thus, the completion cost including IDC with interest rate 1.4% considered for financial analysis, works out to Rs 216,663 Million. The details of completion cost under different scenarios are as per **Table 12.2**

Table 12.2 Details of Completion Costs (Rs in Million)

Particulars	Cost at 2011 Prices	Completion cost including IDC
Cost without taxes	154,686	183,554
With Central taxes	175,118	207,359
With Central & State Taxes	183,104	216,663

12.1.2 Requirement of Funds

The year wise requirement of funds under different scenarios has been given in **Table 12.3** (Without any Taxes), in **Table 12.4** (with Central Taxes only) and in **Table 12.5** (With Central and State Taxes). The cost of acquisition of private land is divided into two initial years during which it is expected that the land acquisition work would be over and related payments would be released.

Table 12.3 Year wise Fund Requirements without Taxes (Rs in Million)

YEAR	COMPLETION COST	LAND COST	IDC	TOTAL COMPLETION COST
2012-13	15719	2493	0	18211
2013-14	33009	2493	132	35634
2014-15	51989		409	52399
2015-16	54589		846	55435
2016-17	19106		1305	20411
2017-18			1465	1465
TOTAL	**174412**	**4,985**	**4,157**	**183,354**

Table 12.4 Year wise Fund Requirements with Central Taxes (Rs in Million)

YEAR	COMPLETION COST	LAND COST	IDC	TOTAL COMPLETION COST
2012-13	17864	2493	0	20357
2013-14	37514	2493	132	40139
2014-15	59085		409	59494
2015-16	62039		846	62885
2016-17	21714		1305	23018
2017-18			1465	1465
TOTAL	**198,217**	**4,985**	**4,157**	**207,359**

Table 12.5 Year wise Fund Requirements with Central & State Taxes (Rs in Million)

YEAR	COMPLETION COST	LAND COST	IDC	TOTAL COMPLETION COST
2012-13	18703	2493	0	21195
2013-14	39275	2493	132	41900
2014-15	61859		409	62268
2015-16	64952		846	65798
2016-17	22733		1305	24038
2017-18			1465	1465
TOTAL	**207,521**	**4,985**	**4,157**	**216,663**

12.2 ADDITIONAL INVESTMENT

The total additional investment cost of Rs 12,390 Million will be required in the years 2024-25 and Rs 13032 Million in 2031.

These costs have been provided for additional Rolling Stock and related equipment to take care of the increased traffic. The additional cost in the year 2031 includes the cost of providing stabling facilities that would be required for additional rolling stock. These costs have been brought to the current price level by using a factor of 5% p.a.

12.3 OPERATION & MAINTENANCE COSTS

The Operation & Maintenance costs can be divided into three major parts:

(i) Staff costs

(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and

(iii) energy costs

The details of these costs are given in Chapter10.

The total O&M cost in the year 2016-17 is estimated at Rs.4,407 Million. The total O&M cost in the year 2024-25 is estimated at Rs 12,390 Million. The year-wise O&M costs and additional investment are as indicated in **Table 12.6**

Table 12.6 Operation and Maintenance Costs (Rs in Million)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total	Addition/ Replacement Cost	Grand Total
2016-2017	1,505.75	1,333.45	1567.8	4,407		4,407
2017-2018	1,641.27	1,400.12	1567.8	4,609		4,609
2018-2019	1,788.99	1,470.13	1645.8	4,905		4,905
2019-2020	1,949.99	1,543.64	1645.8	5,139		5,139
2020-2021	2,125.49	1,620.82	1729	5,475		5,475
2021-2022	2,316.79	1,701.86	1729	5,748		5,748
2022-2023	2,525.30	1,786.95	1814.8	6,127		6,127
2023-2024	2,752.58	1,876.30	1814.8	6,444		6,444
2024-2025	3,000.31	1,970.11	1905.8	6,876	12390	19,266
2025-2026	3,270.34	2,316.42	2565.5	8,152		8,152
2026-2027	3,564.67	2,432.24	2695	8,692		8,692
2027-2028	3,885.49	2,553.85	2695	9,134		9,134
2028-2029	4,235.18	2,681.54	2828	9,745		9,745
2029-2030	4,616.35	2,815.62	2828	10,260		10,260
2030-2031	5,031.82	2,956.40	2971.5	10,960	8382	19,342
2031-2032	5,484.68	3,271.87	3650.7	12,407		12,407
2032-2033	5,978.30	3,435.46	3831.3	13,245		13,245
2033-2034	6,516.35	3,607.23	3831.3	13,955		13,955
2034-2035	7,102.82	3,787.60	4024.8	14,915		14,915
2035-2036	7,742.07	3,976.98	4024.8	15,744		15,744
2036-2037	8,438.86	4,175.82	4222.6	16,837	3,734	20,571

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total	Addition/ Replacement Cost	Grand Total
2037-2038	9,198.36	4,384.62	4222.6	17,806		17,806
2038-2039	10,026.21	4,603.85	4433.3	19,063		19,063
2039-2040	10,928.57	4,834.04	4433.3	20,196		20,196
2040-2041	11,912.14	5,075.74	4656.9	21,645		21,645
2041-2042	12,984.23	5,329.53	4656.9	22,971		22,971
2042-2043	14,152.82	5,596.00	4889.1	24,638		24,638
2043-2044	15,426.57	5,875.80	4889.1	26,191		26,191
2044-2045	16,814.96	6,169.59	5134.2	28,119		28,119
2045-2046	18,328.31	6,478.07	5134.2	29,941	30,929	60,870
2046-2047	19,977.85	6,801.98	5392.2	32,172		32,172

12.4 REPLACEMENT COST

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided for Mumbai Metro, it is expected that only 10% of the equipment comprising Electrical, P-Way and Signalling & Telecom would require replacement after 20 years. Further, 25% of the project cost comprising Rolling Stock and traction is expected to have a life of 30 years after which it shall be required to be replaced. These costs have been provided, duly escalated @ 5% per annum. Rs 3,734 Million have been provided in the year 2036-37 for the replacement of electrical, p-way and signalling & telecom and Rs 30,929 Million for the replacement of replacement of Rolling stock, traction, power supply etc.

12.5 DEPRECIATION

Depreciation is generally not considered in FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided. In the present calculations, the depreciation figures are placed for purpose of record. These are taken @ 3.5% of the total completion cost adjusted for land cost.

12.6 REVENUES

12.6.1 Projected Traffic Demand

In the year 2017 the ridership on the proposed Colaba- Bandra- Seepz metro system has been estimated at 10.38 lakh passenger trips per day. The ridership figures for key horizon years are given in **Table 12.7**

Table No: 12.7 Expected ridership on Colaba- Bandra – Seepz Metro Corridor

Year	Passenger Trips per day (lakh)
2017	**10.38**
2025	**13.87**
2031	**17.00**

12.6.2 Trip Length Distribution

The trip length distribution has been taken on the basis of the available details on land use, corridor composition and existing traffic characteristics in the catchment areas of various sections of the corridor. Average trip length on the corridor is 12 km. The detail distribution is given in **Table 12.8 & figure 12.1**

Table 12.8- Trip Length Distribution

Fare Slab	% of Passengers
0-3	12%
3-8	29%
8-12	16%
12-15	8%
15-20	16%
20-25	10%
25-30	9%
>30	1%

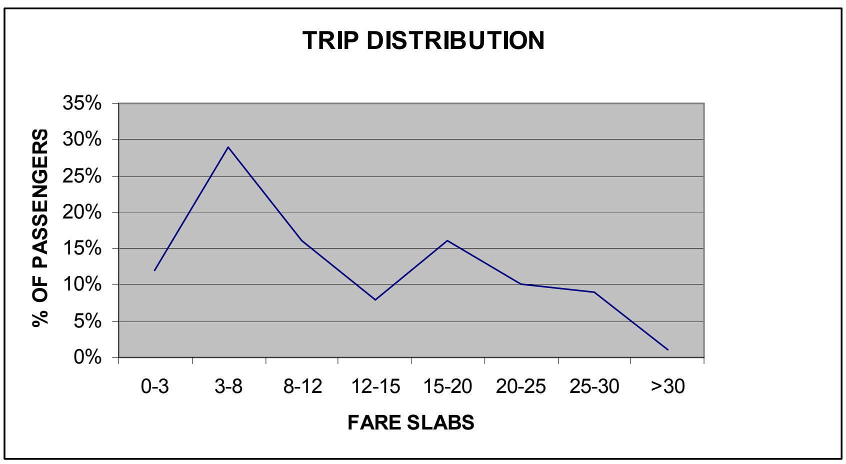


Figure 12.1 Expected Trip Distribution on Colaba-Bandra-Seepz Metro Corridor

12.6.3 Fare Structure

MMRDA has proposed a fare structure for all mass transit systems in Mumbai for the year 2015 with the increase by 11% every fourth year **(Table 12.9).**

Delhi metro rail Corporation (DMRC) has been in metro operation for last 10 years and has revised metro fares on regular intervals. Recently DMRC also proposed a fare structure for the year 2016 for Phase 3 of Delhi metro with the increase of 7.5 % at the end of every two years **(Table 12.10).** A comparison between the two fare structure shows that the DMRC fares slabs are smaller as compared to MMRDA fares. As such for smaller trip lengths, the MMRDA fare structure is quite less as compared to the fare structure adopted by DMRC. For average trip length of 12 Km on the corridor, the difference in fares in two systems in the year 2017 is Rs 6/ trip. The two fare structures are given in **Table 12. 9 & Table 12.10.**

Table 12.9 Fare structure for Colaba- Bandra- Seepz Metro based on MMRDA Fare Structure

Fare	0-3	3-8	8-12	12-15	15-20	20-25	25-30	30-35	>35
2015	10	12	14	18	22	24	27	30	33
2016	10	12	14	18	22	24	27	30	33
2017	10	12	14	18	22	24	27	30	33
2018	11	13	16	20	24	27	30	33	37
2019	11	13	16	20	24	27	30	33	37
2020	11	13	16	20	24	27	30	33	37
2021	12	14	18	22	27	30	33	37	41
2022	12	14	18	22	27	30	33	37	41
2023	12	14	18	22	27	30	33	37	41
2024	13	16	20	24	30	33	37	41	46
2025	13	16	20	24	30	33	37	41	46
2026	13	16	20	24	30	33	37	41	46
2027	14	18	22	27	33	37	41	46	51
2028	14	18	22	27	33	37	41	46	51
2029	14	18	22	27	33	37	41	46	51
2030	16	20	24	30	37	41	46	51	57
2031	16	20	24	30	37	41	46	51	57
2032	16	20	24	30	37	41	46	51	57
2033	18	22	27	33	41	46	51	57	63
2034	18	22	27	33	41	46	51	57	63
2035	18	22	27	33	41	46	51	57	63
2036	20	24	30	37	46	51	57	63	70
2037	20	24	30	37	46	51	57	63	70
2038	20	24	30	37	46	51	57	63	70
2039	22	27	33	41	51	57	63	70	78
2040	22	27	33	41	51	57	63	70	78
2041	22	27	33	41	51	57	63	70	78
2042	24	30	37	46	57	63	70	78	87
2043	24	30	37	46	57	63	70	78	87
2044	24	30	37	46	57	63	70	78	87
2045	27	33	41	51	63	70	78	87	97
2046	27	33	41	51	63	70	78	87	97
2047	27	33	41	51	63	70	78	87	97
2048	30	37	46	57	70	78	87	97	108
2049	30	37	46	57	70	78	87	97	108
2050	30	37	46	57	70	78	87	97	108
2051	33	41	51	63	78	87	97	108	120
2052	33	41	51	63	78	87	97	108	120
2053	33	41	51	63	78	87	97	108	120
2054	37	46	57	70	87	97	108	120	133
2055	37	46	57	70	87	97	108	120	133

Table 12.10 Fare structure for Colaba- Bandra- Seepz Metro based on DMRC Fare Structure

Fare	0-2	2-4	4-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-31	31-35
2016	10	12	15	19	20	22	24	26	27	29	31	34
2017	10	12	15	19	20	22	24	26	27	29	31	34
2018	11	13	16	20	22	24	26	28	29	31	33	37
2019	11	13	16	20	22	24	26	28	29	31	33	37
2020	12	14	17	22	23	25	28	30	31	34	36	39
2021	12	14	17	22	23	25	28	30	31	34	36	39
2022	12	15	19	24	25	27	30	32	34	36	39	42
2023	12	15	19	24	25	27	30	32	34	36	39	42
2024	13	16	20	25	27	29	32	35	36	39	41	45
2025	13	16	20	25	27	29	32	35	36	39	41	45
2026	14	17	22	27	29	32	34	37	39	42	45	49
2027	14	17	22	27	29	32	34	37	39	42	45	49
2028	15	19	23	29	31	34	37	40	42	45	48	52
2029	15	19	23	29	31	34	37	40	42	45	48	52
2030	17	20	25	32	33	36	40	43	45	48	51	56
2031	17	20	25	32	33	36	40	43	45	48	51	56
2032	18	21	27	34	36	39	43	46	48	52	55	61
2033	18	21	27	34	36	39	43	46	48	52	55	61
2034	19	23	29	36	38	42	46	50	52	56	59	65
2035	19	23	29	36	38	42	46	50	52	56	59	65
2036	21	25	31	39	41	45	49	54	56	60	64	70
2037	21	25	31	39	41	45	49	54	56	60	64	70
2038	22	27	33	42	44	49	53	58	60	64	69	75
2039	22	27	33	42	44	49	53	58	60	64	69	75
2040	24	29	36	45	48	52	57	62	64	69	74	81
2041	24	29	36	45	48	52	57	62	64	69	74	81
2042	26	31	38	49	51	56	61	67	69	74	79	87
2043	26	31	38	49	51	56	61	67	69	74	79	87
2044	28	33	41	52	55	61	66	72	74	80	85	94
2045	28	33	41	52	55	61	66	72	74	80	85	94
2046	30	36	44	56	59	65	71	77	80	86	92	101
2047	30	36	44	56	59	65	71	77	80	86	92	101
2048	32	38	48	60	64	70	76	83	86	92	99	108
2049	32	38	48	60	64	70	76	83	86	92	99	108
2050	34	41	51	65	68	75	82	89	92	99	106	116
2051	34	41	51	65	68	75	82	89	92	99	106	116
2052	37	44	55	70	74	81	88	96	99	107	114	125
2053	37	44	55	70	74	81	88	96	99	107	114	125
2054	40	47	59	75	79	87	95	103	107	115	122	134
2055	40	47	59	75	79	87	95	103	107	115	122	134

The revenue streams for the financial analysis have been generated from the above two fare structures.

12.6.4 Commercial development

M/s Louis Berger Group and CBRE have recently carried out a study for MMRDA entitled "Development of commercial complex and shopping centre at underground metro stations on Bandra - Colaba Corridor". The study estimated that the underground stations have limited scope for commercial developments due to limited demand, lower footfalls, safety issues, high maintenance costs, poor visibility etc. Accordingly, no major commercial development at stations has been envisaged as the possible source of funding.

12.6.5 Other sources of revenues

Other sources of revenues considered are the advertisement- which has been estimated at 10% of the fare box revenues during operations. It is possible to raise resources through advertisement on trains and tickets, advertisements within stations and advertisements on other metro structures, co-branding rights to corporates, film shootings and special events on metro premises. There could be some revenue from small kiosks at the stations including those for soft drinks, tea coffee, telecom companies and bank ATM's.

12.6.6 Total Revenue

The total annual revenue, as collected through the fare box and other sources of revenue, for the study corridor based on MMRDA fares and DMRC fares is given in **Table 12.11**. The fare sensitivity of DMRC fares on ridership has not been considered in this comparison.

Table 12.11: Total Revenue Collection (Rs in Millions)

Source of Revenue	2017-2018		2020-2021		2030-2031		2035-2035	
	MMRDA	DMRC	MMRDA	DMRC	MMRDA	DMRC	MMRDA	DMRC
Fare Box Revenue	6001	7029	7421	9391	15964	18512	20975	25347
Revenue from other Sources	600	703	742	939	1596	1851	2097	2535
Total Revenue	**6601**	**7732**	**8163**	**10330**	**17560**	**20364**	**23072**	**27881**

12.7 FINANCIAL INTERNAL RATE OF RETURN OF THE PROJECT

The FIRR calculations with the projected ridership, fare box revenue and based on both MMRDA &DMRC fare structure under various scenarios is given in **Table 12.12**

Table 12.12- Project FIRR under different scenarios

SCENARIO		SCENARIO	
REVENUE BASED ON MMRDA FARES	**FIRR**	**REVENUE BASED ON DMRC FARES**	**FIRR**
Cost Without Any Taxes	2.17%	Cost Without Any Taxes	4.34%
Cost With Central Taxes	1.7%	Cost With Central Taxes	3.8%
Cost With Central & State Taxes	1.6%	Cost With Central & State Taxes	3.7%

The FIRR calculations for each scenario given in **Table 12.13** to **Table12.15** provide FIRR calculations based on MMRDA fares and **Tables 12.16-12.18** provide FIRR calculation based on DMRC fares. It can be seen that project FIRR with DMRC fare structure is much higher than achieved with MMRDA fare structure**.**

Table 12.13- Project FIRR with both Central and State Taxes & MMRDA Fares

Year			Project Completion Cost	Land Cost	Total Taxes	Project Cost with IDC	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	O&M Cost	Additional Capital	Operational Surplus
2012	-	13	15719	2493	2984	21195	0	0	0			-21195
2013	-	14	33009	2493	6266	41900	0	0	0			-41900
2014	-	15	51989		9869	62268	0	0	0			-62268
2015	-	16	54589		10363	65798	0	0	0			-65798
2016	-	17	19106		3627	24038	0	0	0			-24038
2017	-	18				1465	6001	600	6601	4609	0	527
2018	-	19					6902	690	7592	4905	0	2687
2019	-	20					7157	716	7873	5139	0	2733
2020	-	21					7421	742	8163	5475	0	2688
2021	-	22					8406	841	9247	5748	0	3499
2022	-	23					8717	872	9589	6127	0	3462
2023	-	24					9039	904	9943	6444	0	3499
2024	-	25					10532	1053	11585	6876	12390	-7681
2025	-	26					10921	1092	12013	8152	0	3861
2026	-	27					11279	1128	12407	8692	0	3715
2027	-	28					12921	1292	14213	9134	0	5079
2028	-	29					13367	1337	14704	9745	0	4959
2029	-	30					13828	1383	15211	10260	0	4951
2030	-	31					15964	1596	17560	10960	8382	-1782
2031	-	32					16514	1651	18166	12407	0	5759
2032	-	33					17084	1708	18792	13245	0	5547
2033	-	34					19599	1960	21559	13955	0	7604
2034	-	35					20275	2028	22303	14915	0	7387
2035	-	36					20975	2097	23072	15744	0	7328
2036	-	37					24195	2420	26615	16837	3734	6043
2037	-	38					25030	2503	27533	17806	0	9727
2038	-	39					25893	2589	28482	19063	0	9419
2039	-	40					29574	2957	32532	20196	0	12336
2040	-	41					30595	3059	33654	21645	0	12009
2041	-	42					31650	3165	34815	22971	0	11844
2042	-	43					36120	3612	39732	24638	0	15094
2043	-	44					36843	3684	40527	26191	0	14335
2044	-	45					37579	3758	41337	28119	0	13219
2045	-	46					42412	4241	46653	29941	30929	-14216
2046	-	47					43260	4326	47587	32172	0	15414
2047	-	48					44126	4413	48538	34386	0	14152
2048	-	49					50341	5034	55375	36752	0	18623
2049	-	50					51348	5135	56483	39281	0	17201
2050	-	51					52375	5237	57612	41984	0	15628
2051	-	52					59170	5917	65087	44874	0	20214
2052	-	53					60354	6035	66389	47962	0	18427
2053	-	54					61561	6156	67717	51262	0	16455
2054	-	55					70364	7036	77401	54790	0	22611
2055	-	56					71771	7177	78949	58560	0	20389
Total			174412	4985	33109	216631	1121464	112146	1233611	841962	55435	119551
										FIRR %		**1.6**

Table 12.14- Project FIRR with only Central Taxes & MMRDA Fares

Year			Project Completion Cost	Land Cost	Total Taxes	Project Cost with IDC	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	O&M Cost	Additional Capital	Operational Surplus
2012	-	13	15719	2493	2145	20357	0	0	0			-20357
2013	-	14	33009	2493	4505	40139	0	0	0			-40139
2014	-	15	51989	0	7096	59494	0	0	0			-59494
2015	-	16	54589	0	7451	62885	0	0	0			-62885
2016	-	17	19106	0	2608	23018	0	0	0			-23018
2017	-	18				1465	6001	600	6601	4609	0	527
2018	-	19					6902	690	7592	4905	0	2687
2019	-	20					7157	716	7873	5139	0	2733
2020	-	21					7421	742	8163	5475	0	2688
2021	-	22					8406	841	9247	5748	0	3499
2022	-	23					8717	872	9589	6127	0	3462
2023	-	24					9039	904	9943	6444	0	3499
2024	-	25					10532	1053	11585	6876	12390	-7681
2025	-	26					10921	1092	12013	8152	0	3861
2026	-	27					11279	1128	12407	8692	0	3715
2027	-	28					12921	1292	14213	9134	0	5079
2028	-	29					13367	1337	14704	9745	0	4959
2029	-	30					13828	1383	15211	10260	0	4951
2030	-	31					15964	1596	17560	10960	8382	-1782
2031	-	32					16514	1651	18166	12407	0	5759
2032	-	33					17084	1708	18792	13245	0	5547
2033	-	34					19599	1960	21559	13955	0	7604
2034	-	35					20275	2028	22303	14915	0	7387
2035	-	36					20975	2097	23072	15744	0	7328
2036	-	37					24195	2420	26615	16837	3734	6043
2037	-	38					25030	2503	27533	17806	0	9727
2038	-	39					25893	2589	28482	19063	0	9419
2039	-	40					29574	2957	32532	20196	0	12336
2040	-	41					30595	3059	33654	21645	0	12009
2041	-	42					31650	3165	34815	22971	0	11844
2042	-	43					36120	3612	39732	24638	0	15094
2043	-	44					36843	3684	40527	26191	0	14335
2044	-	45					37579	3758	41337	28119	0	13219
2045	-	46					42412	4241	46653	29941	30929	-14216
2046	-	47					43260	4326	47587	32172	0	15414
2047	-	48					44126	4413	48538	34386	0	14152
2048	-	49					50341	5034	55375	36752	0	18623
2049	-	50					51348	5135	56483	39281	0	17201
2050	-	51					52375	5237	57612	41984	0	15628
2051	-	52					59170	5917	65087	44874	0	20214
2052	-	53					60354	6035	66389	47962	0	18427
2053	-	54					61561	6156	67717	51262	0	16455
2054	-	55					70364	7036	77401	54790	0	22611
2055	-	56					71771	7177	78949	58560	0	20389
Total			177755	4985	174412	210771	1121464	112146	1233611	841826	55435	128855
										FIRR %		**1.7**

Table 12.15- Project FIRR without any Taxes & MMRDA Fares

Year			Project Completion Cost	Land Cost	Total Taxes	Project Cost with IDC	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	O&M Cost	Additional Capital	Operational Surplus
2012	-	13	15719	2493	0	18211	0	0	0	0	0	-18211
2013	-	14	33009	2493	0	35634	0	0	0	0	0	-35634
2014	-	15	51989	0	0	52399	0	0	0	0	0	-52399
2015	-	16	54589	0	0	55435	0	0	0	0	0	-55435
2016	-	17	19106	0	0	20411	0	0	0	0	0	-20411
2017	-	18				1465	6001	600	6601	4609	0	527
2018	-	19					6902	690	7592	4905	0	2687
2019	-	20					7157	716	7873	5139	0	2733
2020	-	21					7421	742	8163	5475	0	2688
2021	-	22					8406	841	9247	5748	0	3499
2022	-	23					8717	872	9589	6127	0	3462
2023	-	24					9039	904	9943	6444	0	3499
2024	-	25					10532	1053	11585	6876	12390	-7681
2025	-	26					10921	1092	12013	8152	0	3861
2026	-	27					11279	1128	12407	8692	0	3715
2027	-	28					12921	1292	14213	9134	0	5079
2028	-	29					13367	1337	14704	9745	0	4959
2029	-	30					13828	1383	15211	10260	0	4951
2030	-	31					15964	1596	17560	10960	8382	-1782
2031	-	32					16514	1651	18166	12407	0	5759
2032	-	33					17084	1708	18792	13245	0	5547
2033	-	34					19599	1960	21559	13955	0	7604
2034	-	35					20275	2028	22303	14915	0	7387
2035	-	36					20975	2097	23072	15744	0	7328
2036	-	37					24195	2420	26615	16837	3734	6043
2037	-	38					25030	2503	27533	17806	0	9727
2038	-	39					25893	2589	28482	19063	0	9419
2039	-	40					29574	2957	32532	20196	0	12336
2040	-	41					30595	3059	33654	21645	0	12009
2041	-	42					31650	3165	34815	22971	0	11844
2042	-	43					36120	3612	39732	24638	0	15094
2043	-	44					36843	3684	40527	26191	0	14335
2044	-	45					37579	3758	41337	28119	0	13219
2045	-	46					42412	4241	46653	29941	30929	-14216
2046	-	47					43260	4326	47587	32172	0	15414
2047	-	48					44126	4413	48538	34386	0	14152
2048	-	49					50341	5034	55375	36752	0	18623
2049	-	50					51348	5135	56483	39281	0	17201
2050	-	51					52375	5237	57612	41984	0	15628
2051	-	52					59170	5917	65087	44874	0	20214
2052	-	53					60354	6035	66389	47962	0	18427
2053	-	54					61561	6156	67717	51262	0	16455
2054	-	55					70364	7036	77401	54790	0	22611
2055	-	56					71771	7177	78949	58560	0	20389
Total			177755	4985	177755	4985	1121464	112146	1233611	841826	55435	152660
										FIRR%		**2.17**

Table 12.16 Project FIRR with both Central and State Taxes & DMRC Fares

Year	Project Completion Cost	Land Cost	Total Taxes	Project Cost with IDC	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	O&M Cost	Additional Capital	Operational Surplus
2012 - 13	15719	2493	2984	21195	0	0	0			-21195
2013 - 14	33009	2493	6266	41900	0	0	0			-41900
2014 - 15	51989		9869	62268	0	0	0			-62268
2015 - 16	54589		10363	65798	0	0	0			-65798
2016 - 17	19106		3627	24038	0	0	0			-24038
2017 - 18				1465	7029	703	7732	4609	0	1658
2018 - 19					7835	784	8619	4905	0	3714
2019 - 20					8125	812	8937	5139	0	3798
2020 - 21					9057	906	9962	5475	0	4487
2021 - 22					9391	939	10330	5748	0	4583
2022 - 23					10469	1047	11516	6127	0	5388
2023 - 24					10855	1086	11941	6444	0	5497
2024 - 25					12101	1210	13311	6876	12390	-5955
2025 - 26					12548	1255	13802	8152	0	5650
2026 - 27					13987	1399	15386	8692	0	6694
2027 - 28					14470	1447	15917	9134	0	6782
2028 - 29					16091	1609	17701	9745	0	7956
2029 - 30					16646	1665	18311	10260	0	8051
2030 - 31					18512	1851	20364	10960	8382	1022
2031 - 32					19151	1915	21066	12407	0	8659
2032 - 33					21297	2130	23427	13245	0	10182
2033 - 34					22032	2203	24235	13955	0	10280
2034 - 35					24501	2450	26952	14915	0	12036
2035 - 36					25347	2535	27881	15744	0	12137
2036 - 37					28188	2819	31006	16837	3734	10435
2037 - 38					29160	2916	32076	17806	0	14270
2038 - 39					32428	3243	35671	19063	0	16608
2039 - 40					33547	3355	36902	20196	0	16706
2040 - 41					37307	3731	41038	21645	0	19393
2041 - 42					38594	3859	42453	22971	0	19483
2042 - 43					42920	4292	47212	24638	0	22574
2043 - 44					43778	4378	48156	26191	0	21964
2044 - 45					48003	4800	52803	28119	0	24684
2045 - 46					48963	4896	53859	29941	30929	-7011
2046 - 47					53688	5369	59056	32172	0	26884
2047 - 48					54761	5476	60237	34386	0	25851
2048 - 49					60046	6005	66050	36752	0	29298
2049 - 50					61247	6125	67371	39281	0	28090
2050 - 51					67157	6716	73873	41984	0	31888
2051 - 52					68500	6850	75350	44874	0	30476
2052 - 53					75110	7511	82621	47962	0	34660
2053 - 54					76613	7661	84274	51262	0	33012
2054 - 55					84006	8401	92406	54790	0	37617
2055 - 56					85686	8569	94254	58560	0	35694
Total	177755	4985	29654	216631	1349144	134914	1484058	841826	55435	369998
								FIRR%		**3.7**

Table 12.17- Project FIRR with only Central Taxes & DMRC Fares

Year			Project Completion Cost	Land Cost	Total Taxes	Project Cost with IDC	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	O&M Cost	Additional Capital	Operational Surplus
2012	-	13	15719	2493	2145	20357	0	0	0			-20357
2013	-	14	33009	2493	4505	40139	0	0	0			-40139
2014	-	15	51989	0	7096	59494	0	0	0			-59494
2015	-	16	54589	0	7451	62885	0	0	0			-62885
2016	-	17	19106	0	2608	23018	0	0	0			-23018
2017	-	18				1465	7029	703	7732	4609	0	1658
2018	-	19					7835	784	8619	4905	0	3714
2019	-	20					8125	812	8937	5139	0	3798
2020	-	21					9057	906	9962	5475	0	4487
2021	-	22					9391	939	10330	5748	0	4583
2022	-	23					10469	1047	11516	6127	0	5388
2023	-	24					10855	1086	11941	6444	0	5497
2024	-	25					12101	1210	13311	6876	12390	-5955
2025	-	26					12548	1255	13802	8152	0	5650
2026	-	27					13987	1399	15386	8692	0	6694
2027	-	28					14470	1447	15917	9134	0	6782
2028	-	29					16091	1609	17701	9745	0	7956
2029	-	30					16646	1665	18311	10260	0	8051
2030	-	31					18512	1851	20364	10960	8382	1022
2031	-	32					19151	1915	21066	12407	0	8659
2032	-	33					21297	2130	23427	13245	0	10182
2033	-	34					22032	2203	24235	13955	0	10280
2034	-	35					24501	2450	26952	14915	0	12036
2035	-	36					25347	2535	27881	15744	0	12137
2036	-	37					28188	2819	31006	16837	3734	10435
2037	-	38					29160	2916	32076	17806	0	14270
2038	-	39					32428	3243	35671	19063	0	16608
2039	-	40					33547	3355	36902	20196	0	16706
2040	-	41					37307	3731	41038	21645	0	19393
2041	-	42					38594	3859	42453	22971	0	19483
2042	-	43					42920	4292	47212	24638	0	22574
2043	-	44					43778	4378	48156	26191	0	21964
2044	-	45					48003	4800	52803	28119	0	24684
2045	-	46					48963	4896	53859	29941	30929	-7011
2046	-	47					53688	5369	59056	32172	0	26884
2047	-	48					54761	5476	60237	34386	0	25851
2048	-	49					60046	6005	66050	36752	0	29298
2049	-	50					61247	6125	67371	39281	0	28090
2050	-	51					67157	6716	73873	41984	0	31888
2051	-	52					68500	6850	75350	44874	0	30476
2052	-	53					75110	7511	82621	47962	0	34660
2053	-	54					76613	7661	84274	51262	0	33012
2054	-	55					84006	8401	92406	54790	0	37617
2055	-	56					85686	8569	94254	58560	0	35694
Total			177755	4985	23795	210771	1349144	134914	1484058	841826	55435	379302
										FIRR%		**3.8**

Table 12.18- Project FIRR without any Taxes & DMRC Fares

Year			Project Completion Cost	Land Cost	Total Taxes	Project Cost with IDC	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	O&M Cost	Additional Capital	Operational Surplus
2012	-	13	15719	2493	0	18211	0	0	0	0	0	-18211
2013	-	14	33009	2493	0	35634	0	0	0	0	0	-35634
2014	-	15	51989	0	0	52399	0	0	0	0	0	-52399
2015	-	16	54589	0	0	55435	0	0	0	0	0	-55435
2016	-	17	19106	0	0	20411	0	0	0	0	0	-20411
2017	-	18				1465	7029	703	7732	4609	0	1658
2018	-	19					7835	784	8619	4905	0	3714
2019	-	20					8125	812	8937	5139	0	3798
2020	-	21					9057	906	9962	5475	0	4487
2021	-	22					9391	939	10330	5748	0	4583
2022	-	23					10469	1047	11516	6127	0	5388
2023	-	24					10855	1086	11941	6444	0	5497
2024	-	25					12101	1210	13311	6876	12390	-5955
2025	-	26					12548	1255	13802	8152	0	5650
2026	-	27					13987	1399	15386	8692	0	6694
2027	-	28					14470	1447	15917	9134	0	6782
2028	-	29					16091	1609	17701	9745	0	7956
2029	-	30					16646	1665	18311	10260	0	8051
2030	-	31					18512	1851	20364	10960	8382	1022
2031	-	32					19151	1915	21066	12407	0	8659
2032	-	33					21297	2130	23427	13245	0	10182
2033	-	34					22032	2203	24235	13955	0	10280
2034	-	35					24501	2450	26952	14915	0	12036
2035	-	36					25347	2535	27881	15744	0	12137
2036	-	37					28188	2819	31006	16837	3734	10435
2037	-	38					29160	2916	32076	17806	0	14270
2038	-	39					32428	3243	35671	19063	0	16608
2039	-	40					33547	3355	36902	20196	0	16706
2040	-	41					37307	3731	41038	21645	0	19393
2041	-	42					38594	3859	42453	22971	0	19483
2042	-	43					42920	4292	47212	24638	0	22574
2043	-	44					43778	4378	48156	26191	0	21964
2044	-	45					48003	4800	52803	28119	0	24684
2045	-	46					48963	4896	53859	29941	30929	-7011
2046	-	47					53688	5369	59056	32172	0	26884
2047	-	48					54761	5476	60237	34386	0	25851
2048	-	49					60046	6005	66050	36752	0	29298
2049	-	50					61247	6125	67371	39281	0	28090
2050	-	51					67157	6716	73873	41984	0	31888
2051	-	52					68500	6850	75350	44874	0	30476
2052	-	53					75110	7511	82621	47962	0	34660
2053	-	54					76613	7661	84274	51262	0	33012
2054	-	55					84006	8401	92406	54790	0	37617
2055	-	56					85686	8569	94254	58560	0	35694
Total			152570	4985	0	186976	1349144	134914	1484058	841826	55435	403107
										FIRR%		**4.33**

12.7.1 Sensitivity Analysis

The FIRR of the project is sensitive to revenues, capital and O&M costs. The sensitivity of the project with respect to these factors is given in **Table 12.19**. The revenue sensitivity has been carried out with respect to MMRDA fares only.

Table 12.19 FIRR SENSTIVITY ANALYSIS

Cost With Central & State Taxes				Cost With Central Taxes				Cost Without Any Taxes			
CAPITAL COSTS											
10%	**20%**	**-10%**	**-20%**	**10%**	**20%**	**-10%**	**-20%**	**10%**	**20%**	**-10%**	**-20%**
1.3%	1%	1.9%	2.2%	1.4%	1.1%	2.0%	3.0%	1.82%	1.5%	2.56%	2.4%
REVENUE											
10%	**20%**	**-10%**	**-20%**	**10%**	**20%**	**-10%**	**-20%**	**10%**	**20%**	**-10%**	**-20%**
2.7%	3.7%	-0.1%	-2.9%	2.9%	3.9%	0.1%	-2.8%	3.38%	4.36%	0.5%	-2.3%
O&M COSTS											
10%	**20%**	**-10%**	**-20%**	**10%**	**20%**	**-10%**	**-20%**	**10%**	**20%**	**-10%**	**-20%**
0.5%	-0.9%	2.4%	3.1%	0.7%	-.07%	2.6%	3.3%	1.11%	-.31%	3.02%	3.75%

12.7.2 Conclusions

It is concluded that the project will be able to comfortably bear the O&M cost and thus, has operational sustainability. A public service project like urban mass transit system require government support for funding, which may be suitably worked out and considered**.**

12.8 FUNDING OPTIONS

12.8.1 Metro Rail Projects are highly capital intensive with long gestation period. Given the tariff constraints, they are not commercially attractive for investment. However, Mumbai's Colaba- Bandra- Seepz MRTS project is estimated to give a high economic rate of return to the tune of 17%, which means investment on this project will be recovered by the city/society within 6 to 7 years time. Only a few metros in the world make operational profits. Thus, the Government involvement in the funding of metro systems is a foregone conclusion.

Experience all over the world reveals that both construction and operations of a metro are highly subsidised and funded by the Government. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the subsequent 2 lines. Others run on Governmental support and subsidies. Some of the metros which have access to tax levies are Sao Paulo, New York and Paris. If commercial capital city of India is to have Metro System on self sustainable basis, it is necessary to keep down the capital cost as much as possible by way of giving government land as grant /exempting taxes for the project and also required funding is made available from the Government sources.

12.8.2 Indian Experience

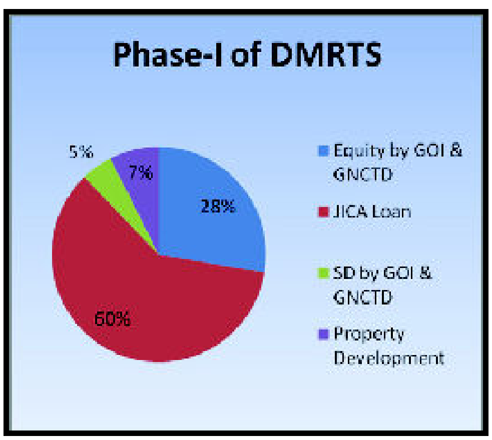
The Metro Rail projects implemented and those under implementation have huge government funding either directly as equity and subordinate debt or through government guaranteed Japanese ODA loan from JICA. The financial patterns of some of the Indian metros are as follows: -

12.8.3 Kolkata Metro:

Metro Railway, Kolkata is the first underground Metro Railway in India. It extends from Dum-Dum near Netaji Subhash Chandra Bose airport, Kolkata to Tollygunj, the busy north south axis of Kolkata over a length of 16.45 KMs. The Metro Railway Kolkata was constructed progressively from 1972 to 1995 by the Indian Railways who also operate the system on a highly subsidised fare.

12.8.4 Delhi Metro:

Delhi Metro Rail Corporation was established in 1995 to construct metro rail system in the capital city of Delhi. The company was formed as a Joint Venture between GOI & GNCTD with equal equity contribution by these two governments. The first phase covering 65.1 KMs route length was commissioned in phased manner. The last section was commissioned in Nov-2006. About 60% of the project was funded by Japanese ODA loan through JICA. The balance cost was contributed by GOI & GNCTD as equity and subordinate debt apart from raising funds from Property Development. The second phase of DMRTS project covering a distance of 82.11 KMs within the Delhi Area has also been funded by both the governments in the same pattern with JICA funding of 46% and raising of part funding from Property Development and internal accruals. In addition to expansion of metro network in the city of Delhi, extension to National Capital Regions (NCR) viz., Noida, Gurgaon and Vaishali are also been undertaken by DMRC as a deposit work with the entire cost other than Rolling Stock being contributed by these states. The funding pattern of Delhi Metro Phase-I & II is depicted in **Figure 12.2 .**



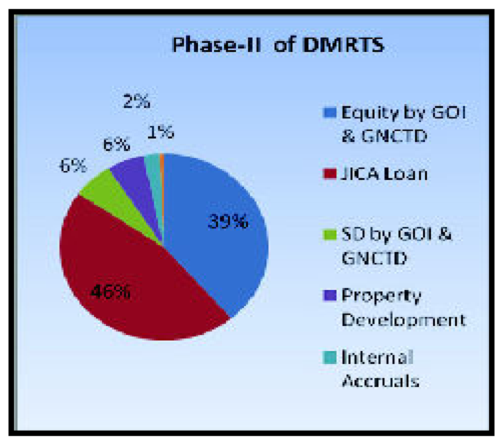


Fig 12.2: Funding Pattern of Delhi Metro Phase-I & II

Airport Line under PPP Model at New Delhi :

Apart from the above, DMRC has executed a High Speed Airport Link from New Delhi Railway Station to IGI Airport and further extension to Sector-21, Dwarka covering a distance of 22.7 KMs.

The project with an estimated cost of Rs. 3869 Crore has been implemented under a unique model of PPP where in the DMRC has undertaken the civil works with the funds being contributed by GOI, GNCTD, Delhi International Airport Limited and DDA (54%) and the cost of systems and Rolling Stock (46%) is being met by the private operator who will operate the system for 30 years, after which the system will revert back to DMRC. The approved funding pattern of the line is depicted in **Figure 12.3.**

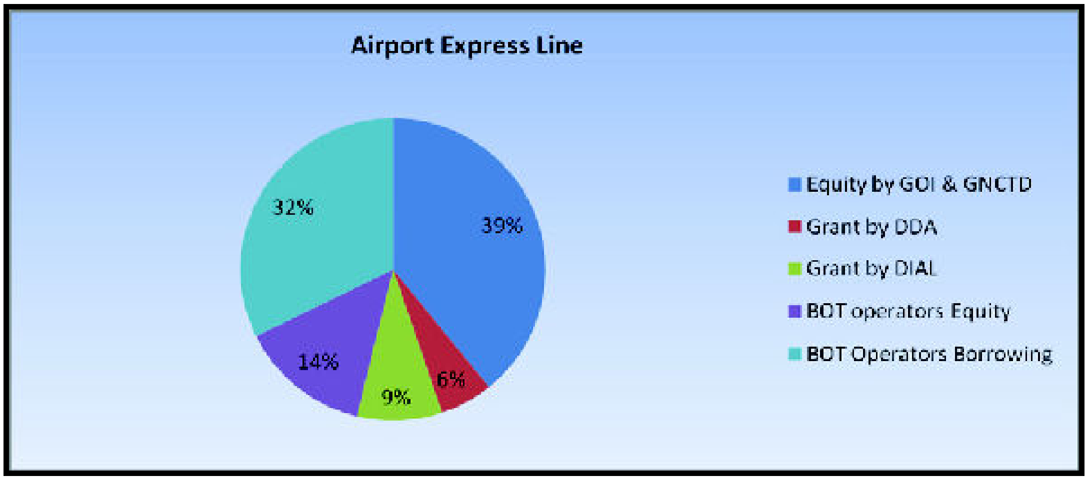


Figure 12.3: Funding Pattern of Airport Line

12.8.5 Bangalore Metro

Bangalore Metro Rail Corporation has been formed as a Joint Venture between GOI & Karnataka State Government with equal equity contribution by these two governments for construction of 33 KMs of metro. Out of the estimated total cost of Rs. 6395 Crore, 55% has been funded by GOI & GOKN and the balance 45% is being raised as senior debt including JICA ODA Loan. The Phase-I project has started operation recently. The state Government has already enacted a law to charge Rs. 2 a litre on diesel and petrol sold in the city of Bangalore for raising the funds required for Metro Project. The approved funding pattern of the line is depicted in **Figure 12.4.**

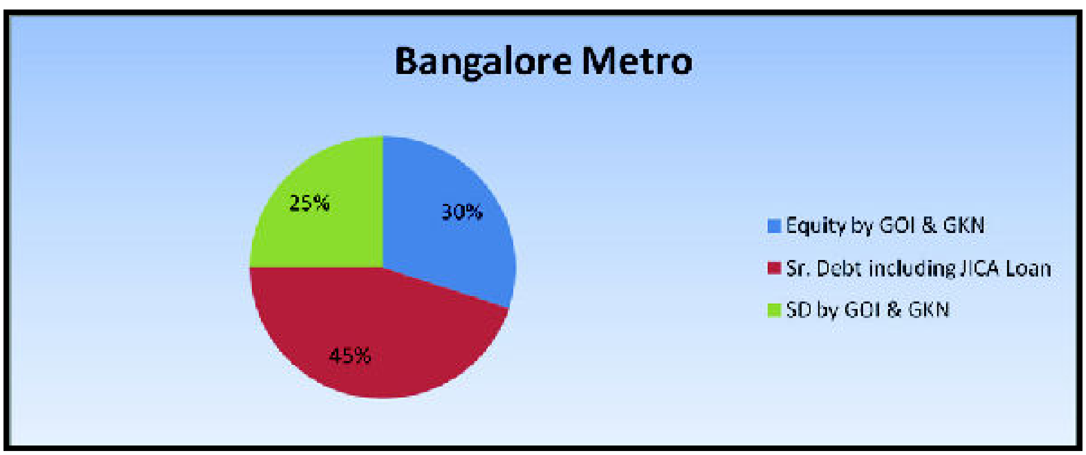


Figure 12.4: Funding Pattern of Bangalore Metro

12.8.6 Chennai Metro

Chennai Metro Rail Corporation has been formed as a Joint Venture between GOI & Tamilnadu State Government with equal equity contribution by these two governments for construction of 45.046 KMS of metro. Out of the estimated total cost of Rs. 14600 Crore, 40.78% has been funded by GOI & GOTN and the balance 59.22% is being contributed by JICA ODA Loan. The construction works of Phase-I project is under progress. The approved funding pattern of the line is depicted in **Figure 12.5.**

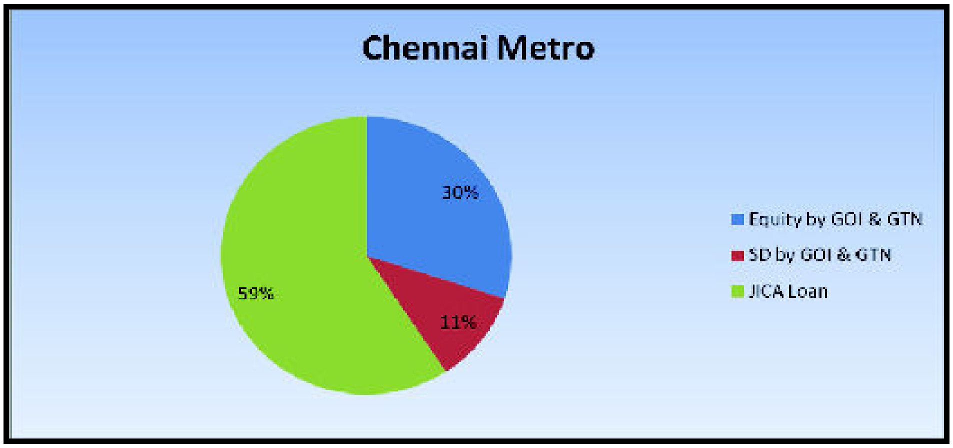


Figure 12.5: Funding Pattern of Chennai Metro

12.8.7 Kolkata Metro (East West Corridor):

Kolkata Metro Rail Corporation was also formed as a Joint Venture between GOI & West Bengal State Government with equal equity contribution by these two governments for construction of 13.77 KMs of metro. Out of the estimated total cost of Rs. 4676 Crore, 55% has been funded by GOI & GOWB and the balance 45% is being contributed by JICA ODA Loan. The construction works are under progress. The approved funding pattern of the line is depicted in **Figure 12.6.**

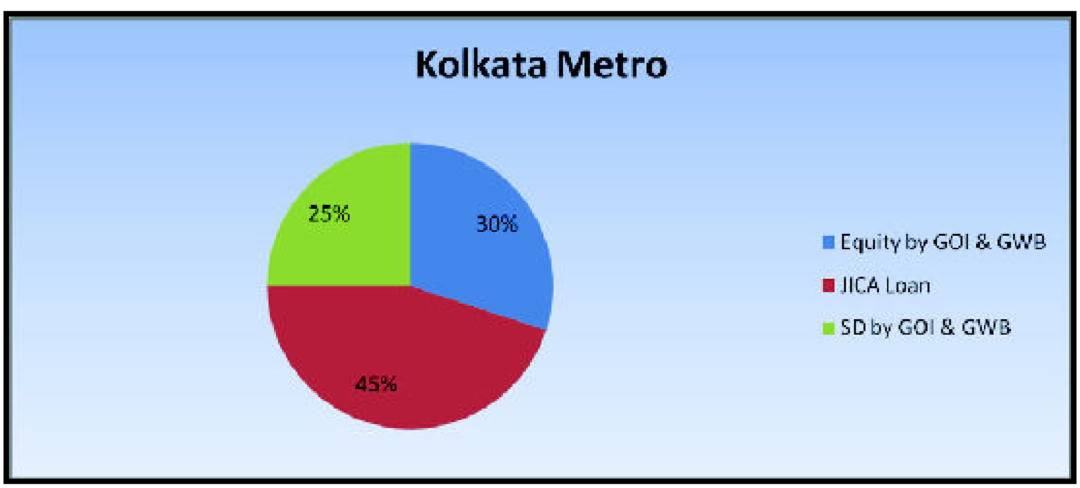


Figure 12.6: Funding Pattern of Kolkata Metro

12.8.8 Mumbai Metro Line 1 & 2:

In contrast to the SPV model adopted for construction of metro rail system in the city of Delhi, Bangalore, Chennai & Kolkata, the Maharashtra state government has opted Build Own, Operate & Transfer (BOOT) model in the city of Mumbai. So far, 2 lines covering a distance of 44 KMs (Line 1 of 11.07 KMs from Versova – Andheri - Ghatkopar with a total cost of Rs. 2356 Crore and Line 2 of 32 KMs from Charkop – Bandra – Mankurd with an estimated cost of Rs. 8250 Crore) have been awarded to private operator for construction and operation by giving Viability Gap Funding by GOI & Maharashtra State Government to the extent of Rs. 650 Crore and Rs. 1532 Crore for Line 1 & Line 2 respectively

12.9 SOURCES OF FINANCING FOR LINE-III OF MUMBAI METRO

(i) Equity

DMRC/BMRC pattern of Financing: Under this pattern a Special Purpose Vehicle (SPV) is set up for the implementation of the project and for its subsequent Operation & Maintenance. Under this arrangement Government of India and Government of Maharashtra (GOM) shall make equal contribution and run SPV as a commercial enterprise. As per the prevalent practice, Central Government may be willing to contribute 20% of the project cost as their equity contribution. An equal amount can be contributed by GOM aggregating the total equity to 40%. With the equal ownership of the SPV, both the governments nominate their representatives as members of the Board of Directors, which in turn select functional directors. Such a SPV has a benefit of independent management under the aegis of Indian Companies Act, 1956. Delhi Metro Rail Corporation, Bangalore Metro Rail Corporation, Chennai Metro Rail Corporation & Kolkatta Metro Rail Corporation are some of the examples of success of such a SPV. For the balance 60% funding requirement, options available are as follows: -

(i) Debt: - The balance cost is to be met through loans from various institutions namely **JICA,** Local borrowing, loans from ADB/World Bank and Suppliers Credit.

JICA Loan: - Overseas Development Loan from Japan Bank for International Cooperation (JICA) can be availed of for metro rail projects. The prevailing interest rate is 1.40% p.a. The loan is repayable in 30 years including moratorium period of 10 years. The loan is up to 60% of the project cost excluding cost of land and taxes and is provided to Central Government which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Normally, JICA agrees to fund for underground civil works, Electrical, Signalling &Telecom and Rolling Stock only. Since the loan will be in Japanese Yen any fluctuation in exchange rate at the time of repayment shall be borne by the Central Government and GOM in proportion to which their share holding. The loan in equivalent INR shall be repaid by SPV from the income streams of metro operations.

(ii) Subordinate Debt: - For existing Phase-I & Phase-II projects of Delhi Metro, land and rehabilitation and resettlement cost have been borne by GOI & GNCTD equally as interest free subordinate debt. This mezzanine financing is of extreme help in quickening the pace of the project. In this project Subordinate debt can be procured to pay back state and central taxes and duties. The loan is of longer duration and becomes repayable only after other loans raised for the project are repaid.

Loan from Asian Development Bank (ADB)/World Bank: - The Loan shall be available from ADB/World Bank, but as per the experience, it's processing and approval normally takes 8-12 months. This may delay the implementation of the project resulting in avoidable increase in the completion cost.

Domestic Loan from Banks and Financial Institutions: - Funds can be arranged from Indian Financial Institutions like India Infrastructure Finance Company Limited (IIFCL), India Development Financing Corporation (IDFC), Life Insurance Corporation of India (LIC), State Bank of India, IDBI Bank, ICICI Bank Ltd etc. These institutions are increasingly engaged to fund infrastructure projects subject to their commercial viability. There are many models available under which the funds can be arranged by these financial institutions with or without syndicating with other commercial banks. IIFCL e.g. fund 20% of the project cost and arrange balance through the syndication of commercial banks with a lead banker among the consortium of bankers. The loan can be given for a period of 20-30 years with interest rate ranging from 9.50% to 12% PA. The funding arrangement may require submission of central government guarantee as well. Since the rate of interest of these financial institutions is much higher than the interest rates of soft loan provided by JICA, Central Government and GOM shall have to bear the interest difference and provide subsidy to the SPV.

Value Capture from Real Estate – Value from real estate should be captured after completion of the project along its alignment. Further there is always an issue of timing mismatch in the requirement of funds and availability of money from Value Capture during the construction stage. It is prudent to have a conservative approach towards value capture during construction period; it is more ideally suited for supplementing the fare-box revenues during the operating stage.

Stakeholder contribution- The stakeholders who get benefited with the coming up of the project can contribute by sharing the cost of land/stations.

12.9.1 Involvement of the Government:

Government contribution is essential to keep debt-servicing levels of metro systems low with a view to maintain overall long term sustainability of the system. Government involvement also generates considerable amount of confidence in other players involved in the process of construction & operation. The capital investment of Line-III of Mumbai metro project is estimated to give an economic rate of return to the tune of 17% and the city/society can recover the investment within 6 to 7 years time, therefore involvement of Government is very much essential to provide integrated, efficient public transport system in the city of Mumbai. Apart from financial support, social considerations require the involvement of the government to ensure a minimum essential level of service to the society. This project, thus serving primarily a social purpose/goal, is needed for improving the overall health of the city and therefore to make the system self sustainable and to achieve its potentials and desired social goals to the fullest extent possible, its construction cost needs to be kept bare minimum. Following are the assumptions made for the finalising the funding pattern of the project:

Cost of Land: Govt land required for the project shall be given as grant by the State Government. Cost of private land has been added to the project and included as government equity but efforts shall be made to meet this cost through TDR and higher FAR.

Exchange Rate Fluctuation Risk- As adopted for Phase-I and Phase-II of Delhi Metro and recently approved Phase III of Delhi Metro, it has been assumed that exchange rate fluctuation risk on the repayment of the JICA loan, shall be borne in equal proportion by the equity holders, viz, GOI & GOM.

Payment of Dividend- As adopted for Phase-I & Phase-II of Delhi Metro, this metro corridor of Mumbai MRTS shall be exempted from the payment of dividend till the senior debt has been fully repaid.

12.10 PROPOSED FUNDING FOR THE PROJECT

The total completion cost of the project including IDC and excluding govt land works out to Rs 216,663 Million. The funding for the same shall be as under:

a. Government Contribution – GOI & GOM will contribute a total equity of Rs 64,343 Million which is 30% of the total completion cost. This means that both GOI and GOM will share 15% of the total cost amounting to Rs 32,172 Million.

b. JICA Loan – JICA funding of 60 % of total completion cost excluding taxes, duties and land cost, works out to 48% of the total completion cost including land and taxes and amounts to Rs 104,647 million as loan.

c. Subordinate Debt: To pay back state and central taxes and duties amounting to Rs 33,109 Million which is 15% of the total completion cost of the project, interest free Subordinate Debt from GOI and GOM is considered. It includes Rs 2471 Million Octroi which can be waived off by the City agencies as the project is for the benefit of the City. The payment of this loan will be after the payment of JICA loan.

d. Stake holder Contribution: It is understood that the cost of stations falling in the areas belonging to MIAL (Mumbai International Airport Authority & ASIDE (Assistance to States for Infrastructure Development for Export Promotion) will be borne by them. Total 5 stations fall in their area and cost of the stations amounting to Rs 14,653 Million (7% of the total project cost) is proposed to be contributed by these agencies as stake holder contribution.

MMRC may also consider asking the stakeholders to pay for additional corridor length for providing connectivity and additional rolling stock for carrying these passengers.

MMRC may however, consider making some design modifications to accommodate the special requirements of the stakeholders.

Figure12.7 gives the funding pattern of cost of Line III of Mumbai MRTS and the **Table 12.20** gives the year wise funds requirement from different sources

Table 12.20 Financing of Project Completion Costs Including IDC

					Rs. Million
Year	JICA Debt	Sub Debt	Equity	Stake Holder Contribution	Total
2012-2013	9431	2984	7467	1313	21195
2013-2014	19805	6266	13072	2756	41900
2014-2015	31194	9869	16864	4341	62268
2015-2016	32753	10363	18123	4558	65798
2016-2017	11464	3627	7352	1595	24038
2017-2018			1465		1465
TOTAL	104647	33109	64343	14563	216663
% Share	48	15	30	7	100

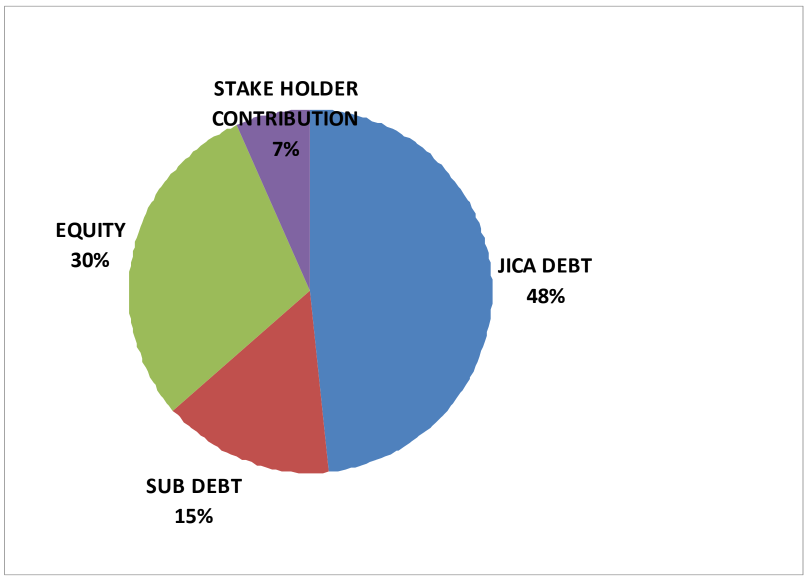


Fig12.7 The Funding Pattern Of Completion Cost of Line III of Mumbai MRTS

12.11 RECOMMENDATIONS

With above funding pattern, the project generates positive cash flows during the analysis period of 44 years **(Table 12.21).** But once the payment of loan starts the project has negative cash flows for 11 years and the project is not able to meets its loan obligations. However, after these 11 years, the project has positive cash flows except two years when replacement of the equipments is required. During the when negative cash flow period, the loan liability of the project can be met by soft loans from MMRDA/MMRC which will be adjusted from future surplus revenues. Thus, the project has potential to service its debt.

All over the world all metro systems do require support from government in initial years till the system gets established and its revenue generation potential is truly exploited. Mumbai Metro Line III may also be implemented on the basis of these international practices.

Table 12.21 Statement of Cash flow with JICA Loan and Taxes as Subordinate Loan

Year	Total Project Completion Cost	Project Cost with IDC	Additional Capital	O&M Cost	Total costs	Fare Box Revenue	Revenue from Adv & PD	Gross Revenue	OPERATIONAL SURPLUS	JICA DEBT	SUB DEBT	Stake Holder (SH)	EQUITY excl SH	INT	DPRCN	PBT	TAX	PAT	Repayment of Principal	Net Surplus
2012-13	21195	21195			21195	0.00	0.00	0.00	-21195	9431	2984	1313	7467				0	0		0
2013-14	41768	41900			41900	0.00	0.00	0.00	-41900	19805	6266	2756	13072				0	0		0
2014-15	61859	62268			62268	0.00	0.00	0.00	-62268	31194	9869	4341	16864				0	0		0
2015-16	64952	65798			65798	0.00	0.00	0.00	-65798	32753	10363	4558	18123				0	0		0
2016-17	22733	24038			24038	0.00	0.00	0.00	-24038	11464	3627	1595	7352				0	0		0
2017-18		1465	0	4609	6074	6001	600	6601	527				1465	0	4536	-4010	0	-4010		527
2018-19			0	4905	4905	6902	690	7592	2687					1465	4536	-3314	0	-3314		1222
2019-20			0	5139	5139	7157	716	7873	2733					1465	4536	-3268	0	-3268		1268
2020-21			0	5475	5475	7421	742	8163	2688					1465	4536	-3313	0	-3313		1223
2021-22			0	5748	5748	8406	841	9247	3499					1465	4536	-2502	0	-2502		2034
2022-23			0	6127	6127	8717	872	9589	3462					2512	4536	-3586	0	-3586	4138	-3188
2023-24			0	6444	6444	9039	904	9943	3499					2412	4536	-3449	0	-3449	4237	-3150
2024-25			12390	6876	19266	10532	1053	11585	-7681					2311	4536	-14528	0	-14528	4339	-14331
2025-26			0	8152	8152	10921	1092	12013	3861					2206	4536	-2882	0	-2882	4443	-2789
2026-27			0	8692	8692	11279	1128	12407	3715					2100	4536	-2921	0	-2921	4550	-2934
2027-28			0	9134	9134	12921	1292	14213	5079					1991	4536	-1448	0	-1448	4659	-1571
2028-29			0	9745	9745	13367	1337	14704	4959					1879	4536	-1456	0	-1456	4771	-1691
2029-30			0	10260	10260	13828	1383	15211	4951					1764	4536	-1350	0	-1350	4885	-1699
2030-31			8382	10960	19342	15964	1596	17560	-1782					1647	4536	-7965	0	-7965	5003	-8431
2031-32			0	12407	12407	16514	1651	18166	5759					1527	4536	-305	0	-305	5123	-891
2032-33			0	13245	13245	17084	1708	18792	5547					1404	4536	-393	0	-393	5246	-1102
2033-34			0	13955	13955	19599	1960	21559	7604					1278	4536	1790	591	1199	5371	364
2034-35			0	14915	14915	20275	2028	22303	7387					1149	4536	1702	562	1140	5500	176
2035-36			0	15744	15744	20975	2097	23072	7328					1017	4536	1775	586	1189	5632	93
2036-37			3734	16837	20571	24195	2420	26615	6043					882	4536	625	206	419	5768	-812
2037-38			0	17806	17806	25030	2503	27533	9727					744	4536	4447	1468	2980	5906	1610
2038-39			0	19063	19063	25893	2589	28482	9419					602	4536	4281	1413	2868	6048	1357
2039-40			0	20196	20196	29574	2957	32532	12336					457	4536	7343	2423	4920	6193	3263

2040-41			0	21645	21645	30595	3059	33654	12009					308	4536	7165	2364	4800	6342	2995
2041-42			0	22971	22971	31650	3165	34815	11844					156	4536	7152	2360	4792	6494	2835
2042-43			0	24638	24638	36120	3612	39732	15094						4536	10558	3484	7074	2207	9403
2043-44			0	26191	26191	36843	3684	40527	14335						4536	9799	3234	6565	2207	8894
2044-45			0	28119	28119	37579	3758	41337	13219						4536	8682	2865	5817	2207	8146
2045-46			30929	29941	60870	42412	4241	46653	-14216						4536	-18753	0	-18753	2207	-16424
2046-47			0	32172	32172	43260	4326	47587	15414						4536	10878	3590	7288	2207	9617
2047-48			0	34386	89821	44126	4413	48538	-41283						4536	-45819	0	-45819	2207	-43490
2048-49			0	36752	36752	50341	5034	55375	18623						4536	14087	4649	9438	2207	11767
2049-50			0	39281	39281	51348	5135	56483	17201						4536	12665	4179	8486	2207	10815
2050-51			0	41984	41984	52375	5237	57612	15628						4536	11092	3660	7431	2207	9760
2051-52			0	44874	44874	59170	5917	65087	20214						4536	15677	5173	10504	2207	12833
2052-53			0	47962	47962	60354	6035	66389	18427						4536	13891	4584	9307	2207	11636
2053-54			0	51262	51262	61561	6156	67717	16455						4536	11918	3933	7985	2207	10314
2054-55			0	54790	54790	70364	7036	77401	22611						4536	18075	5965	12110	2207	14439
2055-56			0	58560	58560	71771	7177	78949	20389						4536	15852	5231	10621	2207	12950

13. IMPLEMENTATION PLAN

13.1 WAY FORWARD

On receipt of the Detailed Project Report, following action will be required for implementing the Colaba – Bandra – SEEPZ metro line:

- Approval of Maharashtra State Government (Cabinet Approval) to the Detailed Project Report
- Issue of notification for the project and alignment
- The DPR to be forwarded to the Ministry of Urban Development, Planning Commission and Finance Ministry with the request for approving the Metro project and for financial participation through equity contribution to the SPV
- Land acquisition related issues
- Examination and appraisal of DPR by JICA
- Stakeholder consultation on environmental and social impact
- Signing of an MOU between Maharashtra State Government and Government of India giving all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure, operational subsidy, if any, etc.
- Loan approval
- Set up a Special Purpose Vehicle (SPV) or implementing the project and for its subsequent Operation and Maintenance
- Appointment of General Consultants (G.C.) for the project
- Providing legal cover for construction as well as operation and maintenance stages of the project
- Agreement between the State and Central Government for financing the debt portion of the project alongwith the setting up of time frame for completing the project
- Packaging and invitation of bids for various contracts

13.2 INSTITUTIONAL ARRANGEMENTS

Effective institutional arrangements need to be set up to enable the Colaba - Bandra - SEEPZ Metro Corridor project to be implemented without any loss of time and cost over-run. Details of these arrangements are discussed in following sections.

13.2.1 Setting Up of Special Purpose Vehicle (SPV)

Experience of implementing Delhi Metro project has shown that a Special Purpose

Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro rail project.

An SPV named **MMRC** (Mumbai Metro Rail Corporation Ltd.) has already been incorporated on 30.4.2008 with the mandate "To establish, Operate and Maintain Guided Urban Transit Systems in and around Mumbai City so as to meet the urban transport needs of Mumbai". This SPV with a re-structured board of directors (wityh GOI representatives) may implement the Colaba – Bandra – SEEPZ Metro project.

Metro construction is a very specialized and multi disciplinary job. It is therefore, impossible to have a single organizational set up which can be responsible for all aspects of metro implementation, namely investigation, planning, design, drawing up of specifications, preparation of tender documents, fixing of contractors, supervising the contractors' works, ensuring interface fusion between different contractors, ensuring quality and safety during constructions, planning and supervising integration system trials and getting the project commissioned in time.

It is suggested to have a two tier organization with well defined responsibilities for getting this project executed. At the apex will be the restructured **MMRC** (with representation of Govt. Of India) - a lean but effective organization with full mandate and total power – with accountability The second level will be a project management team called "General Consultants" who will be engaged by the **MMRC** on contract basis and who will be fully responsible for planning, design and project management. In fact they will be the "Engineers" for the **MMRC**, who is the "client". General Consultants may be fixed on the basis of competitive bidding, the way General Consultants were fixed for the Delhi Metro Project. Any further detailed design consultants required may be engaged by General Consultants as their sub-Consultants within their own contract responsibilities.

Since the complete alignment is underground, it is recommended that the contracts be made on "design and build" basis, based on broad technical specifications and performance requirements drawn up by the G.C.. International Consultants are very expensive and should be engaged only in area where Indian experts cannot manage and they should invariably be part of the General Consultants' team.

The restructured **MMRC** Organization (**Figure 13.1**) may consist of a non-executive Chairman, a Managing Director with full Executive Powers and three Functional Directors. The Functional Directors will be the full members of the Management Board. The Directors will be assisted by Heads of Departments in each of the major disciplines and they in turn will have deputy heads of Departments. The organization should be basically officer-oriented with only Personal Assistants and Technical Assistants attached to senior officers by eliminating unproductive layers of staff such as Peons, Clerks, etc. It is strongly recommended that the total organizational strength is limited to 45 to 50 eliminating too many tiers to enable faster decision making.

13.2.2 High Power Committee

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Maharashtra should be set up. Other members of this Committee may be the Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project.

This Committee should meet once a month and sort out all problems brought before it by MMRC. For Delhi Metro also, such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro rail project.

13.2.3 Empowered Committee

At the Central Government level an Empowered Committee, under the chairmanship of Cabinet Secretary, is presently functioning for Delhi Metro project. Other members of this Committee are Secretaries of Planning Commission, Ministry of Home Affairs, Ministry of Urban Development, Ministry of Surface Transport, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi Government and a representative from the PMO. The Empowered Committee meets regularly and takes decisions on matters connected with inter-departmental coordination and overall planning, financing and implementation of the Delhi Metro project.

It is suggested that the role of this Empowered Committee is extended to include Mumbai Metro project also and the Chief Secretary, Maharashtra is inducted as a member of this Committee.

13.2.4 Group of Ministers

Union Cabinet had set up a Group of Ministers (GOM) to take decisions on behalf of the Cabinet on policy matters concerning Delhi Metro project. The Group of Ministers is chaired by the Home Minister. Other members of the GOM are Minister of Urban Development and Poverty Alleviation, Minister of Railways, Minister of Finance and Company Affairs and Deputy Chairman Planning Commission. The GOM meets whenever any problem requiring decision on behalf of the Union Cabinet is to be taken. It is suggested that the role of this GOM is enlarged to include Mumbai Metro. The Chief Minister, Maharashtra should be inducted as a member and attend the meetings whenever any issue concerning Mumbai Metro is to be deliberated upon.

13.3 IMPLEMENTATION SCHEDULE

SPV may initiate action for appointment of General Consultants for project management including preparation of tender documents. The proposed date of commissioning of the section with suggested dates of important milestones is given in **Table 13.1**.

Table 13.1: Project Implementation Schedule

Sr. No.	Tasks	Duration (in weeks	Start Date	Finish Date
1	PREPARATION OF DPR	17.4	2.8.2011	30.11.2011
2	APPROVAL OF DPR & G.R. REVISION	15	1.12.2011	14.3.2012
3	LAND ACQUISITION AND CLEARANCES	52.4	15.9.2011	14.9.2012
4	PARALLEL ACTIVITIES	27	1.12.2011	6.6.2012
5	GoI Approval	52.4	15.9.2011	14.9.2012
6	APPOINTMENT OF G.C.	29	2.11.2011	22.5.2012
7	PACKAGING AND INVITATION OF BIDS BY GENERAL CONSULTANT	24	1.10.2012	15.3.2013

13.4 CONTRACTS

13.4.1 Civil Works

Since the complete corridor is underground, design and build contracts are recommended as in Delhi Metro phase I. Architectural finishes, fire fighting arrangements and general electrification, will form part of civil contracts.

13.4.2 System Contracts

These contracts will generally be on 'design construct and installation' basis. The number of contracts may be as under:-

- Design, construct and installation for Traction and Power Supply.
- Design, construct and installation of Signal and Telecommunication works.
- Design, construct and installation of lifts.
- Design, construct and installation of escalators.
- Design, construct and commissioning of Automatic Fare Collection System.
- Design, manufacture and supply of rolling stock.
- Installation of track in Depot and on main line.
- Design and installation of Signages.

13.4.3 Depot Contracts

Following contracts are proposed for Depot works:

- Design of Depot layout and buildings.
- Construction of Depot including general electrification.

For the supply of depot equipments, the number of contracts may be decided as and when the work is in progress.

13.5 LEGAL FRAMEWORK

Metro rail projects are undertaken in congested urban environment. Metro lines have, therefore, to pass through heavily built-up areas. As vacant land for laying these lines is seldom available, they have to be constructed either as elevated or underground. When elevated, the metro lines are generally located along the medians of the existing roads to obviate the need for acquiring land. Even in such cases, land is to be acquired for sitting station buildings, traffic integration areas, etc. After construction of a metro line is complete, it has to be certified as 'safe' by a statutory authority before it can be opened for public carriage of passengers.

For operation and maintenance of a metro line, which has been commissioned for traffic, several crucial issues having legal implications need to be taken care of. These include continued monitoring of safety of train operations, security of metro properties, maintaining law and order within metro premises, enquiries into accidents involving metro trains whenever they happen, deciding the extent of compensation payable for damages/injuries/casualties arising out of such accidents, laying down passenger fares and their subsequent revision etc. There has, therefore, to be a proper legal frame-work to take care of such problems encountered during construction as well as operation of metro rail lines. Hence there is a need for a comprehensive legislation on Metro Railways.

Ministry of Urban Development, Government of India, vide its letter no. K-14011/40/2003-Metro, dated 8.9.2011 conveyed the decision of GoI on the legislative framework of Metro Rail Projects in India. It states that Metro Railway being 'Railway' shall be treated as a Central subject. The Ministry of Urban Development is the nodal Ministry for Planning and Coordination of all urban transport systems including Metro Railways.

Through Metro Railways (Amendment) Act, 2009, the Metro Railways (Construction of Works) Act, 1978 & its amendment and the Delhi Metro Railway (Operation & Maintenance) Act, 2002 were amended and their provisions have been made applicable to all metropolitan areas in India.

It is, therefore, recommended that the construction of Colaba – Bandra – SEEPZ metro line is taken under the Metro Railways Act 1978. As and when the comprehensive Metro Act is processed and enacted, it will give the required legal cover for the Operations and Maintenance of Colaba – Bandra – SEEPZ metro line.

13.6 CONCESSIONS FROM GOVERNMENT

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return though their economic internal rate of return is very high. With reasonable fare levels, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus, the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level.

Experience of Delhi Metro project has shown that the taxes and duties (including custom duty, Excise Duty, Sales Tax, Taxes on electricity, Municipal Taxes) constitute about 15 – 16% of a metro project cost. **MMRDA/MMRC** may try to get exemption from these for the implementation of this important infrastructure project.

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- Sales Tax on works contracts to be executed for the implementation of the -project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

Further, the transfer of Govt. land required for the project could be considered free of cost or at the most at Govt. rates. The cost of private land could also be recovered through TDRs and higher FARs.

MMRDA/MMRC may consider roping in more stakeholders, who would directly/ indirectly benefit from the system, for partly sharing the cost of metro construction.

Additional taxes due to improved accessibility, higher property rates (as a result of metro availability) may also be considered in the immediate influence area of metro corridor.

Figure 13.1: Organization Structure of MMRC