DETAILED PROJECT REPORT(UPDATED)
Andheri (E) – Dahisar (E) CORRIDOR
(FINAL)

CLIENT : MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY (MMRDA)

Prepared By

DELHI METRO RAIL CORPORATION LTD.

August 2015

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Contents

SALIENT FEATURES

1.	**GAUGE (NOMINAL):**	1435 mm
2.	**ROUTE LENGTH:**	16.475 Kms (Completely Elevated)
3.	**NUMBER OF STATIONS:**	16(All Elevated)

4 TRAFFIC PROJECTION

Year	PHPDT	Daily Trips	Average Lead in KM
2016	12800	388440	6.58
2019	15602	472590	6.58
2021	18086	528690	6.58
2031	18584	667698	6.04

5. TRAIN OPERATION:

	Item	**Horizon Year**		
		2019	**2021**	**2031**
a.	Train composition	6 cars	6 cars	6 cars
b.	Designed Train headway (Peak Hour)	6.5 min	5.5 min	5.5 min
c.	PHPDT demand	15602	18086	18584
d.	**PHPDT Capacity**	14136	19156	19156
		(With 6 standees per sqm.)		
e.	Rakes required	13	15	15
f.	Coaches required	68	80	90

6.	i. Design speed	90 Kmph
	ii. Maximum operating speed	80 Kmph
	iii. Schedule (Booked) Speed	32 Kmph

7. Traction Power Supply:

a.	Traction system voltage	25 kV AC
b.	Current Collection	Over Head Catenary
c.	Receiving Sub Stations	One at Mumbai Exhibition ground and secondin Maintenance Depot at Dehisar

8. ROLLING STOCK

a.	3.20 m wide rolling stock with stainless steel body	
b.	Axle load	17 T
c.	Seating arrangement	Longitudinal
d.	Capacity of 6 coach unit	
	i) With 6 standees / sqm.	1756
	ii) With 8 standees / sqm.	2244
e.	Class of accommodation	One (Air conditioned)

9. MAINTENANCE FACILITIES:

Maintenance Depot has been proposed near terminal station at Dahisar in 15 Ha. land area of Airports Authority of India.

10. SIGNALLING, TELECOMMUNICATION AND TRAIN CONTROL:

a)	Type of Signalling	'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.
b)	Telecommunication	i. Integrated System with Optic Fibre cable, SCADA, Train Radio, PA system etc. ii. Train information system, Control telephones and Centralized Clock System. .

11. FARE COLLECTION

Automatic Fare collection system with POM and Smart card etc.

12. STRUCTURE:

i. Viaduct: Precast segment Twin U girders on Single pier with pile / Open foundations upto radius 300m and flatter, for sharper curves I-Girder..

ii. Station structure on columns, independent of viaduct piers.

13. TOTAL ESTIMATED COST:

i) Estimated cost with central taxes only (At July 2015 prices) — **4628.00 Crores**.

ii) Estimated completion cost with central taxes only (by April 2019 At 7.5% p.a escalation) — **5877.00 Crores.**

iii) FIRR **8.20%**

iv) EIRR **22.06%**

EXECUTIVE SUMMARY

0.1 INTRODUCTION:

0.1.1 Background:

Mumbai, the capital of Maharashtra, is the fastest developing city in India and also the commercial capital of India. It is the land of Finance, Trade and Entertainment. The city displays a cosmopolitan character which is reflected in its cuisine, culture, language and inhabitants.

The city offers jobs and professional abilities in different sectors. Lot of migrants from all over India are attracted to Mumbai. This results in very heavy pressure on the city's infrastructure, particularly transportation.

0.1.2 Population:

The total population of Greater Mumbai in 2011 was 124.42 Lakhs, more than double of population of 59.7 Lakhs in 1971. The rise in population was about 38.02 % during 1971 – 81 but was about 20.54 % during 1981 – 91 and 19.94% during 1991 – 2001. Between 2001 to 2011 the growth in population is only 4.5%. Table 0.1 shows the trend of population in Island City, Western Suburbs, Eastern Suburbs and total for greater Mumbai.

Table 0.1 Trend of population in Greater Mumbai (in Millions)

Year	**Island City**		**Western Suburbs**		**Eastern Suburbs**		**Total Greater Mumbai**	
		Decadal Growth		Decadal Growth		Decadal Growth		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%
2011	3.08 (31.92%)	-0.27	5.53 (39.78%)	0.43	3.83 (28.20%)	0.37	12.44 (100%)	4.5%

0.1.3 Employment:

The employment growth during 1971-2015 in different areas of Greater Mumbai is shown in Table 0.2 The share of employment in Island City has fallen to 39% in 2015 from 72% in 1971. However, the share of employment during 1971-2015, has increased in Western suburbs from 16% to 40% and in Eastern Suburbs from 12% to 21%.

Table 0.2 Employment in Different Areas of Greater Mumbai (in Millions)

Year	Island City	Western Suburbs	Eastern Suburbs	Greater Mumbai
1971	**1.09**	**0.24**	**0.19**	**1.52**
1981	**1.39**	**0.51**	**0.29**	**2.19**
1991	**1.34**	**0.64**	**0.44**	**2.42**
1998	**1.59**	**0.65**	**0.38**	**2.62**
2011	**2.25**	**2.32**	**1.23**	**5.80**
2015	**2.30**	**2.40**	**1.24**	**5.94**

0.1.4 Land Use Policy:

MMRDA prepared a Regional Plan for Mumbai Metropolitan Region (MMR) as required under the Maharashtra Regional & Town Planning Act 1966. As per the recommendations in the Plan, a new industrial Growth Policy should be framed with specific economic, environmental and urban development objectives. The plan has proposed a poly-nucleated land use structure for the Mumbai Metropolitan Region.

0.1.5 Road Vehicles:

There has been phenomenal increase in road vehicles in Greater Mumbai. Number of private vehicles per 1000 population was 18.11 in 1971 has increased to 150.32 in 2011. The rate of growth of vehicles has increased further during the last few years.

0.1.6 Suburban Rail Network:

Suburban Rail Network in Mumbai is run by Central and Western Railways. Central Railway Suburban Trains on main lines run from Mumbai CST to Kasara towards Nashik and to Karjat on Pune side. The Harbour Branch trains go from CST to Panvel in Navi Mumbai and to

Andheri on Western Railway. Western Railway suburban section is from Churchgate to Virar. It will be extended to Dahanu this year.

Suburban services are operated with Electric Multiple Units (EMUs), mainly in 9 car trains, which are being gradually converted to 12 car rakes. Western Railway has made a beginning with 15 car trains.

The traction system is 1500 Volt D.C. overhead system. Work is in progress to convert it to 25 kV AC traction.

0.1.7 Road Network:

Road Network developed over many years is prominently in North–South direction following the linear geographical pattern of Mumbai. Lately Eastern Suburbs / Navi Mumbai have also developed commercially and better East–West connectivity is necessary.

0.1.8 Bus Transport System:

Bus services in the Region are provided by BEST, Thane Municipal Transport, Navi Mumbai Municipal Transport and MSRTC.

BEST with over 3000 buses is the largest provider of bus services.

Dispersal of train commuters from Main Railway Terminals to their final destinations in Mumbai such as Fort, Ballard Estate, Colaba, Nariman Point etc. is done primarily by the bus system.

0.1.9 Air Pollution:

In Mumbai, road traffic is a major source of air pollution. Air Pollution due to road traffic has increased by almost 400 % during the last two decades.

Noise pollution is not seen as a widespread problem, though the noise levels in lot of areas are high as compared to specified standards. It is, however, likely that noise will become a more perceived problem as traffic volumes increase.

0.1.10 Need for Metro:

Public Transport System is an efficient user of space and energy, with reduced level of air and noise pollution. As the population of the city grows, the share of public transport, road or rail-based, should increase. For a city with population of 1.0 million, the share of public transport should be about 40 - 45%. The percentage share of public transport should progressively increase with further growth in the population of the city, reaching a value of about 75% when the population of the city touches 5 million mark. With Mumbai's population crossing 12 million, the share of public transport at 88% is quite good. However, over the past decade the share is likely to reduce further if corrective measures are not taken immediately. While up-gradation of existing suburban system is underway through MUTP, it is felt that additional mass transit corridors are required to meet the expanding demand.

0.1.11 Advantages of a Metro System:

Metro systems are superior to other modes because they provide higher carrying capacity, faster, smoother and safer travel, occupy less space, are non-polluting and energy-efficient. To summarise, a Metro system:

- Requires 1/5th energy per passenger km compared to road-based system
- Causes no air pollution in the city
- Causes lesser noise level
- Occupies no road space if underground and only about 2 meter width of the road if elevated
- Carries same amount of traffic as 7 lanes of bus traffic or 24 lanes of private motor cars (either way), if it is a medium capacity system.
- Is more reliable, comfortable and safer than road based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

0.1.12 Past Studies:

A number of transportation studies have been carried out in the past for Mumbai Metropolitan Region. These studies discussed travel pattern, network characteristics, and the degree of traffic saturation on the existing roads in the Study Area. Following major studies have been done in the past and recommendations were made for transportation improvements in Mumbai Metropolitan Region

a. Mass Transport Study (1969)
b. Techno-Economic Feasibility Study for the 7th Rail Corridor
c. East West Rail Corridor Study
d. Comprehensive Transport Study (CTS) for MMR
e. Mumbai Metro Study by Mumbai Metro Planning Group
f. MRTS Study by TEWET
g. Sky Bus Metro Study by MMRDA
h. Comprehensive Transport Study -2008

0.2 EVOLUTION OF MUMBAI METRO MASTER PLAN:

0.2.1 Mumbai does have a very good transportation system but has not been able to keep pace with the increasing demand. The carrying capacity of the Rail and bus based system has been increased considerably over the last 4 – 5 decades but traffic has increased much faster.

0.2.2 Due to various constraints of existing system as also the limitations in increasing their carrying capacity, a new Mass Rapid Transit System is essential to take care for the next few decades.

0.2.3 A master plan has been prepared and various corridors finalised. The master plan includes nine corridors with a total length of 146.5 kms. to be completed in the three phases. The network will cover North–South and also East–West transportation requirements.

0.2.4 The Master Plan network was split in suitable corridors are shown in Table 0.3

Table 0.3

S. No.	Corridor	Length (Km)		
		Total	Elev.	U.G
1	Versova – Andheri – Ghatkopar	15.00	15.00	-
2	Coloba – Mahim (Bandra)	18.00	8.10	9.90
	Mahim (Bandra) – Charkop	18.00	18.00	
3	Mahim – Kurla – Mankhurd	12.80	10.70	2.10
4	Charkop – Dahisar	7.50	7.50	
5	Ghatkopar – Mulund	12.40	12.40	
6	BKC – Kanjur Marg via Airport	19.50	11.00	8.50
7	Andheri (E) – Dahisar (E)	18.00	18.00	
8	Hutatma Chowk – Ghatkopar	21.80	13.30	8.50
9	Sewri – Prabhadevi	3.50		3.50

0.2.5 Present Status:

0.2.5.1 Line no 1 viz. Versova – Andheri – Ghatkopar has been implemented and commissioned on 8th June 2014 The work was done on Public Private Partnership (PPP) mode by a Special Purpose Vehicle, Mumbai Metro one, comprising of Government of Maharashtra, Reliance Infrastructure and VEOLIA of France.

0.2.5.2 A special purpose vehicle (SPV) was formed for line no 2, viz. Charkop – Mahim – Mankhurd corridor. SPV comprises of Government of Maharashtra, Reliance Infrastructure and SNC Lavalin of Canada. However, the implementation of this Line did not take off.

0.2.5.3 An SPV named as Mumbai Metro rail Corporation Ltd. (MMRC) is incorporated and implementation of Line -3 between Colaba- BKC-Aarey is being done by the SPV.

0.2.5.4 MMRDA is intending to implement other corridors by itself.

0.3 TRAFFIC FORECAST:

The station to station segment flows in both directions during peak hours for the years 2016, 2021 and 2031 are shown in Table no 0.4 and peak hour total boarding and alighting figures in table 0.5.

Table No 0.4 Peak Hour Station to Station Segment Flows

From	To	2021		2031	
		Forward	Reverse	Forward	Reverse
Station 1 (ANDHERI.)	Station 2 (Shankarwadi)	4289	8553	4688	7306
Station 2 (Shankarwadi)	Station 3 (JVLR Jn.)	5421	8344	6207	7452
Station 3 (JVLR Jn.)	Station 4 (Bombay Exhibition)	11300	17153	14318	17778
Station 4 (Bombay Exhibition)	Station 5 (Hub Mall)	11505	17831	14460	18353
Station5 (Hub Mall)	Station 6 V. Nagar	11440	18086	14406	18584
Station 6 (V. Nagar)	Station 7 (Aarey Road Junction)	11221	17870	13991	18371
Station 7 (Aarey Road Junction)	Station 8 (Vitt Bhatti Jn.)	11048	17086	13834	17612
Station 8 (Vitt Bhatti Jn.)	Station 9 (Kurar Village)	11099	16550	13976	17214
Station 9 (Kurar Village)	Station 10 (Bandongri)	10758	15493	13514	17186
Station 10 (Bandongri)	Station 11 (Mahindra & Mahindra)	9938	15105	12500	17175

From	To	2021		2031	
		Forward	Reverse	Forward	Reverse
Station 11 (Mahindra & Mahindra)	Station 12 (Thakur Complex)	9206	12935	11747	14938
Station 12 (Thakur Complex)	Station 13 (Borivali Bus Stop)	8785	10894	11353	13140
Station 13 (Borivali Bus Stop)	Station 14 (Borivali Omkareshwar)	7950	9942	10438	13472
Station 14 (Borivali Omkareshwar)	Station 15 (Shrinath Nagar)	6745	7875	10436	9442
Station 15 (Shrinath Nagar)	Station 16 (DAHISAR)	5859	6851	8817	7541
Maximum PHPDT		**11505**	**18086**	**14460**	**18584**

Table 0.5 Peak Hour Boarding and Alighting

Station	2021		2031	
	Boarding	Alighting	Boarding	Alighting
Station 1 (ANDHERI.)	4289	8553	4688	7306
Station 2 (Shankarwadi)	2547	1206	2750	1377
Station 3 (JVLR Jn.)	7237	10167	9679	11894
Station 4 (Bombay Exhibition)	2311	2784	2339	2773
Station 5 Hub Mall	171	490	182	467
Station 6 (V. Nagar)	1851	1854	1936	2138
Station 7 (Aarey Road Junction)	1961	1350	2127	1525
Station 8 (Vitt Bhatti Jn.)	2629	2042	2979	2439
Station9 (Kurar Village)	3530	2813	3278	3710
Station 10 (Bandongri)	1777	2210	1816	2821

Station	2021		2031	
	Boarding	**Alighting**	**Boarding**	**Alighting**
Station 11 (Mahindra & Mahindra)	3968	2530	4504	3020
Station 12 (Thakur Complex)	3682	2061	4660	3257
Station 13 (Borivali Bus Stop)	1851	1734	1681	2928
Station 14 (Borivali Omkareshwar)	3348	2486	7649	3620
Station 15 (Shrinath Nagar)	4867	4730	8961	8680
Station 16 (DAHISAR)	6851	5859	7541	8817
Total	**52869**	**52869**	**66770**	**66770**

Daily Trips projected for different horizon years is given in Table 0.6 below.

Table 0.6 Trips per day (lakhs)

Year	Trips per day (lakhs)	
	Daily Trips	Average Lead in KM
2016	**388440**	**6.58**
2019	**472590**	**6.58**
2021	**528690**	**6.58**
2031	**667698**	**6.04**

0.4 SYSTEM SELECTION:

0.4.0 General:

0.4.0.1 Andheri (East) – Dahisar (East) Corridor of Mumbai Metro starts at the junction of Western Express Highway and M.V. Road at Andheri East. The alignment runs through Jogeshwari, Goregaon, Malad, Kandivali, Thakur Village, Poisar and Borivali to end at Dahisar (E).

Versova – Ghatkopar corridor also passes through the junction of W.E.H and M.V. Road. One station of this corridor is located on East side of W.E.H. Chainage 0.0 for Andheri East – Dahisar corridor is about 95 m North of Versova to Ghatkopar Metro Line.

0.4.0.2 Length of Andheri Dahisar Metro corridor is 16.476 Kms. The entire corridor will be elevated. Maintenance Depot has been proposed near Dahisar Terminal station on Land belonging to Airport Authority of India.

0.4.0.3 Sixteen stations have been proposed on the corridor. Efforts have been made to keep the inter station distance about a kilometer. However the closest inter- station distance is 540 metres and farthest 1728 metres.

0.4.1 Permanent Way:

0.4.1.1 Choice of Gauge:

The issue of Broad Gauge vs. Standard Gauge for Metro in India has been debated widely and the decision has been in favour of Standard Gauge. It is advantageous for many reasons as indicated below:

- In general alignment has to follow the road alignment, which has sharp curves. Standard Gauge permits adoption of sharper curves.
- In Standard Gauge 1 in 7 and 1 in 9 turn-outs which occupy lesser length can be used while in Broad Gauge 1 in 8 ½ and 1 in 12 turnouts are required.
- For Standard Gauge, optimized state-of-the-art rolling stock designs are available 'of-the-shelf' which is not so in case of Broad Gauge.
- Standard gauge has been adopted for metros all over the world. Due to large market, constant up-gradation of technology takes place on a continued basis. This is not available Broad Gauge.
- Once technology for Standard Gauge coach gets absorbed and manufacturing base for this setup in India, there will be considerable export potential for the coaches.

0.4.1.2 Track Structure:

Two types of Track Structure have been proposed. The ballastless track has been proposed for viaduct, while normal ballasted track has been proposed in the maintenance depot. The track will be completely welded and even the turn outs will be incorporated in LWR / CWR. The rails section used will be UIC – 60 (60 kg / mtrs). The grade of rails on main lines will 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.

0.4.2 Traction System:

Keeping in view the ultimate traffic requirements, uniformity, standardization and other techno economic consideration, 25 KV AC traction system is considered to be the best alternative and same has been proposed for this corridor. 25 KV AC traction system has economical advantages of minimal number of traction sub stations and potential to carry large traffic.

0.4.3 Signalling:

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

Metro carries 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 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

0.4.4 Telecommunication:

The Telecommunication system acts as the communication backbone for Signalling systems and other systems such as SCADA, AFC etc and provides Telecommunication services to meet operational and administrative requirements of the metro network. The Telecommunication facilities proposed are helpful in meeting the requirements for :

1. Supplementing the Signalling system for efficient train operation.
2. Exchange of managerial information
3. Crisis management during emergencies
4. Passenger information system

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
- Integrated Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralised Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving Cars and maintenance personnel.
- Data Channels for Signalling, SCADA, Automatic Fare Collection etc.
- E&M SCADA is not envisaged as part of Telecomm System as such, hence catered to separately in DPR
- Integrated Network Control System
- Access Control System

0.4.5 Automatic Fare Collection:

0.4.5.1 Mass Rapid Transit System handles 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 less manpower. In view of the 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 of 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.

Seamless ticketing is now being thought of for Mumbai. This system is recommended to be adopted as this will enable the commuters to travel hastle free by different modes of transport viz. Metro, suburban trains, buses, water transport (whenever introduced) and even taxies without purchasing multiple tickets for each mode separately.

A. Manual fare collection systems have the following inherent disadvantages:

1. Large number of staff is required for issue and checking of tickets.
2. Change of fare structure is time consuming as it has to be done at each station.
3. Manipulation possible by jamming of mechanical parts.
4. Staff and passenger interaction leading to more chances of confrontation.
5. 100 % ticket checking at entry / exit impossible.

B. Automatic fare collection systems have the following advantages:

1. Less number of staff required.
2. Less possibility of leakages of revenue due to 100% ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.
4. Efficient and easy to operate.
5. System is amenable for quick fare changes.
6. Management information reports generation is easy.
7. System has multi operator capabilities. Same Smart Card can be used for other applications also.
8. AFC systems are the world wide accepted systems for Metro environment.

0.4.5.2 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 offices 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 Contactless 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 prone to dusty environment.

0.4.5.4 Choice of Control Gates:

Retractable flap type or Turnstile type Control Gates are proposed.

0.4.5.5 Passenger Operated Machines:

Space for provision of Passenger Operated Machines (Automatic Ticket Dispensing Machines) in future has been earmarked at the stations. It is proposed to provide sufficient number of POMs so that passengers get issued token to the maximum extent by these machines.

0.4.5.6 Integration of AFC with other Lines and Modes of Transport:

In Mumbai, different metro lines are being constructed and operated by different operators. In view of passenger convenience and operational efficiency, it is proposed that AFC 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 may be 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. This will facilitate the passengers as they need not carry different cards for different applications

0.4.6 Rolling Stock:

0.4.6.1 Rolling Stock proposed will be most advanced and have sophisticated system with latest State of Art Technology. The important criteria for selection of rolling stock are:

- Proven equipment with high reliability
- Passenger safety features
- Energy efficiency
- Light weight equipment and coach body
- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low life cycle cost
- 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 will have high rate of acceleration and deceleration.

0.4.6.2 The Coach will be of stainless steel, approximately 22 m long, 3.2 m wide and 3.9 high. Overall length of a train of 6 coaches will be about 132 m. The axle load will be 17 tonnes. The coaches will be fitted with asynchronous 3 phase AC squirrel cage induction motors. Trains will have regenerative braking system to save energy cost.

Current will be drawn through overhead catenary. Train will be air conditioned and provided with automatic door closing and opening system.

The coaches will have longitudinal seats with seating 50 passengers and 250 standees (With 6 persons per sq.m). With dense crush density of 8 passengers per sq.m, standees will go up to 325.

Maximum design speed will be 90 kmph. Maximum acceleration is proposed to be 0.8 m / sec / sec. and maximum deceleration 1.2 m / sec / sec.

0.5 CIVIL ENGINEERING:

0.5.1 Geometric Design Norms:

0.5.1.1 The design parameters proposed for the Corridor are, in general, same as for other corridors of Mumbai Metro Project. The parameters have been finalised based on detailed evaluation, experience and internationally adopted practices.

Minimum horizontal curve radius specified is 200 m but in extreme cases it can be reduced to 120 m. Minimum curve radius at stations is specified as 1000 m.

Vertical curves are proposed at every change of grade. Radii of vertical curves are 2500 m desirable and 1500 m minimum.

It is proposed to use twin U - girder for the alignment upto the curvature of 300m radius and I-Girder for the sharper curves.

The track centers on the elevated section with twin U – Girders are kept at 5.0 m uniform throughout the corridor to standardize the superstructure, excepting at few locations as detailed below:

- On curves below 300 m radius — 4.30 m (I- girder to be used) but upto 120 m radius

- At scissors crossing — 4.50 m

The viaduct carrying the tracks will have a vertical clearance of minimum 5.5 m above road level.

0.5.1.2 Gradients:

Normally stations should be on a level stretch. In limiting cases, stations may be on a grade of 0.1%. In Andheri (E)–Dahisar (E) corridor all stations are on level stretch.

Between stations, generally grades may not be steeper than 2.0%. However, in where existing road gradients are steeper than 2%, gradients up to 4% (compensated) can be provided in short stretches.

0.5.1.3 Design Speed:

The maximum Design speed has been proposed as 90 kmph and maximum sectional speed 80 kmph. The booked speed has been taken as 32 kmph.

0.5.2 Alignment:

0.5.2.1 Andheri (East) – Dahisar (East) corridor of Mumbai Metro Project is proposed to start at junction of Western Express Highway and MV Road in Andheri (East). The alignment stretches from Andheri (E) to Dahisar (E) via Jogeshwari, Goregaon, Malad, Kandivali, Thakur Village, Poisar and Borivali along and parallel to Western Express Highway (W.E.H.). Andheri (E) Metro Station on this corridor is proposed on Right Hand Side of WEH between L&T building and Flyover.

The chainage of Andheri(E) proposed station is taken as 0.0 and dead end chainage of this station as (-) 450 m.

Total length of the corridor from dead end to dead end is 16.475 km. The entire corridor proposed is elevated.

The corridor has been proposed on the East side of the flyover on W.E.H. to start with first station as Andheri(E). Just after station, the alignment crosses to West side of the WEH and thereafter it runs on West side only upto Dahisar.

Sixteen stations have been proposed on the corridor. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one Km. distance apart. The maximum and minimum inter station distances are 1727.7 m and 540.3 m respectively.

0.5.3 Station Locations:

Stations have been located so as to serve major passenger destinations and enable convenient integration with other modes of transport. Average spacing of stations is close to one km.

All stations will be two level stations except Dahisar Terminal Station. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. Dahisar station is proposed to have two towers one on either side

An index map showing the alignment and location of stations is given in Fig. 0.1

The proposed Andheri (E) – Dahisar (E) Metro Corridor runs northwards from Andheri East to S.V & L.R Junction at Dahisar (E), parallel to Western Express Highway, covering a distance of 15.525 km from centre of Andheri(East) Station to Dahisar(East) station. A total of 16 stations have been planned along the proposed corridor. All stations are planned as elevated stations. Stations are generally located around 900 -1100 m apart, though the inter station distance varies from 540 m to 1728 m due to traffic and topographic reasons as well as design constraints. List of stations with chainages and inter station distances is given below in Table 0.7.

Table 0.7 List of Stations

Andheri To Dahisar Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G / ELEVATED**
0	DEAD END	(-) 450		
1	ANDHERI	0.0	450	ELEVATED
2	SHANKARWADI	1229.8	1229.8	ELEVATED
3	JVLR Jn.	2413.9	1184.1	ELEVATED
4	BOMBAY EXHIBITION	3781.5	1367.6	ELEVATED
5	HUB MALL	4580.0	798.5	ELEVATED
6	VISHVESHWAR NAGAR	5559.7	979.7	ELEVATED
7	AAREY ROAD Jn.	6100.0	540.3	ELEVATED
8	VITT BHATTI Jn.	7180.0	1080.0	ELEVATED
9	KURAR VILLAGE	8068.0	888.0	ELEVATED
10	BANDONGRI	9075.7	1007.7	ELEVATED
11	MAHINDRA & MAHINDRA	9700.0	624.3	ELEVATED
12	THAKUR COMPLEX	11427.7	1727.7	ELEVATED
13	BORIVALI BUS STOP	12250.0	822.3	ELEVATED
14	BORIVALI OMKARESHWAR	13376.5	1126.5	ELEVATED
15	SHRINATH NAGAR	14384.5	1008.0	ELEVATED
16	DAHISAR (E)	15524.9	1140.4	ELEVATED
	DEAD END	16025.7	500.8	

0.5.4 Terminals:

- **Andheri East Terminal:**

Southern terminal of the corridor is proposed Andheri(E) with its centre line at Ch.0.0km. The station is located at junction of Western Express Highway and Mathurdas Vasanji Road on East side of the Andheri flyover on Western Express Highway. The station is elevated with rail level at about 14.0m above the road level. This terminal station is accessible from many residential and commercial establishments. Metro Line No.1 also crosses W.E.H. at this location and a station on this line is being constructed on the East of W.E.H. Rail level at this station of line no. 1 is about 21.50m above road level due to Andheri flyover on W.E.H. The two stations will be connected by an elevated walkway .Other side of WEH will be connected to this station by the help of walkway provided under the existing Andheri flyover as sufficient headroom being available.

- **Dahisar Terminal:**

  The last station proposed on the corridor is Station No.16 (S.V & L.R. Junction) near junction of S.V. Road and Link Road at Dahisar(East), the centre line being at Ch.15.525. Station is in the midst of residential and commercial area of Dahisar.

  Feasibility of connecting this corridor with Charkop-Dahisar Corridor has also been examined. It is possible to terminate D. N. Nagar-Charkop-Dahisar Corridor on this terminal station of this corridor. The provision to extend this corridor to further North is also kept in view

0.5.5 Scissors Crossovers:

Scissors Crossovers will be provided at both the terminal stations viz. Andheri(E) and Dahisar (S.V. & L.R Junction). In between scissors crossovers are proposed at two stations for use in emergencies.

0.5.6 Maintenance Depot:

It is proposed to provide the Car maintenance depot at Dahisar in the land of Airport Authority of India. The land parcel available is of 18. Ha but of irregular shape. Detailed planning of depot in this area has been done.

0.5.4 Viaduct–Elevated Structure:

The proposed Viaduct Structure is fully elevated. Normally in metro elevated section, following two types of segmental superstructure are adopted;

(A) Pre-cast segmental box girder using external unbounded tendon.

(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.

(C) Precast segment Twin U girders

Twin U Girders are normally economical as compared to segmental U girders and box girders. Twin U girder is recommended for adoption.

0.5.5 Geo Technical Investigations:

Geotechnical Investigations were done on the whole length by taking 18 bore holes at different locations.

Boring was done for a depth of about 15 m. and 5 to 8 m in rock. Piles have been proposed for foundations with about 1.8 m. grip length in rock.

0.5.6 Utility Diversions:

A number of utilities like sewer lines, water pipelines, gas pipelines, power and communication cables etc. are there along and across the alignment. Some of these will have to be diverted. Details are given in chapter 5 on Civil Engineering

A fresh Utility survey is being done by DMRC as all the above utilities were identified as per the old alignment by SPAN. Separate report on the utilities will be made available. However the provision in the cost for handling utilities have been made on per kilometer basis.

0.5.7 Land:

Keeping in view the scarcity of land in Mumbai, requirement of land has been kept to the minimum. The full corridor including stations is proposed to be elevated. As such land will be required for the following only.

- Entry/Exit Structures
- Station utilities like Diesel generator room, underground water tank, etc.
- Traffic integration facilities
- Depot
- Traction Receiving Substations
- Mid section for viaduct

Entire corridor is planned along slip road and service road of Western Expressway on the West side. In many sections service road is not available and in some section width of slip road is reduced due to less ROW and encroachments by shops, hutments, etc. As such adequate land is not available in many stretches and requisite land has to be acquired.

Summary of Permanent land acquisition required is shown in Table 0.8.

Table 0.8 Summary of Permanent Land Requirement				
		Govt	Private	Total
1	Stations	**2787**	**12373**	**15160**
2	Depot including one RSS	**150000**	**0**	**150000**
3	Receiving Sub stations (RSS)	**5000**	**0**	**5000**
	Total	**157787**	**12373**	**170160**

- **Temporary Construction Depot:**

It is proposed to provide the Government land to the civil Contractors for developing their construction depot at two locations one each with the area of 4 Ha.

0.5.8 Safety & Security Systems:

This chapter lays down the standards and requirements for safety & security, arising out of fire and unauthorized entry into premises. The system will be designed and installed for safe transportation of passengers & premises safety in Metro Railway System.

0.5.8.1 Requirements:

i. The System shall protect the passengers against the fire in train services and at the premises of Metro Railway.

ii. The system shall protect vulnerable premises from fire.

iii. The system shall be able to detect the unauthorized entry and exit at nominated places.

iv. The system shall include

- Fire alarm system.
- Fire Hydrant and Sprinkler System.
- Fire Extinguishers.
- Closed circuit television with video analytics.
- Security Gates – Metal Detector.
- Baggage Scanner.

0.6 TRAIN OPERATION PLAN:

0.6.1 Salient Features:

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for this corridor has been taken as 35 Kmph.

0.6.2 Train Formation

To meet the above projected traffic demand, the possibility of running trains with composition of 6 Car trains with different headways have been examined.

Composition

DMC : Driving Motor Car

MC : Motor Car

TC : Trailer Car

6-car train composition: DMC+TC+MC+ MC+TC+DMC

Capacity@ 6 passengers per square meter of standee area

DMC : 282 passengers (Sitting-42, Standing-240)

MC : 298 passengers (Sitting-50, Standing-248)

TC : 298 passengers (Sitting-50, Standing-248)

6 Car Train : 1756 Passengers (Sitting-284, Standing-1472)

The PHPDT capacity provided on this corridor in different years of operation is given in Table 0.9 :

Table 0.9 PHPDT Capacity Provided

	YEAR			
	2016	2019	2021	2031
Cars/trains	6	6	6	6
Head way (Minutes)	8	6.75	5.5	5.5
Max. PHPDT Demand	12800	15602	18860	18752
PHPDT Capacity Available	13170* (16830**)	15609* (19947**)	19156* (24480**)	19156* (24480**)

0.6.3 YEARWISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and has been tabulated below in Table 0.10:

Table 0.10: Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
Andheri-Dahisar	2016	8	10	6 car	60
	2019	6.75	13		78
	2021	5.5	15		90
	2031	5.5	15		90

0.7 POWER SUPPLY:

0.7.1 Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, 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. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 80 KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated/at –grade station load – initially 250 kW, which will increase to 500 kW in the year 2031

(iv) Depot auxiliary load - initially 2000 kW, which will increase to 2500 kW in the year 2031.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2016, 2019, 2021 and 2031 are summarized in table 0.11 below:

Table 0.11 Power Demand Estimation (MVA)

Corridor	Load	Year			
		2016	2019	2021	2031
Andheri to Dahisar	Traction	7.74	9.30	10.83	11.06
	Auxiliary	7.41	9.70	10.69	12.97
16 Stations (16.48 km)	**Total**	**15.15**	**19.00**	**21.52**	**24.03**

0.7.2 Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in brief. The city has 220, 110 and 66 kV network to cater to various types of demand in vicinity of the proposed corridors.

Keeping in view the reliability requirements, two Receiving Sub-stations are proposed to be set up for the line. This is an economical solution without compromising reliability. It is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations of TATA Power Company Limited at 110 kV voltage through cable feeders:

Table 0.12 Sources of Power Supply

	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length cables from GSS to RSS
Andheri to Dahisar 16 Stations (16.48 km)	220 or 110 or 66 kV Grid Sub Station (GSS) Near Andheri	RSS Near Andheri Station	To be confirmed by TATA Power
	110 kV Grid Sub Station (GSS) Near Dahisar	RSS Near Dahisar Depot	To be confirmed by TATA Power

Tata Power company have assured that reliable power supply from their 110 kV Borivali Sub-station will be provided for Dahisar Depot RSS (Annexure – 8.2) and for Supply of Andheri RSS, a letter No. DMRC/Elect/Mumbai/2015, dated 04.08.2015 has been sent to TATA Power Company for confirmation of source of power supply (Annexure – 8.3). In view of this, during the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 0.13

Table 0.13 – Power Demand projections for various sources

Corridor	**Input Source**	Peak demand – **Normal (MVA)**		**Peak demand** – **Emergency (MVA)**	
		Year (2016)	Year (2031)	Year (2016)	Year (2031)
Andheri to Dahisar 16 Stations	**RSS Near Andheri Station**				
	Traction	3.04	4.42	7.74	11.06
	Auxiliary	2.47	4.94	7.71	12.97
	Sub-total (A)	**5.51**	**9.36**	**15.15**	**24.03**

(16.48 km)	**RSS Near Dahisar Depot**				
	Traction	4.70	6.63	7.74	11.06
	Auxiliary	4.94	8.04	7.71	12.97
	Sub-total (B)	**9.64**	**14.67**	**15.15**	**24.03**
	Total (A+B)	**15.15**	**24.03**		

** Incase of failure of other source of power

0.7.3 Various options of Traction system:-

There are three options available for power supply system for MRTS:-

- 25 kV & 2X25 kV AC Overhead Catenary system
- 750 V DC third rail system
- 1500 V DC Overhead Catenary system.

On the basis of techno-economic considerations, 25 kV AC traction system is recommended.

0.7.4 Standby Diesel Generator Set:

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 a standby DG set of 180 kVA capacity at the elevated stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

0.7.5 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 fiber provided for telecommunications will be used as communication carrier for SCADA system.

0.7.6 Energy Saving System:

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.

0.7.7 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 45.97 million units in initial years (2016), which will be about 67.80 Million Units in the 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 110 kV voltage level) plus nominal administrative Charges i.e. on a no profit no loss basis. The power tariff of Maharashtra Electricity Regulatory Commission for TATA power Company, FY 2015 – 16 demand charges Rs 200/ kVA per month and energy charges Rs 7.63/ kWh. Therefore it will be in the about **Rs 8.46 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. Similar approach has been adopted for Delhi Metro.

0.8 ENVIRONMENTAL IMPACT ASSESSMENT:

0.8.1 A detailed Environmental Impact Assessment study has been done along the full length of the proposed corridor. Baseline environmental data has been collected for all the relevant elements of environment.

Apart from the normal parameters of air pollution, water pollution, noise pollution etc. a quantitative evaluation of ‘Total Environmental Impact’ has also been done. Total score of environmental impact of this infrastructure project can be obtained by aggregating all individual impacts. Even though such an aggregation involves a certain degree of subjectivity, a rationalized procedure based on logic, experience and expertise can minimize subjectivity. In the study, a simple and reliable procedure of ‘Modified Matrix’ used by National Environmental Engineering Research Institute (NEERI) has been used.

Result of this impact procedure shows that the overall impact is quite low for an infrastructure of this type and therefore accepted even without remedial measures from Environmental Impact point of view.

It is possible and is felt desirable to further reduce the negative impact or even to convert it to a positive score by adopting a certain mitigation plan. An Environment Management Plan has been suggested.

A revised Environment Score indicates that the adverse impact is almost totally balanced by beneficial impact.

EIA Assessment has concluded that there will be only minor adverse impacts while beneficial effects are very significant. ‘No Project Alternative’ will have extremely high negative impacts on the environment. Implementation of the project is strongly recommended.

0.9 Socio Economic Impact of the Project:

0.9.1 A good portion of land required for the corridor is occupied by residential hutments, shops and commercial establishments. Rehabilitation and resettlement of affected person is a pre requisite for execution of the project. A fresh socio economic study is underway and the report is being prepared separately. However, for rehabilitation and resettlement funds provision have been made in cost at per kilometre basis

0.10 COST ESTIMATE:

Project Cost estimates for the Andheri(E) – Dahisar (E) Metro Corridor has been prepared covering civil, electrical, signalling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction at July 2015 price level.

The overall Capital Cost for the Andheri – Dahisar Metro Corridor of Mumbai at July 2015 price level works out to **Rs. 4158 Crores** excluding applicable Taxes & Duties of **Rs 774 Crores.** as tabulated hereunder in Tables 0.14 and 0.15.

Table 0.14

Andheri (E) to Dehisar (E) Corridor

Capital Cost Estimate **July 2015 level**

Total length = 16.475 km Elevated (including elevated ramp) =16.475 km					
Total Station (All Elevated) =16					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	15.78	315.57
b	Private	ha	100.00	1.24	123.73
1.2	Temporary Land for Construction Depot	Ha.	5.00	8.00	40.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.52	16.48	58.04
	Subtotal (1)				**537.34**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	16.48	608.39
2.2	Depot entry connection	R. Km.	36.92	1.00	36.92
	Subtotal (2)				**645.31**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	13.00	378.13
b	Type (A) way side- EM works etc	Each	8.06	13.00	104.80
c	Type (B) Way side with signalling-civil works	Each	28.48	1.00	28.48
d	Type (B) Way side with signalling-EM works etc	Each	8.06	1.00	8.06
a	Type (C), Terminal station -civil works	Each	32.45	2.00	64.90
b	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	2.00	16.12
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	32	78.4
3.3	Metro bhawan, OCC bldg. Staff quarters				
a	civil works	LS			50.00
b	EM works etc	LS			25.00
	Subtotal (3)				**753.89**
4.0	**Maintenance Depot at Dehisar**	LS			
4.1	Depot				
a	Civil works	LS			90.00
b	EM works etc	LS			60.00

	Subtotal (4)				**150.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	**8.58**	17.48	149.94
5.2	Ballasted track for Depot	R. Km.	**4.72**	5.00	23.60
	Subtotal (5)				**173.53**
6.0	**Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R.Km.	10.50	16.48	173.04
	Subtotal (6)				**173.04**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	16.48	263.58
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	5.50	16.00	88.00
	Subtotal (7)				**351.58**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.5 cr/km)** + EM works (**3.5 cr/km**)	R. Km.	8.00	16.48	131.84
	Subtotal (9)				**131.84**
10.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	78.00	764.40
	Subtotal (10)				**764.40**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.30	16.48	4.92
b	EM works etc	R.Km.	0.06	13.27	0.82
	Subtotal (11)				**5.74**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.32	16.48	21.82
b	EM works etc	R.Km.	0.28	16.48	4.68
	Sub Total (12)				**26.49**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	16.00	36.96
	Sub Total (13)				**36.96**
14.0	**Total of all items except Land**				**3270.82**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**228.96**
16.0	**Total of all items including G. Charges except land**				**3499.77**
17.0	**Contingencies @ 3 %**				**104.99**
18.0	**Gross Total**				**3604.77**
	Cost without land			=	**3605**
	Cost with land including contingencies on land			=	**4158**

Table 0.15 Details of Taxes and Duties

Andheri (E)to Dehisar (E) Corridor

Customs duty =	23.4155	%
Excise duty =	12.50	%
VAT =	**12.5**	**%**
Octroi	**4**	**%**

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT(Cr.)		
1	**Alignment & Formation**						
	Underground	0.00	0.00	0.00	0.00		**0.00**
	Elevated, at grade & entry to Depot	645.31		56.46	63.52	14.04	**119.99**
2	**Station Buildings**						
	Elevated station - civil works	549.90		48.12	54.13	11.96	**102.25**
	Elevated station-EM works	128.99	6.04	10.96	12.33	4.09	**29.34**
	OCC bldg-civil works	50.00		4.38	4.92	1.09	**9.30**
	OCC bldg-EM works	25.00	1.17	2.13	2.39	0.79	**5.69**
3	**Depot**						
	Civil works	90.00	6.32	5.51	6.20	2.04	**18.04**
	EM works	60.00	2.81	5.10	5.74	1.90	**13.65**
4	**P-Way**	173.53	32.51	3.69	4.15	5.87	**40.34**
5	**Traction & power supply**						
	Traction and power supply	173.04	16.21	11.03	12.41	5.61	**39.65**
6	**S and T Works**						
	S & T	263.58	49.38	6.59	7.41	8.95	**63.38**
	AFC	88.00	15.45	2.75	3.09	2.97	**21.30**
	PSD	0.00	0.00	0.00	0.00	0.00	**0.00**
7	**R & R hutments**	58.04			3.63	1.16	**3.63**
8	**Misc.**						
	Civil works	153.34		13.42	15.09	3.34	**28.51**
	EM works	47.69		5.07	5.70	1.48	**10.77**
9	**Rolling stock**	764.40	157.51	7.45	8.38	29.74	**173.35**
	Total	**3270.82**	**287.40**	**182.65**	**209.11**	**95.02**	**774.18**
	Total taxes & Duties						**774**

0.11 FINANCIAL VIABILITY, FARE STRUCTURE AND FINANCING OPTIONS:

It is assumed that the construction work will start on 01.10.2015 and is expected to be completed on 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2019 for the corridor. The total completion costs duly escalated and shown in the table 0.16 have been taken as the initial investment. The cash flow of investments separately is placed in Table –0.16 as below.

Table 0.16 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost
2015-16	225.00	229.00
2016-17	592.00	648.00
2017-18	1163.00	1369.00
2018-19	1019.00	1289.00
2019-20	815.00	1108.00
2020-21	408.00	596.00
2021-22	406.00	638.00
Total	**4628.00**	**5877.00**

Fare Structure

The fare structure for the FY 2019-20 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 0.17 below:

Table 0.17 Fare Structure in 2019-20

Sr. No.	Distance	Proposed Fare in 2019-20
1	0-2	11
2	2-4	13
3	4-6	16
4	6-9	20
5	9-12	22
6	12-15	24
7	15-18	26

The above fare structure has been taken as furnished by MMRDA due to the same having approval of GOM. DMRC proposes that the under mentioned fare structure in the multiple of Rs. 10 be adopted in 2019-20 at the time of commissioning of this Line.

Year 2019-20	
SLAB	**FARE (Rs)**
0-3 Kms	**10.00**
3-12 Kms	**20.00**
12 Kms and More	**30.00**

The proposed Fare Structure will have convenience in making use of ticket vending machine and also in issuing the ticket manually without having much effect on total revenue.

The Financial Internal Rate of Return (FIRR) obtained costs for 30 years business model including construction period is followings:-

Corridor	FIRR
Andheri(E) – Dahisar (E) Corridor	**8.20%**

Alternative Models of Financing

The financing option shall depend upon selection of the dedicated agency created to implement the project. The prominent models are: -

Special Purpose Vehicle under the State Government Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC) and
Built, Operate & Transfer (BOT).

SPV Model: - The State Government has already constituted a fully owned company in the name of Mumbai Metro Rail Corporation (MMRC), a SPV company and is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The issue of extending JICA loan for the project was discussed informally with JICA India Office. It was told that an informal understanding between GOI & GOJ has taken place. According to which JICA will extend only modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan will be 40 years with 10 years moratorium period. JICA shall fund to the extent of 85% of the cost of project excluding cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. However, pending formal notification from the MOF, GOI, the existing terms applicable for JICA loan have been assumed except the quantum of project cost eligible for funding. The funding pattern under this model (SPV) is placed in table 0.18 as under: -

Table 0.18
Funding pattern under SPV model (with central taxes and land) (Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	747.00	14.17%
Equity By GOM	747.00	14.17%
SD for CT by GOM	307.00	5.82%
SD for CT by GOI	307.00	5.82%
1.40% Step Loan from JICA / 12% Market Borrowings	3163.00	60.02%
Total	**5271.00**	**100.00%**
SD for Land by GOM	**606.00**	
Total	**5877.00**	
Interest During Construction	**20.00**	
Grand Total	**5897.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.443.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

BOT Model: - In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Maharashtra will be limited to cost of land only. Such a project become eligible for Viability Gap Funding (VGF) upto 20% from the Central Government provided the state government also contribute same or more amount towards the project. The metro being a social sector project not much private parties are available to bid for such a project. Besides quite expectedly the private operator may demand assured rate of return in the range of 16% to 18% or a comfort of guaranteed ridership. Here the BOT option has been worked out taking 16% pre- tax return to the BOT operator

The funding pattern assumed under this model excluding the cost of land is placed in table 0.19 as under: -

Table 0.19 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1054.00	20.00%
VGF by GOM	1396.00	26.48%

Equity by Concessionaire	940.00	17.83%
Concessionaire's debt @12% PA	1881.00	35.69%
Total	**5271.00**	**100.00%**
Land Free by GOM	606.00	
Total	**5877.00**	
IDC	29.00	
Total	**5906.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.443.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

0.11.1. RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 8.13% with revenue from additional property development on 10 hectares of land. The pre-tax Equity FIRR to the BOT operator worked out to 18% with total VGF of Rs.3036.00 crore excluding the cost of 10 hectare Land. Since the Maharashtra State Government is providing land parcels for PD, it is advisable to take up the job on DMRC/BMRCL/CMRL model. Accordingly, the corridors are recommended for implementation.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 0.20 excluding state taxes.

Table 0.20

Rs. In crore

Particulars	SPV Model	BOT Model
GOI	1054.00	1054.00
GOM	1660.00	2002.00
Total	**2714.00**	**3056.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.443.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Considering the difference, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern.

0.12 ECONOMIC ANALYSIS:

Economic benefits are social and environmental benefits which are quantified and then converted into money cost and discounted against the cost of construction and maintenance for deriving Economic Internal Rate of Return (EIRR). When actual revenue earned from fare collection, advertisement and property development are discounted against construction and maintenance cost, interest (to be paid) and depreciation cost, Financial Internal rate of Return (FIRR) is obtained. Therefore, EIRR is viewed from socio-economic angle while FIRR is an indicator of pure financial profitability and viability of any project.

0.12.1 Economic appraisal of a project starts from quantification of measurable economic benefits in economic money values, which are basically the savings of resource cost due to introduction of the metro line. Economic savings are derived from the difference of the cost of the same benefit components under 'with' and 'without' metro line.

0.12.2 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **table 0.21**. Project period is 2015-2045, On the basis of completion cost, EIRR is found to be **22.06%** and B/C ratio as 4.9 and with 12 % discount, EIRR is **8.98%** and B/C ratio is **2.05.** NPV without discount is **Rs 77023 Cr**. and with 12% discount rate, NPV is Rs. **6174 Cr.** In this case (completion cost) escalation factor of 7.5% is applied on both cost and benefit components. On the basis of economic cost, EIRR is 27.9% B/C Ratio is 14.2 and NPV is 89567, both shows that the project is economically viable.

Table 0.21: Economic Indicator Values (2044-45)

ANDHERI-DAHISAR	(Completion Cost Basis)		(Economic Cost Basis)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	19774	5883	7230	3669
Cumulative benefit(Cr.)	96797	12056	96797	12056
Benefit Cost Ratio	4.90	2.05	13.39	3.29
NPV(Cr.)	77023	6174	89567	8388
EIRR	22.06%	8.98%	27.90%	14.20%

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 16.04%.

0.13 IMPLEMENTATION PLAN:

0.13.1 The Andheri (E)–Dahisar (E) Corridor is one of the phase–III corridors, with route length of 16.475 Kms and its a completion cost of Rs 5877 Crores**.** World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for the Andheri (E)–Dahisar (E) Corridor is **8.20 %**.

The only Metro which has been implemented on BOT model so far is the Rapid Metro in Gurgaon. Financially this Metro has been a total failure since the revenues are not able to meet even the interest payment on the loans raised.

It is therefore recommended that the project is implemented fully as a Government initiative. By this route the project can be completed at the shortest time and at the lowest cost. This is important because then only ticket can be priced low, affordable to the common citizens and make the system truly a popular public transport.

0.13.2 Implementation Schedule

A suggested project implementation schedule for Project Implementation on Turnkey Basis (Deposit Terms) is given in Table 0.22

Table 0.22 Project Implementation on Turnkey basis (Deposit Terms)

S.No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D+15 days
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D+30 days
4.	Sanction of Project by GOI	D+60 days
5.	Appoint an agency on deposit terms	D+30 days
6.	Implementation of the project	D+43 months
7.	Testing and Commissioning	D+44 months
8.	CMRS Sanction	D+45 months
9.	ROD	D+ 45 months

0.13.3 Institutional Arrangements:

Govt. of Maharashtra will have to approve the implementation of the project by Mumbai Metro Rail Corporation Ltd. or MMRDA

0.13.4 Legal Cover for Mumbai Metro

Implementation of proposed **Andheri (E)–Dahisar (E)** Metro can now be done under “The Metro Railways (Amendment) Act 2009”..

0.14 CONCLUSIONS:

0.14.1 Mumbai is the Commercial Capital of India and it’s fast growth especially in the suburbs is causing heavy stress on all infrastructure, especially the Transport. Being a linear city, the existing suburban rail services are very effective and the modal split in favour of public transport is about 88%, which is very high. Since the existing transport infrastructure has been heavily loaded, it has been observed that the population of private vehicles is increasing and it was also predicted that, the modal split in favour of public transport may also recede. Hence, it is proposed by MMRDA to introduce a rail based Mass Transportation System in Greater Mumbai and a master plan has been prepared for the same. It is proposed to take up the Andheri (E)–Dahisar (E) Corridor with route length of 16.475 Kms immediately for implementation**. It is also proposed that extension of this corridor from Andheri end to Domestic Airport of Mumbai should closely follow for which DPR may be got prepared by the consultants. Prima facie the extension to Domestic Airport , Mumbai is feasible with some portion elevated and underground thereafter. By doing so it will give connectivity to the public coming from Dahisar(E) end to Colaba with one interchange at Domestic Airport.**

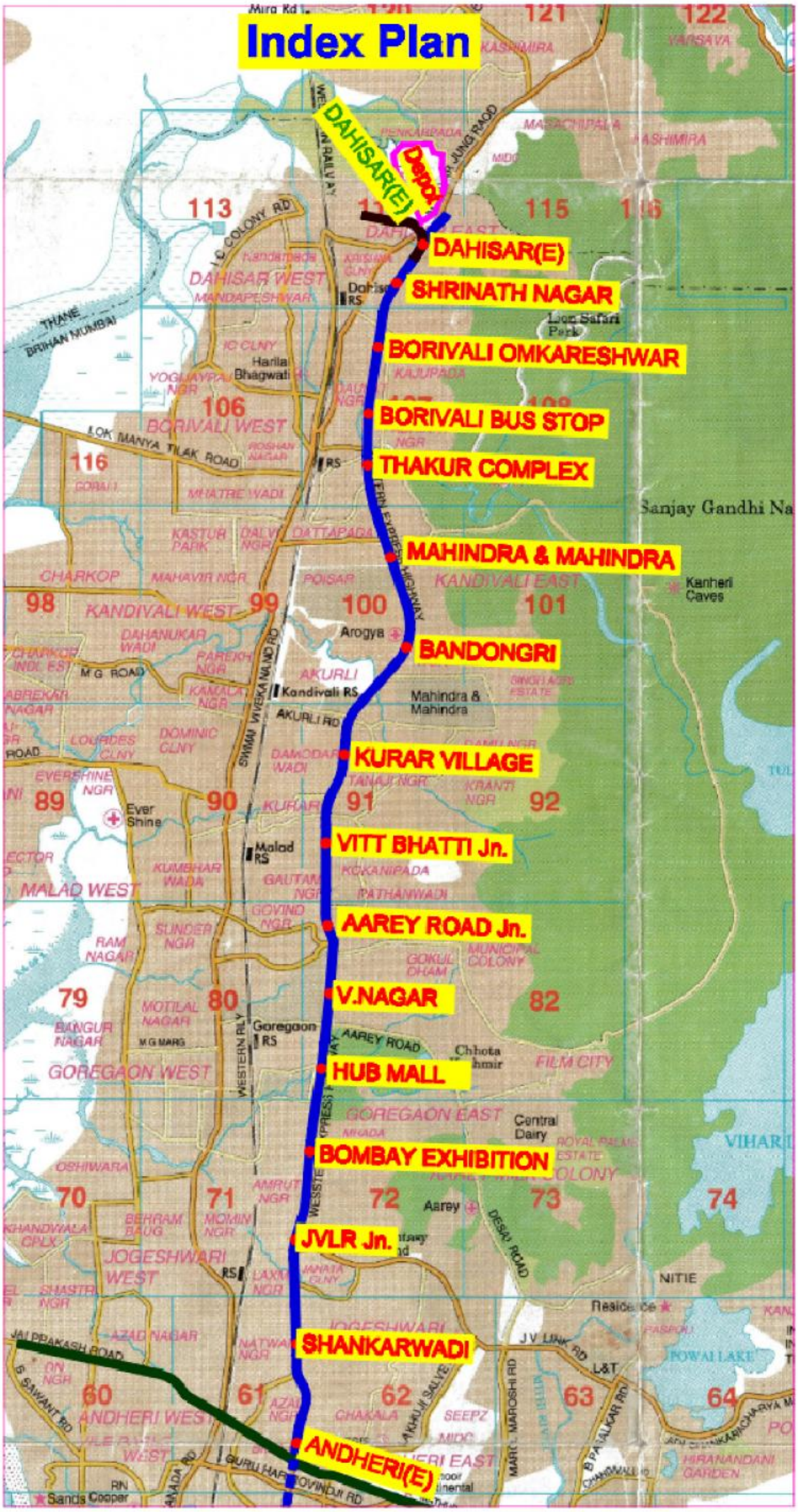
0.14.2 The proposal of this corridor is technically feasible but involves acquisition of land as well as rehabilitation of some hutments and shops.. This is a socio-economic problem and has to be tackled for execution of the project.

0.14.3 Cost of the project at July 2015 price level with central taxes and duties only is Rs. 4628 crores exclusive of State taxes and Octroi of Rs 304.13 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 5877 crores excluding State taxes and Octroi of Rs 443 Crores

0.14.4 After examining the various options for execution of Andheri (E)–Dahisar (E) Metro Project, it has been recommended that the project should be got executed through a SPV on DMRC funding pattern

0.14.5 While the Financial Internal Rate of Return (FIRR) for the project has been assessed as 8.20%, the Economic Internal Rate of Return (EIRR) works out to 22.06%

0.14.6 It is recommended to hand over the project to an agency having the experience of planning, implementing, commissioning and operating on turnkey basis as was done by Rajasthan and Kerala Governments in regard to Jaipur and Kochi Metro projects respectively to complete it within the time period of about three and half year. The second option may be through General Consultants which may take about 8 to 9 months more as compared to turn key Consultancy.


Index Plan
Depot
DAHISAR(E)
SHRINATH NAGAR
BORIVALI OMKARESHWAR
BORIVALI BUS STOP
THAKUR COMPLEX
MAHINDRA & MAHINDRA
BANDONGRI
KURAR VILLAGE
VITT BHATTI Jn.
AAREY ROAD Jn.
V.NAGAR
HUB MALL
BOMBAY EXHIBITION
JVLR Jn.
SHANKARWADI
ANDHERI(E)

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND:

1.1.1 Mumbai, the capital of Maharashtra, is the fastest developing city of India. Being the commercial capital of India, Mumbai is the land for finance, trade and entertainment. The city is full of excitement, energy and enthusiasm in practically all the fields.

1.1.2 The city displays a cosmopolitan character which is reflected in its cuisine, culture, inhabitants and language. The bustling city is the most busy port in India and handles about 40 % of India's maritime trade. The city which is part of India's splendid coast has a natural harbour, well developed over a period of time.

1.1.3 Mumbai initially comprised of seven islands which are today known as Colaba, Mahim, Mazgaon, Parel, Worli, Girgaum and Dongri. This group of islands has been joined together by a series of reclamations. As the population grew, areas beyond this Island City developed very fast and the areas considered as outskirts became large residential nodes. What is now called Greater Mumbai extends upto Dahisar on Western Railway, Mulund on Main Line of Central Railway and upto Mankhurd on Harbour Branch of Central Railway.

1.1.4 The city offers lot of job and professional opportunities in different sectors. About thirty years back, there was an article in Times of India, in which it was stated that gold is scattered in the streets of Mumbai and people have only to collect it. This is the reason for large number of migrants from all over India being attracted to Mumbai to earn their livelihood.

This, however, results in very heavy pressure on the city's infrastructure like housing, water supply, transport etc. The concentration of jobs is in the island city, but increase of population is mainly accommodated in the suburbs. As the city is linear with very little width, the major development of suburbs has been in the North only. Since people have to travel long distances from their homes to work places, transportation assumes a very major role. The ever growing vehicular and passenger demands coupled with constraints on capacity augmentation of the existing network have resulted in chaotic conditions, particularly during peak hours.

1.1.5 The Government of Maharashtra have implemented a few measures to alleviate this situation by decentralizing the city. Most notables of these include the development of Navi Mumbai and Bandra – Kurla Complex. Though Navi Mumbai was started long back, the job creation lagged behind but is now picking up. The shifting of city wholesale markets to Navi Mumbai and establishment of new container port at Nava Sheva have helped in redistributing commercial vehicle trips and reducing the congestion in the Island City.

1.2 DEMOGRAPHIC PROFILE:

1.2.1 The total population of Greater Mumbai in 2011 was 124.42 Lakhs, more than double of population of 59.7 Lakhs in 1971. The rise in population was about 38 % during 1971 – 81 but was about 20 % during 1981 – 91 and 1991 – 2001. Between 2001 to 2011 the growth in population is only 4.5%. Table 1.2 shows the trend of population in Island City, Western Suburbs, Eastern Suburbs and total for greater Mumbai.

Table 1.1

Trend of population in Greater Mumbai (in Millions)

Year	**Island City**		**Western Suburbs**		**Eastern Suburbs**		**Total Greater Mumbai**	
		Decadal Growth		Decadal Growth		Decadal Growth		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%
2011	3.08 (31.92%)	-0.27	5.53 (39.78%)	0.43	3.83 (28.20%)	0.37	12.44 (100%)	4.5%

1.2.2 There is no population growth in the Island City during 1971 – 2015. The population growth during 1971 – 2015 in Western Suburbs is 235% and in Eastern Suburbs is 233%. It is evident that the share of Island City population is declining continuously. The proportion of population in Island City compared to total population of Greater Mumbai declined from 51% in

1971 to 24% in 2015. In the same period the proportion for Western Suburbs went up from 28% to 44% and that in Eastern Suburbs from 20 % to 31%.

1.2.3 The spatial growth of population in Greater Mumbai is shown in table 1.2

Table 1.2: Spatial Growth Profile of Greater Mumbai

Description	Area (Sq.Kms.)	Population ('000)						Gross Density (Person / Sq.km)					
		1971	1981	1991	2001	2011	2015	1971	1981	1991	2001	2011	2015
Mumbai Island	67.67	3070.38	3285.04	3174.91	3326.84	3085	3036	45,373	48,545	46,918	49,163	45,589	44,865
Western Suburbs	207.1	1705.49	2858.17	3947.99	5095.68	5527	5719	8,235	13,801	19,063	24,605	26,688	27,615
Eastern Suburbs	171.09	1194.71	2100.22	2803.03	3491.89	3829	3986	6,983	12,276	16,383	20,410	22,380	23,298
Greater Mumbai	**445.86**	**5970.58**	**8243.43**	**9925.93**	**11914.41**	**12442**	**12742**	**13,391**	**18,489**	**22,262**	**26,722**	**27,906**	**28,578**

It is interesting to see that the gross density in persons per sq.km in Island City has decreased from 45,373 in 1971 to only 44,865 in 2015. The corresponding figures for Western Suburbs are increased from 8,235 to 27,615 and for Eastern Suburbs increased from 6,983 to 23,298. All the above figures show Western Suburbs are more popular than the Eastern Suburbs.

1.2.4 Last census was done in 2011. At that time population of Mumbai was 12.44 million. Current Population of MCGM for the year 2015 is 12.74 Million

1.2.5 As per the comprehensive Traffic Study for Mumbai Metropolitan Region, the planning parameters in MCGM are:

Table 1.4: Planning Parameters

Year	Population (Million)	Employment (Million)
2015	12.74	5.96
2021	15.71	6.62
2031	15.99	7.35

1.3 EMPLOYMENT SCENARIO:

1.3.1 The employment data of Greater Mumbai collected from the *National Economic Census* for 1971, 1981, 1991 and 1998 is classified in 10 categories as given below:

1. Agriculture, Forestry and Fishing
2. Mining and Quarrying
3. Manufacturing and Repair services

4. Electricity, Gas and Water
5. Construction
6. Wholesale & Retail trade and Restaurants & Hotels
7. Transport, Storage and Communication
8. Financing, Insurance, Real estate and Business services
9. Community, Social and Personal services
10. Others

1.3.2 The employment growth during 1971-2015 in different areas of Greater Mumbai is shown in Table 1.5. The share of employment in Island City has fallen to 39% in 2015 from 72 percent in 1971. However, the share of employment during 1971-2015, has increased in Western suburbs from 16% to 40% and in Eastern Suburbs from 12% to 21%.

Table 1.5
Employment in Different Areas of Greater Mumbai (in Millions)

Year	Island City	Western Suburbs	Eastern Suburbs	Greater Mumbai
1971	1.09	0.24	0.19	1.52
1981	1.39	0.51	0.29	2.19
1991	1.34	0.64	0.44	2.42
1998	1.59	0.65	0.38	2.62
2011	2.25	2.32	1.23	5.80
2015	2.30	2.40	1.24	5.94

The change in employment in Greater Mumbai is presented in Table 1.6. It may be seen that during 1991-98, the growth of employment in Island area was 18 percent, while in Western suburbs it was only 2 - 3 percent. In the Eastern suburbs, this figure has reduced by about 13 percent during 1991-98.

Table 1.6
Change in Employment growth rate in Greater Mumbai (in %)

Year	Island City	Western Suburbs	Eastern Suburbs	Greater Mumbai
1971-1981	27.34	115.41	51.12	43.92
1981-1991	- 3.57	25.97	49.34	10.30
1991-1998	17.74	2.53	- 12.69	8.24
1998-2011	41.51	256.92	223.68	121.37
2011-2015	2.22	3.45	0.81	2.41

1.4 LAND USE POLICY:

MMRDA prepared a Regional Plan 1996 – 2011, for Mumbai Metropolitan Region (MMR) as required under the Maharashtra Regional & Town Planning Act 1966, which was approved by GOM.

1.4.1 Major recommendations of the Regional Plan are as follows:

- A new Industrial Growth Policy should be framed with specific economic, environmental and urban development objectives. Unlike the past, it should also promote modern, technologically advanced, environment friendly industries in Mumbai Municipal limits, and encourage changes in Mumbai's industrial structure, by facilitating revival of sick and obsolete industries.
- The policy should minimise the adverse impact of new industrial growth on environmental and civic infrastructure.
- The policy should facilitate direct industrial growth in the underdeveloped part of the Region to achieve balanced regional development.
- The policy should help generate new employment opportunities.

1.4.2 As per the Regional Plan, a poly-nucleated land use structure has been recommended for Mumbai Metropolitan Region (MMR). This clearly brings out MMRDA's plan of developing alternative employment growth centres at Bandra Kurla Complex (BKC) in addition to the ones at Navi Mumbai. As per latest estimates, BKC will generate around 200,000 jobs as compared to 700,000 jobs in Navi Mumbai.

1.4.3 In the Island City Area and the suburbs, valuable and significant land parcels have not been used since long. These areas belong to textile mills, which were shut down in the eighties. Recently, the Government of Maharashtra through MMRDA has evolved certain strategies for development of these areas and to re-develop valuable land resources. Table 1.7 presents the total land area, which belongs to textile mills, and the envisaged uses of the land area:

Table 1.7
Proposed Redevelopment of Textile Mill Land Area

Sr. No.	Land Uses	Area (Sqm.)
1	BMC : Open Space / Community Facilities	313291
2	MHADA : Low Income Housing	313291
3	Commercial Use	313291
	Total	**939,873**

1.5 VEHICLE REGISTRATION:

1.51 The data on private vehicles in Greater Mumbai is available for three regions, namely, the Island City, the Western suburbs and Eastern suburbs. The number of private vehicles registered in Greater Mumbai is given in Table 1.8. The ratio of private vehicles per thousand population is growing steadily, and has reached 68.30 in 2002. This clearly shows the inclination of people towards private vehicles. The trend is combined effect of the rising income level and saturation of public transport systems in Mumbai.

Table 1.8
Greater Mumbai Motor Vehicle Statistics

Year	Private Vehicle Registration	Population	Private Vehicle per 1000 population
1971	108146	5970575	18.11
1981	229185	8243405	27.80
1986	365190	8958013	40.76
1991	506959	9925891	51.07
1995	516640	10678015	48.38
1997	604503	11075187	54.58
1998	649654	11279279	57.60
2000	736852	11698814	62.99
2011	1870311	12442373	150.32

1.5.2 The proportion of vehicles in island area has steadily reduced from 33.6% in 2010 to 30.93% in 2013, while is the proportion of vehicles in Western suburbs increased from 45.78% in 2010 to 46.94% in 2013. The proportion of vehicles in Eastern suburbs increased from 20.6% in 2010 to 22.1% in 2013. Distribution of vehicles in Island and Suburbs is shown in Table 1.6.

Table 1.9
Distribution and Growth of Vehicles in Island and Suburbs

Year	Island	Western suburbs	Eastern Suburbs	Total
2010	593902 (33.6%)	809225 (45.78%)	364671 (20.6%)	1767798 (100%)
2011	601176 (32.14%)	870558 (46.55%)	398577 (21.3%)	1870311 (100%)

2012	637768 (31.44%)	950394 (46.85%)	440338 (21.7%)	2028500 (100%)
2013	676514 (30.93%)	1026821 (46.94%)	484063 (22.1%)	2187398 (100%)

1.6 SUBURBAN RAIL SYSTEM:

1.6.1 The main skeleton of the rail network in Mumbai was laid over 100 years ago, initially to link Mumbai and adjacent townships. Electric suburban rail services were started in 1925 in Mumbai by the Great Indian Peninsular Railway (Forbearer of the Central Railway in Mumbai).

1.6.2 Today Mumbai is served by two of India's zonal railways, the Western Railway (WR) and the Central Railway (CR). The Western Railway main lines run Northwards from Mumbai Central parallel to the West Coast of the island towards Northern and Western India and Delhi. However Suburban operations start from Churchgate located in the CBD and extend for 60 kms. Northwards as far as Virar. The services will be extended to Dahanu during the current year. The Central Railway runs from Chhatrapati Shivaji Terminus (CST), located on the Eastern side of the CBD (Approximately 1 km Northeast of Churchgate) and serves a large part of Central India. Suburban services extend from Mumbai CST to as far as Kasara in the Northeast (120-Km) on Nasik side and Karjat in the Southeast (100-Km) on Pune side.

1.6.3 The CR is also responsible for services on the "Harbour Line" which runs from CST station along the East Side of Mumbai Island to Raoli junction where the line splits. One branch runs North West to join the Western Railway main line at Bandra and continues further upto Andheri, with the other line continuing Northwards to Kurla, and turns Eastwards to serve Chembur and Mankhurd and cross the Thane Creek to reach Navi Mumbai. At Wadala, the Mumbai port rail lines join the Harbour line, the Harbour lines north of Wadala are shared with freight traffic to and from Mumbai docks.

1.6.4 Within the Mumbai area both zonal railways carry a combination of suburban, long distance passengers and freight traffic. Daily passenger volumes are about 6.5 million mostly commuter trips within the Metropolitan Region and approximately 2.0 lakh long distance travellers.

1.6.5 Within Mumbai many suburban stations are less than 1.5 km apart and in some cases less than 1 km. Such closely spaced stations are characteristic of a metropolitan urban railway rather than a suburban system. In addition to the three radiating lines from Mumbai CBD there is also a double line track connection beyond Greater Mumbai limits between Vasai Road on the Western Railway and Diva / Dombivali on the Central Railway. This allows long distance North-South trains to bypass Mumbai.

1.6.6 All Western and Central railway lines within the Mumbai suburban area are Broad Gauge (1.676 m) and electrified using the 1500 volt D.C. overhead system. The traction system is being converted to 25 kV A.C. In some areas tracks are prone to flooding during the monsoon season due to drainage system shortcomings on adjacent land or due to inadequate or partially blocked storm water outlets.

1.6.7 Suburban services operate Electric Multiple Units (EMU's) predominantly formed as 9 car rakes (being upgraded to 12 car rakes). A start has been made by Western Railway to run 15 coach trains on a limited schedule and limited stops. A multiple aspect colour light signalling system is used. EMU's are fitted with an Auxiliary Warning System (AWS) which prevents motormen from exceeding 38 km/h when running under single yellow (caution) signals and makes an emergency brake application if a red (danger) signal is passed. The rail network is shown in **Figure 1.1**.

1.7 THE ROAD NETWORK:

1.7.1 The road network has developed over many years, predominately in north-south direction radial to the CBD within the constraints of the islands. There are very few E-W cross links with any continuity across all radials. Extensive development over much of the island has led to the major traffic movements being concentrated into three main corridors; Western, Central and Eastern. The Western corridor generally provides a higher level of service than the Central and Eastern corridors. The central corridor, especially in the South Island area, is severely congested with high pedestrian movements and bus traffic. The Eastern corridor, which runs adjacent to the port, carries large volume of truck traffic and suffers badly from parking and informal roadside vehicle maintenance activities. The network is shown in **Figure 1.2.**

1.7.2 The East – West vehicular movement is constrained by the Western and Central Railway tracks which also run for the majority of the length of the Island city. Consequently major traffic movements are concentrated on relatively few roads, resulting in major points of congestion where East-West movements intersect the north-south corridor at points such as Parel Junction, Khodadad Circle, Gadkare Chowk and Sion intersection.

1.7.3 To the North of Mumbai Island, the East – West movements are further restricted by the limited number of crossing points of the River Mithi. The lack of a good link between places such as Santa Cruz and Chembur or Vashi often results in considerable detours via Sion and the Western and Eastern Express Highways. A major North – South link from Santacruz to Chembur via Kurla has been completed and opened for public.

1.7.4 The roads of Mumbai serve not only as a means of transport but also function as parking areas for vehicles, sites for hawkers and other commercial activities, and extended footways. In some places, notably on the Western Express Highway, part of the right of way (though not the carriageway) has also been encroached upon by slums. These other functions, together with frequent disruption due to service provision and maintenance, severely reduce the traffic capacity of the highways.

1.8 BUS TRANSPORT SYSTEM:

1.8.1 Public stage carriage bus services in the region are provided by BEST, (within BMC and up to 20 km beyond the corporation boundary), TMT in Thane and MSRTC elsewhere.

1.8.2 With over 3,030 buses, BEST is by far the largest provider of bus services in the region. However, due to financial limitations bus replacement has been deferred in recent years and some 25% of this fleet is now more than 10 years old which is the company's preferred limit to bus life.

1.8.3 All routes within Mumbai are provided by BEST. These include radial routes to and from main centres, trunk routes linking main centres and feeder services linking to the trunk routes and to railway stations. Additionally, some routes operate on a limited stop basis providing slightly faster journey times on the trunk routes between the Island City area and outlying parts of Greater Mumbai. However, the improvement in journey time in many cases is marginal due to the traffic congestion and the retention of too many stops on the routes due to public demand and buses not plying on the flyovers. Recently the BEST has introduced "Express" services. These services are allowed to use N-S flyovers and skip few stops thus improving the journey times.

1.8.4 Bus routes from Mumbai City to Navi Mumbai are provided by BEST, MSRTC and Navi Mumbai Municipal Corporation (NMMC). Routes from other points in Greater Mumbai to Navi Mumbai and Thane are provided by BEST, MSRTC, TMT and NMMC.

1.8.5 The dispersal of rail commuters from the main railway terminals to their final destinations in the Mumbai CBD such as Fort, Ballard Estate, Colaba or Nariman point is at present carried out primarily by the bus system. Shared taxi routes are also operated, whilst a large number of people make this final stage of their journey on foot. In the morning peak these movements involve substantial volumes running into the order of 30,000 – 40,000 passenger per hour from each terminus.

1.8.6 BEST operates an "on demand" feeder service during the morning peak hour from Churchgate and CST to Nariman Point or Colaba. This entails constantly having buses queued up at the rail terminus to take passengers so as to avoid any build up of waiting time for the passengers.

1.9 AIR POLLUTION:

1.9.1 In Mumbai road traffic is a major source of air pollution, which has worsened significantly in the last two decades and now poses a considerable health problem and potentially lethal hazard.

1.9.2 Data derived from the ambient air quality monitoring by MCGB shows that air pollution due to road traffic has increased by almost 400% over the last two decades. Transport (principally road traffic) now accounts for about 52% of the overall air pollution load in Greater Mumbai. The air pollution from traffic is principally carbon monoxide (CO), Nitrous Oxide (NOx) and hydrocarbons (HC) whereas industrial pollution takes the form of suspended particulates (SPM), sulphur dioxide (SO_2) and to a lesser degree NOx.

1.9.3 Within the traffic stream the large number of motor cycles, motor scooters and auto rickshaws are estimated to produce 34.5% of total pollutants. This is more than trucks and buses (33.2%) or cars (32.3%). Carbon monoxide and hydrocarbons are the main pollutants from two and three wheelers. Since auto rickshaws are concentrated in the suburbs (they are banned from operations in the Island City), they are an important source of air pollution in the suburban centres of Mumbai and in the principal towns of the region. The GOI Central Motor Vehicle Rules lay down emission standards for new two and three wheeler vehicles and for "light duty vehicles" in respect of CO and HC for current application, with tighter standards for application after 1995 and 2000. These future higher standards aim to reduce emissions to less than 20% of the currently permitted levels.

1.9.4 Many people in Mumbai would appear to have a high tolerance to traffic noise, which is at present not seen as a widespread problem, although levels of noise near the main highways are high by Western standards. It is likely that noise will become more of a perceived problem as traffic volumes increase and if increased traffic flows take to filtering through residential areas. Traffic engineering and environmental traffic management measures will be necessary to control this in future.

1.10 NEED FOR METRO:

Public Transport System is an efficient user of space and energy, with reduced level of air and noise pollution. As the population of the city grows, the share of public transport, road or rail-based, should increase. For a city with population of 1.0 million, the share of public transport should be about 40 - 45%. The percentage share of public transport should progressively increase with further growth in the population of the city, reaching a value of about 75% when the population of the city touches 5 million mark. With Mumbai's population crossing 12 million, the share of public transport at 88% is quite good. However, over the past decade the share has reduced from 91% to 88% and is likely to reduce further if corrective measures are not taken immediately. While up-gradation of existing suburban system is underway through MUTP, it is felt that additional mass transit corridors are required to meet the expanding demand.

Whether the public transport system on a corridor in the city should be road-based or rail-based will depend primarily on the traffic density during peak hours on the corridor. Experience has shown that in mixed traffic conditions, comprising slow and fast moving traffic prevailing in most of our cities, road buses can optimally carry 10,000 persons per hour per direction (phpdt). When traffic density on a corridor exceeds 10,000 phpdt, the average speed of buses comes down, journey time increases, air pollution goes up, and commuters are put to increased level of inconvenience.

Thus when on a corridor, traffic density during peak hours crosses this figure, provision of rail-based mass transport, i.e. Metro system should be considered. In any case, Metro system may become inescapable if the traffic density on a corridor reaches 20,000 PHPDT.

1.11 TYPES OF METROS AND THEIR CAPACITY:

Rail based mass transport in cities can be brought mainly under three categories:- Light Rail, Medium Capacity Metro and Heavy Capacity Metro. The number of commuters to be dealt is relatively less in LRTS, its trains consist of 2 to 3 coaches and other related infrastructure is also of a smaller size. For medium capacity Metro systems, the train generally comprises 3 to 6 coaches with ultimate train headway of about 3 minutes. The other related infrastructure e.g. civil works, stations, passenger handling equipment etc. are also planned accordingly.

Heavy capacity metro systems have to deal with large traffic densities ranging from 50,000 to 80,000 PHPDT. Accordingly, the trains have 6 to 9 coaches and other related infrastructure is also of large size. Beyond the traffic level of 80,000 PHPDT, additional parallel lines are normally planned.

1.12 ADVANTAGES OF A METRO SYSTEM:

Metro systems are superior to other modes because they provide higher carrying capacity, faster, smoother and safer travel, occupy less space, are non-polluting and energy-efficient. To summarise, a Metro system:

- Requires 1/5th energy per passenger km compared to road-based system
- Causes no air pollution in the city
- Causes lesser noise level
- Occupies no road space if underground and only about 2 meter width of the road if elevated
- Carries same amount of traffic as 7 lanes of bus traffic or 24 lanes of private motor cars (either way), if it is a medium capacity system.
- Is more reliable, comfortable and safer than road based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

1.13 REVIEW OF PAST STUDIES:

A number of transportation studies were carried out in the past for Mumbai Metropolitan Region (MMR). These studies discussed travel pattern, network characteristics, and the degree of traffic saturation on the existing roads in the Study Area. The following major studies, which recommended transportation improvements in MMR, have been reviewed.

(i) **Mass Transport Study (1969):** The objective of this Study was to determine the existing conditions of available mass transportation services, future desired lines and to evolve a comprehensive, long term mass transportation plan for Greater Mumbai. Travel projections were made upto the year 1981. These projections formed the basis for identifying the 6th and 7th Rail Corridors.

(ii) **Techno-Economic Feasibility of the 7th Rail Corridor:** Indian Railways carried out the techno-economic feasibility study of the Seventh Corridor in the year 1974. Mumbai Metropolitan region was considered as the Study Area. Passenger traffic of 1.78 million per day was estimated to be carried by the 7th Corridor in 1981.

Detailed engineering feasibility was also carried out and the corridor alignment was fixed. The corridor runs underground (South to North) from Colaba to Bandra (17.38 km) and East to West from Bandra to Kurla elevated (4.90km) and a spur to the airport (4.1 km).

(iii) **East West Rail Corridor Study:** MMRDA got this Study done in the year 1975 for developing rail corridor connecting Bandra – Kurla – Mankhurd – Panvel. The objective of this Study was to provide access to Navi Mumbai with a view to assisting in its development.

Out of the proposed corridor, Mankhurd – Vashi – Panvel section has been completed. The Bandra-Kurla section of this corridor has not been developed so far.

(iv) **Comprehensive Transport Study (CTS) for MMR:** A study was commissioned by the World Bank and MMRDA in 1993 to develop a strategy for transport development in MMR.

The Study focused on the strategies for transport development, institutional strengthening for effective implementation of the proposed strategies and suggesting an investment program with appropriate prioritization.

The recommended strategy covers investments worth a total of Rs. 11,300 crore, including rail system investment of Rs. 7000 crore, bus and ferry system investments of Rs. 570 crore and a highway programme of Rs. 3730 crore including a substantial traffic engineering and management component.

(v) **Mumbai Metro Study, by Mumbai Metro Planning Group:** The Study examined the feasibility of constructing and operating the 7^{th} rail corridor as a heavy metro, and covers a detailed techno-economic study, market survey, estimates of ridership on the new corridors, cost estimates of capital investments and operation, revenue expected and financial aspects.

(vi) **MRTS Study by TEWET:** The study objective was to identify two rail based Mass Rapid Transit (MRT) Systems, one for the CBD and one in Greater Mumbai outside the CBD, and to develop feasibility studies for the two projects.

The TEWET study also identified total network for Greater Mumbai after examining 3 alternatives. The recommended Network is of 57 km length with an estimated cost of Rs. 12,000 crore and in Island city it follows the 7^{th} Corridor alignment. In the suburbs, the line is extended North upto Andheri with two branches; one going upto Charkop in Western suburbs & other leading to Mulund via Ghatkopar.

The detailed feasibility study was done for part of the Master Plan namely Andheri – Ghatkopar section with a spur to Sahar Airport. Total length was about 10 km and estimated cost Rs. 800 crore. Most of the alignment was elevated except small underground stretch of 1.5 km below flyover at Andheri.

(vii) **Sky Bus Metro Study by MMRDA:** The Konkan Railway Corporation presented to GOM a proposal for development of a new transport system called sky bus metro system. It envisages a system, which will be elevated and supported on central columns. MMRDA carried out a techno-economic feasibility study of this system for Andheri – Ghatkopar section. The conclusion of this Study was that since this system has not been implemented anywhere in the world, it needs to be further examined on a 2 km pilot section.

(viii) **Comprehensive Transportation Study**: To improve the traffic and transportation facilities in Mumbai Metropolitan Region (MMR), MMRDA with World Bank assistance under Mumbai Urban Transport Project (MUTP) successfully completed the Comprehensive Transport Study in July, 2008

Following were the objectives of the study:

I. Identify travel pattern of residents of MMR
II. Select, develop and operationalise an Urban Transport Planning model using state-of-the-art modeling techniques and software package, appropriate to the conditions and planning needs of MMR;
III. Assess the relevance of the1994 strategy, identify the consequences of pursuing alternative transport strategies, and recommend/update a long-term comprehensive transport strategy for MMR
IV. Identify for all modes a phased program of appropriate and affordable investments and policy proposals up to 2016; and
V. Help strengthen transport planning skills, and transfer all data, planning model/tools and knowledge obtained through the study to MMRDA and other agencies such as Mumbai Rail Vikas Corporation (MRVC), City & Industrial Development Corporation (CIDCO) and Municipal Corporation of Greater Mumbai (MCGM).

In this study, required short term, medium and long term transport infrastructure for year 2016, 2021 and 2031 respectively was recommended. Following are the CTS recommendations by year 2031:

- Development of mass transit system & road network.
- Proposed 435 kms Metro network, 1740 kms Highway network and 248 kms suburban railway network by 2031.
- Assist in establishment of Unified Mumbai Metropolitan transport Authority (UMMTA).
- Updation of the schemes in MMR and development plan of the Urban Local Bodies based on Transportation Strategy.

As per CTS recommendation, it was proposed to implement the 435 kms Metro network, 1740 kms Highway network and 248 kms suburban railway network by 2031 in a planned and phased manner as per availability of fund.

Figure 1.1

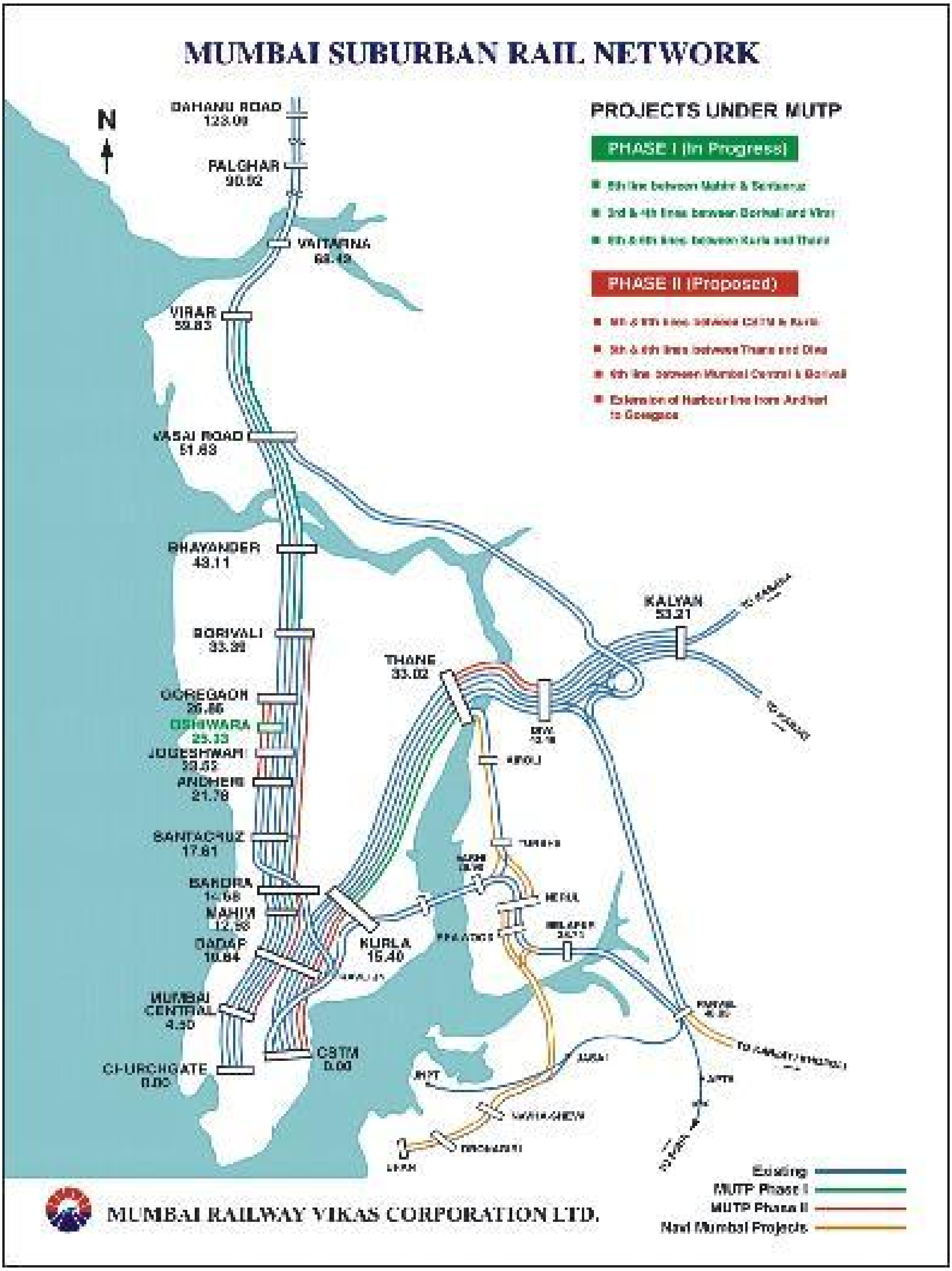
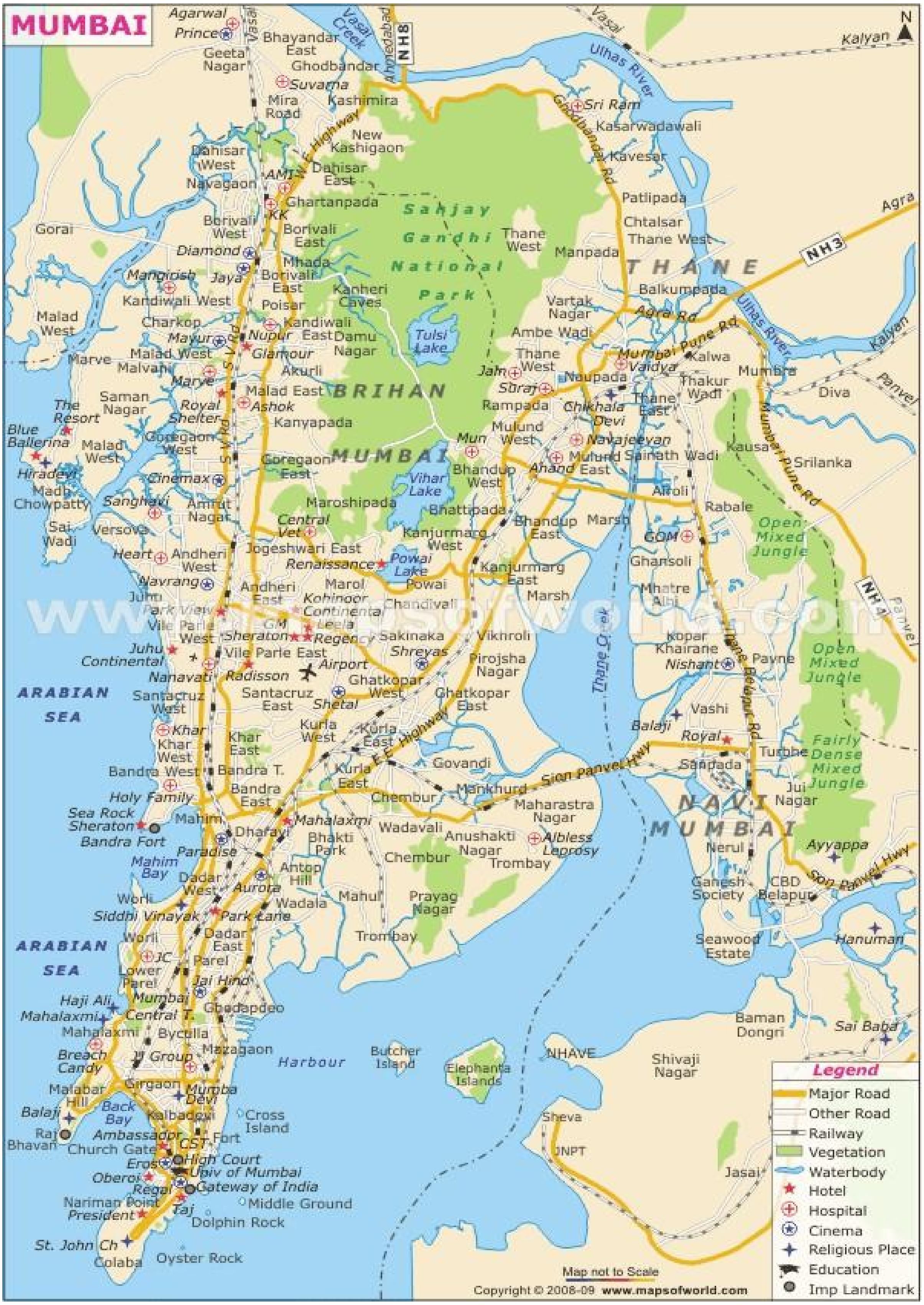

MUMBAI SUBURBAN RAIL NETWORK
N
DAHANU ROAD
123.09
PALGHAR
90.92
VAITARNA
VIRAR
VASAI ROAD
51.63
BHAYANDER
43.11
BORIVALI
GOREGAON
OSHIWARA
JOGESHWARI
ANDHERI
21.78
SANTACRUZ
17.81
BANDRA
MAHIM
DADAR
10.84
MUMBAI CENTRAL
CHURCHGATE
CSTM
0.00
KURLA
15.40
THANE
33.02
KALYAN
53.21
PROJECTS UNDER MUTP
PHASE I (In Progress)
3rd & 4th lines between Borivali and Virar
PHASE II (Proposed)
5th & 6th lines between Thane and Diva
6th line between Mumbai Central & Borivali
Extension of Harbour line from Andheri to Goregaon
MUMBAI RAILWAY VIKAS CORPORATION LTD.
Existing
MUTP Phase I
MUTP Phase II
Navi Mumbai Projects

Figure 1.2


MUMBAI
N
Kalyan
Agra
NH3
NH8
NH4
THANE
BRIHAN MUMBAI
NAVI MUMBAI
Sanjay Gandhi National Park
Tulsi Lake
Vihar Lake
Powai Lake
ARABIAN SEA
ARABIAN SEA
Harbour
Ulhas River
Vasai Creek
Thane Creek
Bhayandar East
Mira Road
Kashimira
Dahisar West
Dahisar East
Borivali West
Borivali East
Kandiwali West
Malad West
Malad East
Goregaon West
Goregaon East
Jogeshwari East
Andheri West
Andheri East
Vile Parle East
Santacruz West
Santacruz East
Khar West
Khar East
Bandra West
Bandra East
Kurla West
Kurla East
Ghatkopar West
Ghatkopar East
Vikhroli
Bhandup West
Bhandup East
Mulund West
Mulund East
Thane West
Thane East
Kalwa
Mumbra
Diva
Airoli
Ghansoli
Kopar Khairane
Vashi
Turbhe
Sanpada
Nerul
CBD Belapur
Chembur
Govandi
Mankhurd
Trombay
Dharavi
Mahim
Dadar West
Dadar East
Worli
Parel
Lower Parel
Byculla
Mazagaon
Mahalaxmi
Colaba
Gateway of India
Elephanta Islands
Butcher Island
Middle Ground
Dolphin Rock
Oyster Rock
Cross Island
Sion Panvel Hwy
Mumbai Pune Rd
E.E. Highway
NHAVE
Sheva
JNPT
Jasai
Shivaji Nagar
Baman Dongri
Open Mixed Jungle
Fairly Dense Mixed Jungle
Legend
Major Road
Other Road
Railway
Vegetation
Waterbody
Hotel
Hospital
Cinema
Religious Place
Education
Imp Landmark
Map not to Scale
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CHAPTER 2

EVOLUTION OF MUMBAI METRO MASTER PLAN AND PRESENT STATUS

2.1 BACKGROUND:

Mumbai does have a very good transportation system but has not been able to keep pace with rising demand. The carrying capacity of the Rail and bus based system has been increased considerably over the last 4 – 5 decades but traffic has increased much faster. Even in the fifties of last century, local trains (6 coach trains at that time) used to be very crowded during the peak hours. Number of bogies went up gradually to 9/12 and now even 15. The frequency of trains improved a lot but overcrowding grew worse due to heavier increase in traffic. Suburban rail traffic increased by 6 times while the capacity increased by 2.3 times. Vehicular growth increased from 61,000 to over 1.20 million in the last four decades.

It has been obvious for a long time that the existing rail and bus based transport systems of Mumbai are under extreme pressure.

Due to the various constraints of existing systems as also the limitations in increasing the carrying capacity, a new Mass Rapid Transit System is essential to take care for the next few decades.

Though ‘Metro’ for Mumbai has been talked about for the last 50 or 60 years, something concrete has come through only in the last about ten years.

Improvements in the rail based system are being carried out under Mumbai Urban Transport Project (MUTP) for road based system under Mumbai Urban Infrastructure Project (MUIP), both aided by the World Bank.

Metro had been suggested in the past but not as an integrated system for Greater Mumbai as part of long term planning. However a Master plan has now been prepared and the various corridors finalised. A brief of the work done will not be out of place and is as under.

2.2 PRELIMINARY NETWORK:

All possible routes based on the following inputs were listed with a view to broadly identify the most feasible and apparently advantageous corridors for possible inclusion in the final Master plan:

i) Recommendation of the earlier studies for various rail based systems such as $6^{th}/7^{th}$ corridor, SMART study, MMPG study.
ii) Existing and future land use plans including Regional plan for MMR which indicate the locations and intensity of population and employment growth and development of alternate City centers.
iii) Suburban Rail Improvement Plans arising out of Departmental budgetary schemes and MUTP (phase I & II).
iv) Availability of suitable pieces of land for depot to minimize dead running and land cost.
v) Arterial road network expansion programme envisaged under the sanctioned projects of MUTP and MUIP.
vi) The suggestion of the members of the study review committee. Accordingly, a primary network of about 200 km was identified.

2.3 MASTER PLAN:

Thereafter intensive site reconnaissance surveys were carried out. The alternative probable corridors were discussed with representatives of local authorities and finally a network comprising of 146.5 km was selected as Master Plan for Mumbai Metro. The most important criteria in finalizing the Master plan were:

- To serve areas of population and employment concentration not served here to.
- To ensure regional linkages and connectivity to rail system proposed in adjoining regions like Thane and Navi Mumbai.
- Maximum inter-modal integration with existing and committed suburban rail network.
- Easy connectivity to depot sites.
- Feasibility of the minimum values for system parameters in terms of vertical curves, horizontal curves and gradients.

The Master Plan network was split in suitable corridors as under:

Table 2.1

S. No.	Corridor	Length (Km)		
		Total	Elev.	U.G
1	Versova – Andheri – Ghatkopar	15.00	15.00	-
2	Coloba – Mahim (Bandra)	18.00	8.10	9.90
	Mahim (Bandra) – Charkop	18.00	18.00	
3	Mahim – Kurla – Mankhurd	12.80	10.70	2.10
4	Charkop – Dahisar	7.50	7.50	
5	Ghatkopar – Mulund	12.40	12.40	
6	BKC – Kanjur Marg via Airport	19.50	11.00	8.50
7	Andheri (E) – Dahisar (E)	18.00	18.00	
8	Hutatma Chowk – Ghatkopar	21.80	13.30	8.50
9	Sewri – Prabhadevi	3.50		3.50

2.4 PHASING OF MASTER PLAN:

The Master Plan of Metro finalized for Greater Mumbai consists of approximately 146.50 km of network. It is practically not feasible to develop the entire network at one go for many reasons like:

i) Availability of sufficient funds.
ii) Limitation on civil work construction.
iii) The environmental and traffic impacts during construction.
iv) Difficulties in acquisition of open land as well as built up structures.
v) Resettlement of project affected families.

The Master Plan Network was therefore grouped into different phases. The criteria adopted in finalizing the phases were:

i) Ridership per unit length of the corridor.
ii) Ridership per unit investment on the corridor.
iii) Sectional traffic loads.
iv) Environmental Impact.

After detailed deliberation with the study review committee suitable weightages were assigned to these four criteria as under:

i) Ridership per unit length = 40 %
ii) Ridership per unit investment = 25%

iii) Sectional traffic loads = 25 %

iv) Environmental Impact = 10 %

The preliminary results of phasing exercise were discussed in the meetings of the Executive Committee of MMRDA, chaired by the Chief Secretary, GOM and later in the meeting of MMRDA chaired by the Hon'ble Chief Minister. The final approved phasing of the Master plan is as under:

Table 2.2

Phase	Corridors	Length (Kms)		
		Total	Elev.	U.G
1	a) Versova – Andheri - Ghatkopar	63.80	51.80	12.00
	b) Colaba - Charkop			
	c) Mahim - Mankhurd			
2	a) Ghatkopar – Mulund	19.90	19.90	-
	b) Charkop – Dahisar			
3	a) BKC – Airport - Kanjur Marg	62.80	42.30	20.50
	b) Andheri (E) – Dahisar (E)			
	c) Hutatma Chowk – Ghatkopar			
	d) Sewri – Prabhadevi			
	TOTAL	**146.50**	**114.00**	**32.50**

2.5 Implementation Period

The expected period of implementation of three phases at present is shown below:

Table 2.3

S. No.	Corridor	Length of the Corridor (kms)			Phase wise Length (kms)	Period of implementation
		U.G	Elev.	Length		
1	Versova – Andheri – Ghatkopar	0.0	15.0	*15.0	63.80 Phase I	2006 – 2013
2	Colaba – Mahim (Bandra)	9.9	26.1	36.0		
	Mahim (Bandra) – Charkop					
3	Mahim – Kurla – Mankhurd	2.1	10.7	12.8		
4	Charkop – Dahisar	0.0	7.5	7.5	19.90 Phase II	2011 – 2016
5	Ghatkopar – Mulund	0.0	12.4	12.4		
6	BKC – Kanjur Marg via Airport	8.5	11.0	19.5	62.8 Phase III	2016 – 2021
7	Andheri (E) – Dahisar (E)	0.0	18.0	18.0		
8	Hutatma Chowk – Ghatkopar	8.5	13.3	21.8		
9	Sewri – Prabhadevi	3.5	0.0	3.5		
	Total	**32.5**	**114.0**	**146.5**	**146.5**	

The different corridors are shown in **Annexure 2.1**

2.6 PRESENT STATUS:

2.6.1 Line no 1 viz. Versova – Andheri – Ghatkopar has been implemented and commissioned on 8th June 2014 The work was done on Public Private Partnership (PPP) mode by a Special Purpose Vehicle, Mumbai Metro one, comprising of Government of Maharashtra, Reliance Infrastructure and VOELIA of France.

2.6.2 A special purpose vehicle (SPV) was formed for line no 2, viz. Charkop – Bandra – Mankhurd corridor. SPV comprises of Government of Maharashtra, Reliance Infrastructure and SNC Lavalin of Canada. However, the implementation of this Line did not take off.

2.6.3 In November / December 2009, MMRDA awarded the work of preparing Detailed Project Reports for following corridors to parties as indicated below:

i) Charkop – Dahisar (7.50 Km.) – M/s SPAN Consultants Pvt. Ltd.

ii) Andheri(E) – Dahisar(E) (18.00 Km.) – M/s SPAN Consultants Pvt. Ltd.

iii) BKC Kanjur Marg (via Airport) (19.50 Km.) with Extension from BKC to Mahim (4.0 Km.) – M/s RITES.

iv) Ghatkopar – Mulund (12.50 Km.) – M/s Consulting Engineering Services.

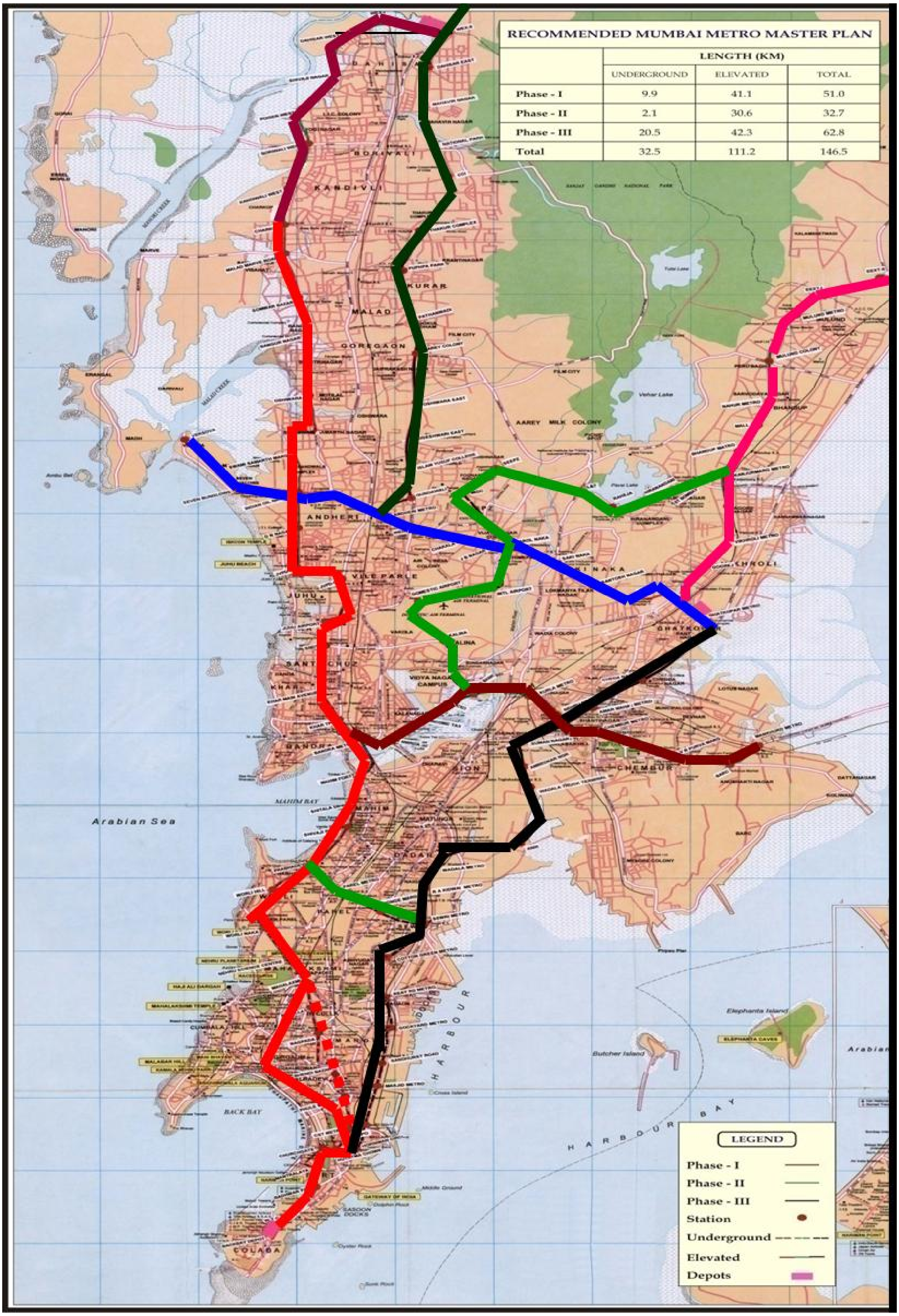
v) Wadala-Carnac Bunder (DPR) – M/s Consulting Engineering Services

2.6.4 All the above reports have been submitted to MMRDA.

2.6.5 An SPV named as Mumbai Metro rail Corporation Ltd. (MMRC) is incorporated and implementation of Line -3 between Colaba- BKC-Aarey is being done by the SPV.

2.6.6 MMRDA is intending to implement other corridors by itself.

Annexure 2.1


RECOMMENDED MUMBAI METRO MASTER PLAN

	LENGTH (KM)		
	UNDERGROUND	ELEVATED	TOTAL
Phase - I	9.9	41.1	51.0
Phase - II	2.1	30.6	32.7
Phase - III	20.5	42.3	62.8
Total	32.5	111.2	146.5

LEGEND
Phase - I
Phase - II
Phase - III
Station
Underground
Elevated
Depots
Arabian Sea
BORIVALI
KANDIVLI
KURAR
MALAD
GOREGAON
ANDHERI
VILE PARLE
JUHU
SANTACRUZ
BANDRA
MAHIM BAY
MAHIM
SION
CHEMBUR
GHATKOPAR
BACK BAY
COLABA
HARBOUR BAY
Elephanta Island
Butcher Island
Vehar Lake
AAREY MILK COLONY

CHAPTER 3

TRAFFIC FORECAST

3.0 As stated on SPAN' s report**,** MMRC had initially given information about planning parameters in MCGM area and the traffic projections for three horizon years viz. 2016, 2021, 2031.

3.1 Proposed Metro Stations on Andheri (E) -Dahisar (E) Corridor

As per the details received, following sixteen stations are envisaged on the Andheri (E) to Dahisar (E) Metro corridor. The locations of proposed stations are as under

Table 3.1Station Locations

Mumbai Metro(Andheri- Dahisar corridor)			
Sl.No	Station Name	Chainage(m)	Inter Distance between two Stations (m)
0	Dead End	(-) 450	
1	ANDHERI	0.0	450
2	SHANKARWADI	1229.8	1229.8
3	JVLR Jn.	2413.9	1184.1
4	BOMBAY EXHIBITION	3781.5	1367.6
5	HUB MALL	4580.0	798.5
6	V.NAGAR	5559.7	979.7
7	AAREY ROAD Jn.	6100.0	540.3
8	VITT BHATTI Jn.	7180.0	1080.0
9	KURAR VILLAGE	8068.0	888.0
10	BANDONGRI	9075.7	1007.7
11	MAHINDRA & MAHINDRA	9700.0	624.3
12	THAKUR COMPLEX	11427.7	1727.7
13	BORIVALI BUS STOP	12250.0	822.3
14	BORIVALI OMKARESHWAR	13376.5	1126.5
15	SHRINATH NAGAR	14384.5	1008.0
16	DAHISAR (E)	15524.9	1140.4
	Dead End	16025.7	500.8
	Length of Corridor		**16475.6**

3.2 Traffic Projections

MMRC were requested to give the traffic data for the above proposed stations. The information received in respect of ridership flows, boarding alighting etc. is shown in Table No. 3.1, 3.2 and Annexures 3.1 to 3.3 for the three horizon years 2016, 2021 and 2031.

Peak hour trip is 9 % of the daily trips.

3.3 Station to station segment flows and Peak Hour Boardings/Alighting

The station to station segment flows in both directions during peak hours for the years 2016, 2021 and 2031 are shown in table no 3.1 and peak hour total boarding and alighting figures in table3.2.

Table no 3.1

Peak Hour Station to Station Segment Flows

From	To	2016		2021		2031	
		Forward	Reverse	Forward	Reverse	Forward	Reverse
Station 1 (ANDHERI.)	Station 2 (Shankarwadi)	8591	12800	4289	8553	4688	7306
Station 2 (Shankarwadi)	Station 3 (JVLR Jn.)	8657	12726	5421	8344	6207	7452
Station 3 (JVLR Jn.)	Station 4 (Bombay Exhibition)	9291	12474	11300	17153	14318	17778
Station 4 (Bombay Exhibition)	Station 5 (Hub Mall)	7673	11876	11505	17831	14460	18353
Station5 (Hub Mall)	Station 6 V. Nagar	7673	11876	11440	18086	14406	18584
Station 6 (V. Nagar)	Station 7 (Aarey Road Junction)	7491	12088	11221	17870	13991	18371
Station 7 (Aarey Road Junction)	Station 8 (VITT Bhatti Jn.)	7781	12751	11048	17086	13834	17612
Station 8 (Vitt Bhatti Jn.)	Station 9 (Kurar Village)	7494	11990	11099	16550	13976	17214
Station 9 (Kurar Village)	Station 10 (Bandongri)	7965	9832	10758	15493	13514	17186
Station 10 (Bandongri)	Station 11 (Mahindra & Mahindra)	7070	8943	9938	15105	12500	17175
Station 11 (Mahindra &Mahindra)	Station 12 (Thakur Complex)	6435	8257	9206	12935	11747	14938

From	To	2016		2021		2031	
		Forward	Reverse	Forward	Reverse	Forward	Reverse
Station 12 (Thakur Complex)	Station 13 (Borivali Bus Stop)	5953	6885	8785	10894	11353	13140
Station 13 (Borivali Bus Stop)	Station 14 (Borivali Omkareshwar)	4975	6008	7950	9942	10438	13472
Station 14 (Borivali Omkareshwar)	Station 15 (Shrinath Nagar)	5164	4507	6745	7875	10436	9442
Station 15 (Shrinath Nagar)	Station 16 (DAHISAR)	4718	3874	5859	6851	8817	7541
Maximum PHPDT		**9291**	**12800**	**11505**	**18086**	**14460**	**18584**

Table no 3.2

Peak Hour Boarding and Alighting

Station	2016		2021		2031	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Station 1 (ANDHERI.)	8591	12800	4289	8553	4688	7306
Station 2 (Shankarwadi)	1138	997	2547	1206	2750	1377
Station 3 (JVLR Jn.)	1899	1013	7237	10167	9679	11894
Station 4 (Bombay Exhibition)	1536	2048	2311	2784	2339	2773
Station5 (Hub Mall)	1536	2049	171	490	182	467
Station 6 (V. Nagar)	304	696	1851	1854	1936	2138
Station 7 (Aarey Road Junction)	947	1319	1961	1350	2127	1525
Station 8 (Vitt Bhatti Jn.)	1505	1032	2629	2042	2979	2439
Station9 (Kurar Village)	4941	2312	3530	2813	3278	3710
Station 10 (Bandongri)	1460	1466	1777	2210	1816	2821
Station 11 (Mahindra & Mahindra)	2456	2404	3968	2530	4504	3020
Station 12 (Thakur Complex)	2725	1834	3682	2061	4660	3257

Station	2016		2021		2031	
	Boarding	**Alighting**	**Boarding**	**Alighting**	**Boarding**	**Alighting**
Station 13 (Borivali Bus Stop)	1622	1722	1851	1734	1681	2928
Station 14 (Borivali Omkareshwar)	3677	1988	3348	2486	7649	3620
Station 15 (Shrinath Nagar)	633	445	4867	4730	8961	8680
Station 16 (DAHISAR)	3874	4718	6851	5859	7541	8817
Total	**38844**	**38843**	**52869**	**52869**	**66770**	**66770**

Year	Trips per day (lakhs)	
	Daily Trips	**Average Lead in KM**
2016	388440	6.58
2019	472590	6.58
2021	528690	6.58
2031	667698	6.04

Annexure 3.1

Peak Hour. Ridership for Andheri - Dahisar Metro Corridor 2016					
Sr. No.	**Station Name**	**Volume Andheri - Dahisar**	**Volume Dahisar-Andheri**	**Boarding**	**Alighting**
1	**Andheri (WEH)**	8591	0	8591	12800
2	Shankarwadi	8657	12800	1138	997
3	JVLR Jn.	9291	12726	1899	1013
4	Bombay Exhibition	7673	12474	1536	2049
5	Hub Mall	7673	11876	1536	2049
6	V. Nagar	7491	11876	304	696
7	Aarey Road Jn.	7781	12088	947	1319
8	Vitt Bhatti Jn.	7494	12751	1505	1032
9	Kurar Village	7965	11990	4941	2312
10	Bandongri	7070	9832	1460	1466
11	Mahindra & Mahindra	6435	8943	2456	2404
12	Thakur Complex	5953	8257	2725	1834
13	Borivali Bus Stop	4975	6885	1622	1722
14	Borivali Omkareshwar	5164	6008	3677	1988
15	Shrinath Nagar	4718	4507	633	445
16	Dahisar (E)	0	3874	3874	4718
	Max PHPDT	9291	**12800**	**38844**	**38844**
	Daily Ridership			**388440**	

Trip Length in Km	Passenger	% of trips
0 to 3	7372	19%
3 to 8	17354	45%
8 to 12	9925	26%
12 to 15	3420	9%
15 to 20	771	2%
Total	**38844**	**100%**

Annexure 3.2

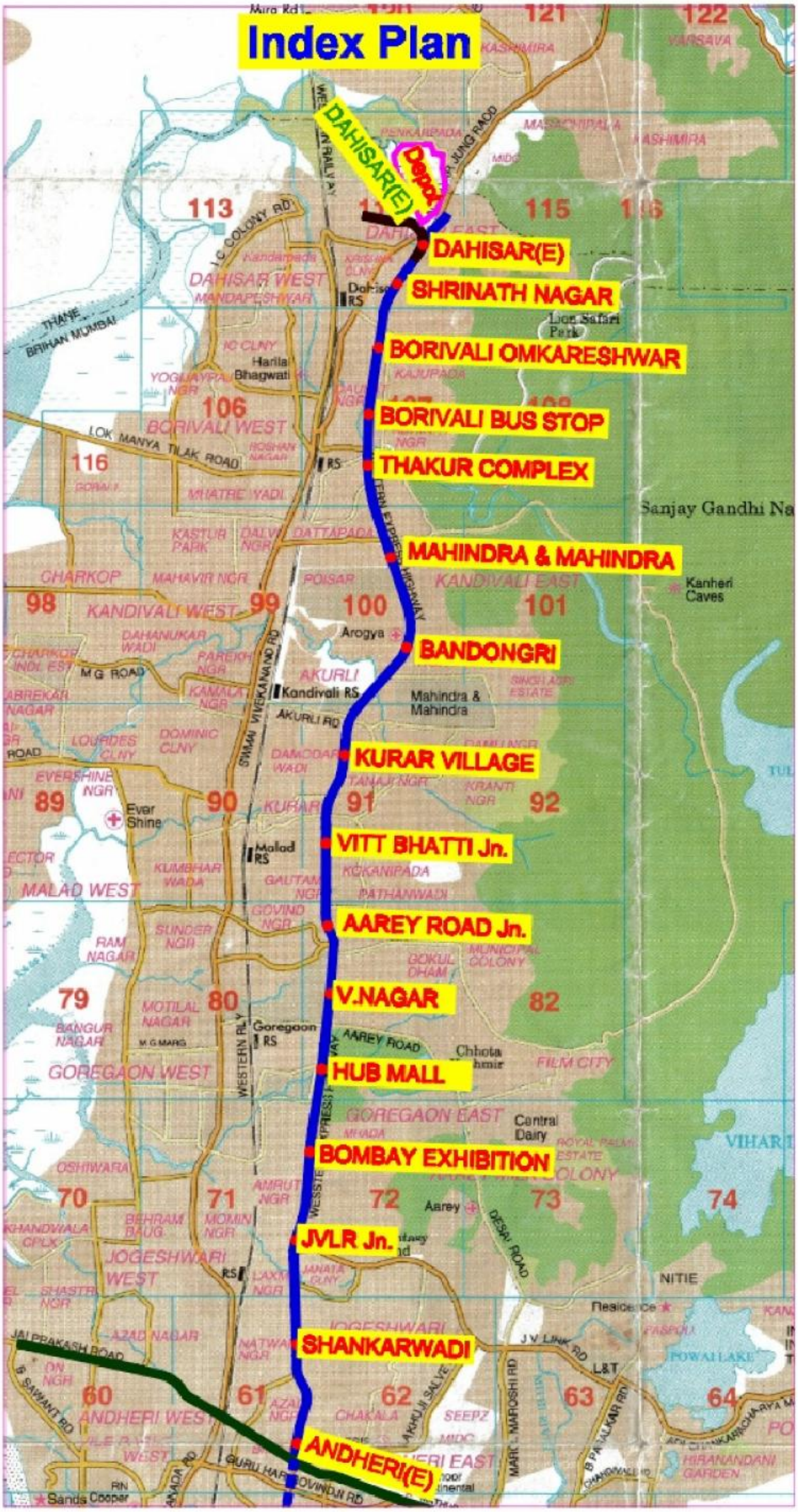
Peak Hour. Ridership for Andheri - Dahisar Metro Corridor 2021					
Sr. No.	**Station Name**	**Volume Andheri - Dahisar**	**Volume Dahisar-Andheri**	**Boarding**	**Alighting**
1	**Andheri (WEH)**	4289	0	4289	8553
2	Shankarwadi	5421	8553	2547	1206
3	JVLR Jn.	11300	8344	7237	10167
4	Bombay Exhibition	11505	17153	2311	2784
5	Hub Mall	11440	17831	171	490
6	V. Nagar	11221	18086	1851	1854
7	Aarey Road Jn.	11048	17870	1961	1350
8	Vitt Bhatti Jn.	11099	17086	2629	2042
9	Kurar Village	10758	16550	3530	2813
10	Bandongri	9938	15493	1777	2210
11	Mahindra & Mahindra	9206	15105	3968	2530
12	Thakur Complex	8785	12935	3682	2061
13	Borivali Bus Stop	7950	10894	1851	1734
14	Borivali Omkareshwar	6745	9942	3348	2486
15	Shrinath Nagar	5859	7875	4867	4730
16	Dahisar (E)	0	6851	6851	5859
	Max PHPDT	11505	**18086**	52869	52869
	Daily Ridership			**528690**	

Trip Length frequency Distribution for Andheri - Dahisar -2021		
Stage	**No. of Trips**	**%**
0 to 3	12899	24.40
3 to 5	8237	15.58
5 to 8	12389	23.43
8 to 12	13593	25.71
12 to 15	4492	8.50
>15	1259	2.38
	52869	**100**
Average Trip Length in Km = 6.58		

Annexure 3.3

Peak Hr. Ridership for Andheri - Dahisar Metro Corridor 2031					
Sr. No.	**Station Name**	**Volume Andheri - Dahisar**	**Volume Dahisar-Andheri**	**Boarding**	**Alighting**
1	**Andheri (WEH)**	4688	0	4688	7306
2	Shankarwadi	6207	7306	2750	1377
3	JVLR Jn.	14318	7452	9679	11894
4	Bombay Exhibition	14460	17778	2339	2773
5	Hub Mall	14406	18353	182	467
6	V. Nagar	13991	18584	1936	2138
7	Aarey Road Jn.	13834	18371	2127	1525
8	Vitt Bhatti Jn.	13976	17612	2979	2439
9	Kurar Village	13514	17214	3278	3710
10	Bandongri	12500	17186	1816	2821
11	Mahindra & Mahindra	11747	17175	4504	3020
12	Thakur Complex	11353	14938	4660	3257
13	Borivali Bus Stop	10438	13140	1681	2928
14	Borivali Omkareshwar	10436	13472	7649	3620
15	Shrinath Nagar	8817	9442	8961	8680
16	Dahisar (E)	0	7541	7541	8817
	Max PHPDT	14460	**18584**	66770	66770
	Daily Ridership			**667698**	

Trip Length frequency Distribution for Andheri - Dahisar -2031		
Stage	**No. of Trips**	**%**
0 to 3	20278	30.37
3 to 5	10361	15.52
5 to 8	14969	22.42
8 to 12	15042	22.53
12 to 15	4721	7.07
>15	1398	2.09
	66769	**100**
Average Trip Length in Km = 6.04		


Index Plan
DAHISAR(E)
Depot
DAHISAR(E)
SHRINATH NAGAR
BORIVALI OMKARESHWAR
BORIVALI BUS STOP
THAKUR COMPLEX
MAHINDRA & MAHINDRA
BANDONGRI
KURAR VILLAGE
VITT BHATTI Jn.
AAREY ROAD Jn.
V.NAGAR
HUB MALL
BOMBAY EXHIBITION
JVLR Jn.
SHANKARWADI
ANDHERI(E)
DAHISAR WEST
BORIVALI WEST
KANDIVALI WEST
KANDIVALI EAST
MALAD WEST
GOREGAON WEST
GOREGAON EAST
JOGESHWARI WEST
ANDHERI WEST
Sanjay Gandhi Na
Kanheri Caves
Lion Safari Park
Kandivali RS
Goregaon RS
Malad RS
Mahindra & Mahindra
FILM CITY
Central Dairy
NITIE

CHAPTER 4

SYSTEM SELECTION

4.0 INTRODUCTION:

4.0.1 Andheri (East) – Dahisar (East) Corridor of Mumbai Metro starts at the junction of Western Express Highway and M.V. Road at Andheri East. The alignment runs through Jogeshwari, Goregaon, Malad, Kandivali, Thakur Village, Poisar and Borivali to end at Dahisar (E).

4.0.2 Versova – Ghatkopar corridor also passes through the junction of W.E.H and M.V. Road. One station of this corridor is located on East side of W.E.H. Chainage 0.0 for Andheri East – Dahisar corridor is about 50 m North of Versova to Ghatkopar Metro Line.

4.0.3 The entire corridor will be elevated.

4.0.4 Length of corridor is 16.475 Kms. (dead end to dead end)

4.0.5 Sixteen stations have been proposed on the corridor. Efforts have been made to keep the inter station distance about a kilometer. However the closest inter-station distance is 540.3 metres and farthest 1727.7 metres.

4.0.6 All stations will be two level stations with the concourse and station facilities on the lower level and platforms on the higher level.

4.0.7 Maintenance Depot has been proposed near Dahisar Terminal station on Land belonging to Airport Authority of India.

4.0.8 The corridor can be extended beyond Dahisar, if required.

4.1 PERMANENT WAY:

4.1.1 Choice of Gauge:

The issue of Broad Gauge vs. Standard Gauge for Metro in India has been debated for quite some time and the decision is in favour of Standard Gauge. Even Delhi Metro which started with Broad Gauge has fallen in line and is now adopting Standard Gauge. It is advantageous to go in for Standard Gauge for many factors as indicated below:

(i) Metro alignments in a city have to pass through heavily built-up areas for optimal passenger utilisation and this imposes severe restrictions on the selection of curves. As in most of the cities in India no 'right of way' has been reserved for metro systems, the alignments have to follow the major arterial roads. These roads often have sharp curves and right-angle bends. In such a situation adoption of Standard Gauge is advantageous since it permits adoption of sharper curves compared to Broad Gauge to minimize property acquisition along the alignments.

(ii) In Standard Gauge 1 in 7 and 1 in 9 turn-outs, which occupy lesser length, are feasible compared to 1 in 8 ½ and 1 in 12 turn-outs required for Broad Gauge. Land requirement for depots, where a large number of lines are connected together in the shape of ladder is also reduced. Standard Gauge is, therefore, more suited for use in built-up environment where land availability is scarce.

(iii) For Standard Gauge, optimized state-of-the-art rolling stock designs are available 'off-the-shelf'. This is not so for Broad Gauge where new designs for rolling stock have to be specially developed which entails extra time and cost.

(iv) Because of the availability of a very large market, constant up-gradation of technology takes place for Standard Gauge coaches. Thus upgraded technology is available on a continued basis in case of Standard Gauge. This is not so in case of Broad Gauge.

(v) For same capacity gross weight of a metro coach is lower for Standard Gauge than for Broad Gauge. Standard Gauge rolling stock thus results in recurring saving in energy consumption during operation.

(vi) Once technology for Standard gauge coaches gets absorbed and manufacturing base for them is set up in India, there will be considerable export potential for the coaches, since almost all the countries use Standard Gauge for their metros. This is not so in case of Broad Gauge.

(vii) It is sometime argued that adoption of Broad Gauge for metros would enable inter-running of metro trains with Indian Railways since the latter use Broad Gauge. Inter- running is, however, technically and / or operationally not feasible as the two systems have different:

- Rolling Stock characteristics,
- Signaling Systems,

- Headways,
- Tariffs,
- Moving dimensions, and
- Loading standards.

(viii) Track gauge is not a technical parameter for any metro rail system. It is a planning parameter. This issue was also examined in January 2000 by the Ministry of Law and Justice who had opined that the choice of gauge is a matter which lies within the jurisdiction of the metro rail organisation entrusted with the responsibility of implementing and operating the metro system.

Since inter – running is not feasible, choice of gauge for a metro system should be based purely on technical and economic considerations on which Standard Gauge turns out to be superior.

It will thus be seen that Standard Gauge will be cost effective and at the same time enable Mumbai Metro to be at par with world class metros and enable it to remain technically up-dated in future. Standard Gauge will also enable setting up a manufacturing base for coaches required for Metros in other cities in the country and as well create an export potential for such coaches.

4.1.2 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 should require 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.

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 as the regular cleaning and replacement of ballast at such location will not be possible. Only in case of the depot normal ballasted track is proposed for adoption.

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.

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 main lines will have sharp curves and steep gradients, 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.

Ballastless Track on Viaducts

On the viaducts, it is proposed to adopt plinth type ballastless track structure with RCC derailment guards integrated with the plinths (shown in Fig.4.1). It is proposed to adopt suitable Fastenings System with a base-plate to base-plate spacing of 65 cm, on viaducts complying of performance criteria laid down by Railway Board vide letter Circular No. 2009/Proj/InAs/9/2, dated 02.05.2010.

Ballastless Track in Depot

The ballastless track in Depot will 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.

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:
    i) 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 (shown in **Fig.4.2**).
    ii) On Depot lines, 1 in 7 type turnout with a lead radius of 190 metres and permissible speed on divergent track as 25 km/h (shown in **Fig.4.3**).

  The Scissors crossovers on Main Lines (1 in 9 type) will be with a minimum track centre of 4.5 m (shown in **Fig.4.4**).

- The proposed specifications for turnouts are given below: -

i) 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.
ii) 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.
- 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.

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.

4.1.3 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 for a maximum gap of 180 mm.

Welding

Flash Butt Welding Technique is to be used for welding of rails. Alumino-Thermic 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.

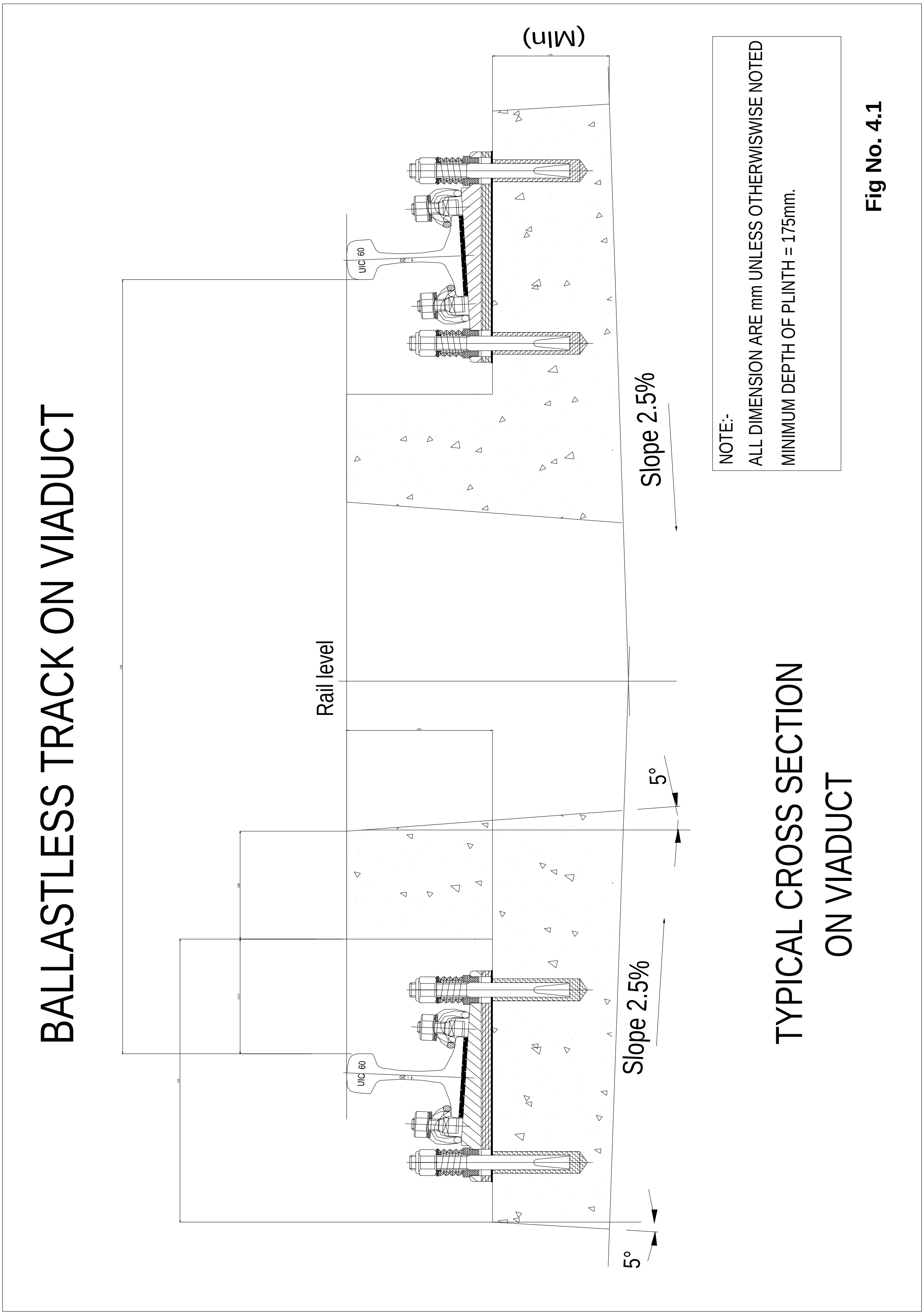
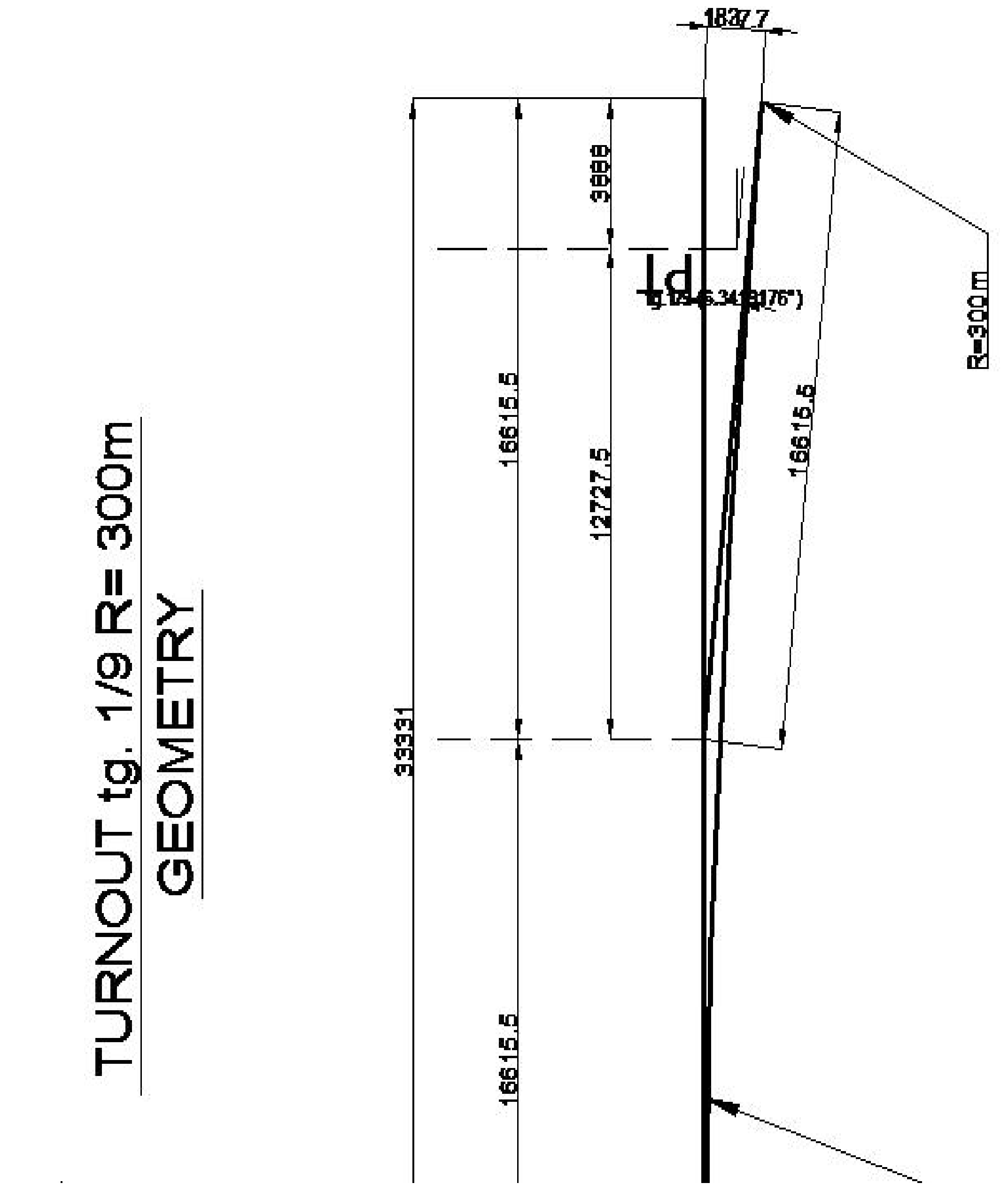

BALLASTLESS TRACK ON VIADUCT
(Min)
UIC 60
UIC 60
Rail level
Slope 2.5%
Slope 2.5%
5°
5°
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWISE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.
TYPICAL CROSS SECTION
ON VIADUCT

Fig No. 4.1

Fig No. 4.2


TURNOUT tg. 1/9 R= 300m
GEOMETRY
33331
16615.5
12727.5
16615.5
16615.5
R=300 m
ld

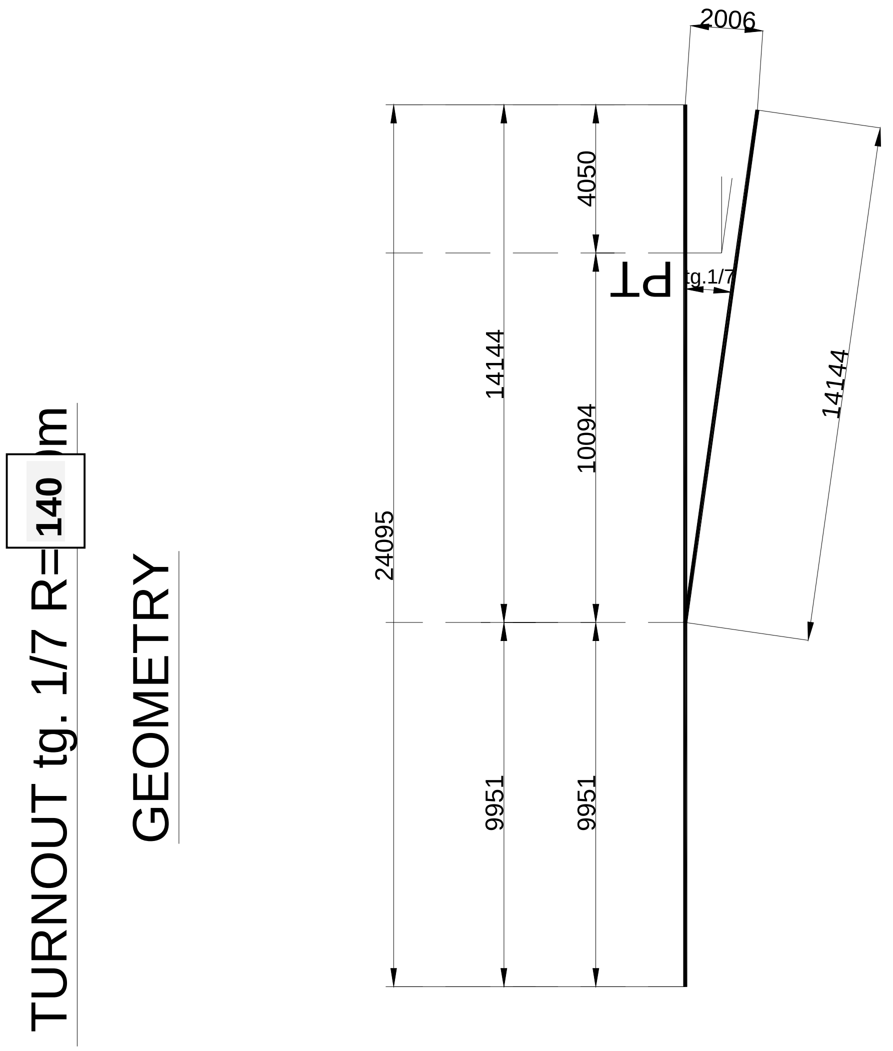

TURNOUT tg. 1/7 R=140m
GEOMETRY
2006
4050
PT
tg.1/7
14144
10094
24095
9951
9951
14144

Fig No. 4.3

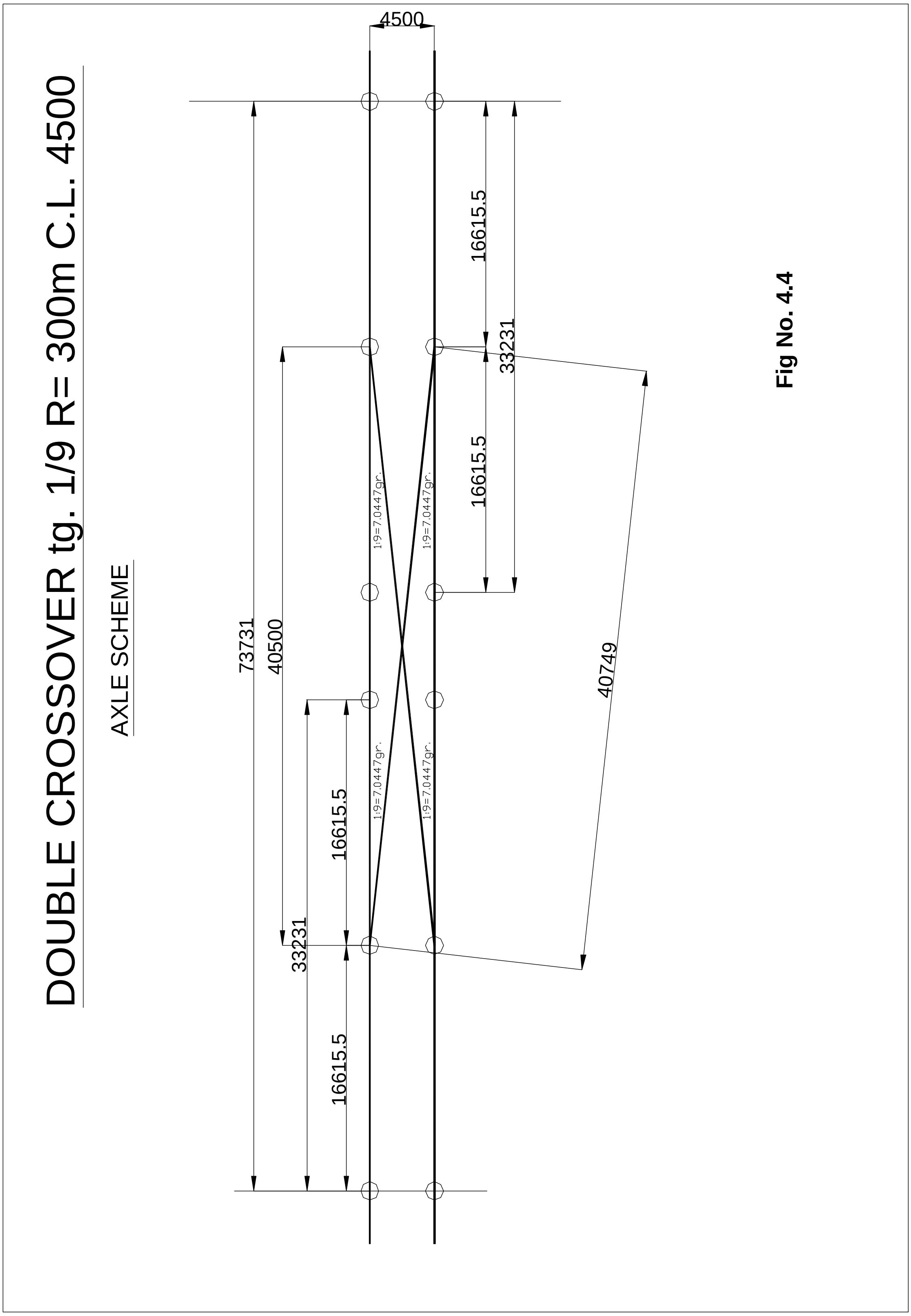

DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500
AXLE SCHEME
4500
16615.5
33231
16615.5
73731
40500
40749
16615.5
33231
16615.5
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.

Fig No. 4.4

4.2 TRACTION SYSTEM:

4.2.1 Introduction:

4.2.1.1 Traditionally, electric traction is used in Indian Railway system as a pre-requisite, for requirements of high acceleration and pollution free services in Urban areas. The system of electric traction selected for the Metro corridors of Mumbai Metro Rail Corporation Ltd. (MMRCL) is of 25 kV AC 50 Hz, single phase for feeding power to the Metro trains. 25 kV AC Electric Traction has the advantage of a considerable low electric energy consumption and also affords considerable safety features. Further, the number of Receiving Sub-Stations for feeding the power supply to overhead traction system also gets reduced with a larger length of feed without the problem of low voltage. Another special feature of going in for 25 kV AC traction is by way of adoption of a very low size of overhead conductors thereby resulting in lighter OHE structures and reduced capital cost as well as running cost. For the purpose of running additional trains at increased frequency, existing 1500 V DC system on Central and Western Railways is under conversion into 25 kV AC system on a programmed basis. This will also result in considerable saving of Electrical Energy and reduction in running cost of the system.

4.2.1.2 The alignment of the proposed corridor from Andheri (E) to Dahisar (E) is on the elevated viaduct. Keeping in view the ultimate traffic requirements, uniformity, standardization and other techno-economic considerations, 25 kV AC traction system is considered to be the best alternative and has been adopted for Metro Railway system. However suitable measures shall have to be taken for reducing the effect of Electro Magnetic Induction (EMI) caused by traction return currents. EMI Mitigation measures are simple & well known compared to DC Stray current corrosion protection.

4.2.1.3 25 kV AC traction has the economical advantages of minimal number of traction sub-stations and potential to carry large traffic. The proposed Mumbai Metro System is being designed to handle PHPDT of around 20000 when trains are expected to run at 3 minutes frequency during peak hours.

4.2.2 Salient Features of the System:

4.2.2.1 25 kV AC OHE shall be of flexible type. It shall comprise of one cadmium copper catenary wire of size 65 Sq.mm and one hard-drawn copper contact wire of size 150 sq.mm. duly supported by copper wire droppers of size 5 mm dia. Normally OHE masts supporting the OHE wires shall be independent cantilever masts on which swiveling type bracket assembly is provided. (A typical sketch showing cantilever arrangement for supporting OHE of a single track is enclosed at Annexure – 4.2 / I). On portal structures bracket assembly for the intermediate tracks is erected on drop arms. The traction power is distributed through overhead catenary system both for the mainline and the Car Depot.

4.2.2.2 The electrical sections on OHE known as ‘Sectors’ are switched “ON” and “OFF” by 25 kV interrupters controlled and monitored from Operation Control Centre (OCC). An electric section comprising of catenary wire and contact wire is fed by a Receiving Sub-Station (RSS) and it consists of several electrically connected elementary sections, like Sectioning Posts (SP) and Sub-Sectioning and Paralleling Posts (SSP). A schematic plan giving the general feeding arrangement at RSS, SP, SSP is enclosed at Annexure – 4.2 / II. The sectionalizing is indispensable from the operation point of view as it would allow de-energizing some portion of the line when any unusual occurrence takes place. This helps in isolation and restoration of the traction power on the affected part of the line.

4.2.2.3 **Span of OHE Mast:**

The distance between the central line of the adjacent supporting structures for the overhead equipment lines is known as span. The standard spans vary in steps of 4.5 m from a minimum of 25 m to a maximum of 72 m. The span of OHE masts shall generally be 50 m.

4.2.2.4 **Height of Contact Wire:**

Normally the height of the contact wire (under side the surface) above the track plane shall not be less than 5.50 M at any point in the span under the worst temperature conditions. To ensure this, the normal height of the suspension point shall be 5.60 M. At car-shed-cum-workshop the minimum height shall be 5.80 M. However, in order to reduce construction cost of Metro Railway system, it is recommended to keep the contact wire height at 5 M against the normal height of 5.5 M and encumbrance at 0.9 M against normal 1.4 M.

4.2.3 Earthing Arrangements:

4.2.3.1 **Earthing of Over Line Structures:**

The metallic parts of foot or road-over-bridges or other over-line structures over wired tracks shall be connected either to a traction rail or to an earth by means of two mild steel strip/flats of cross-section not less than 200 mm^2 each.

4.2.3.2 Earthing of Exposed Metallic Parts:

All exposed metallic parts which are not likely to come in direct contact with 25 kV overhead equipment, such as platform structures/sheds, metallic fencing, wires, pipes and such other items but which are located within a distance of 20m from the nearest railway track shall be connected to an earth or traction rail.

4.2.3.3 Earthing Heel of Isolator Switch:

The earthing heel of an isolator switch shall be connected by two mild steel flats of cross-section not less than 200 mm^2 each to the supporting metallic traction mast or structure or support. Such a traction mast or structure or support shall, in turn, be connected to a traction rail or an earth wire and, in addition to an earth.

4.2.3.4 Provision of Overhead Protection Conductor:

One overhead protection conductor connecting all the traction masts shall be erected over the traction line. Also track rail of the same track to be connected to overhead protection conductor intermittently for proper earthing.

4.2.4 OHE Sectioning:

4.2.4.1 Purpose:

The overhead equipment between two RSS is divided electrically into sections with sectioning post & sub – sectioning posts, with insulated overlaps, with section insulators at turn-outs and cross overs. Under normal working conditions, electrical continuity is maintained by bridging the insulated overlaps by means of interrupters or isolators. Isolation of small sections of OHE is necessary for maintenance and repair. Sectioning of OHE should be kept to a minimum, consistent with operational requirements.

4.3 SIGNALLING AND TRAIN CONTROL:

4.3.1 Introduction:

.

4.3.2 Overview

Metro carries 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 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation and for bidirectional working.
- 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 / and other information in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad 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 equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours. Radio for CBTC shall work in License free ISM band.

4.3.3 System Description and Specifications

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

4.3.3.1 Continuous Automatic Train Control

Continuous Automatic Train Control based on CBTC will consist of - ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems. The Train- borne Automatic Train Control System will consist of Automatic Train Operation (ATO) and Automatic Train Protection (ATP). This will work on moving block principle:

4.3.3.1.1 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) as well as other required locations, which shall serve as backup signalling in case of failure of ATP system.

- Cab Signalling
- Moving block
- 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

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

4.3.3.1.2 Automatic Train Operation (ATO)

This system will operate the trains automatically from station to station while remaining within the safety envelope of ATP & 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.

4.3.3.1.3 Automatic Train Supervision (ATS)

A 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
- Link to Passenger Information Display System for online information
- Computation of train schedules & Timetable.

4.3.3.2 Interlocking System:

4.3.3.2.1 Computer Based Interlocking (CBI)

The entire line including turn back track, transfer track, sidings will be equipped with CBI system 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 operated 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. 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, axle counters, relays, point operating machines, power supply etc.

4.3.3.2.2 Track Vacancy Detection

Primary mode for track vacancy detection system on main line may be through radio and for secondary detection, can be through Track circuit / Axle Counter.

4.3.3.2.3 Signals

Multi Aspect Colour Light (LED) type Line side signals shall be installed on the Main Line and depot entry/ exit.

(a) At stations with point and crossing for point protection catering for bidirectional working

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4.3.3.2.4 Point Machines

Non-Trailable Electrical Point Machine capable of operating with 3-phase, 50 Hz. 380V AC will be used on main line and the depot point machine will be trailable/non trailable type electrical point machine capable of operating with either 3 phase, 50 Hz. 380V AC or 110V DC.

4.3.3.3 Train Depot: Signalling

All depot lines except the one which is used for shunting and in the workshop shall be interlocked. A workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. Audio Frequency Track Circuits/ Axle Counter will be used in the depot as well. A test track with similar Signalling and Train control system as adopted in Main Line shall be provided at Depot.

4.3.3.4 Interface for PSD

Interface for PSD should be provided at all stations which can be utilized as and when PSDs are provided.

4.3.4 Standards

The following standards will be adopted with regard to the Signaling system.

Table 4.1

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 workshop lines, inspection shed lines etc.
▪ Block Working	Moving Block working concept may be followed.
▪ Operation of Points	Non-Trailable Electrical Point Machine capable of operating with 3-phase, 50 Hz. 380V AC will be used on main line and the depot point machine will be trailable/ non -trailable type electrical point machine capable of operating with either 3 phase, 50 Hz. 380V AC or 110V DC.
▪ Track Vacancy Detection System	Primary mode for track vacancy detection system on main line and test track in depot may be through radio and for depot and secondary detection it can be through Track circuit / Axle Counter.
▪ 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 AFC.
▪ Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide for redundancy. The system will conform to IEEE 1474 standards.
▪ Train Describer System	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. The system architecture shall provide for redundancy.
▪ Cables	Outdoor cables will be steel armoured as far as possible.

▪ Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for Signal and Train Control System.
▪ Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables as per standard. CENELEC standards to be implemented for EMC.
▪ Train Working under emergency	Running on site 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.

4.3.5 Space Requirement for Signaling Installations

Adequate space for proper installations of all Signalling equipment and Platform screen doors 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 sqm. for UPS Room (common for signalling and telecom). For Signalling Equipment Room the area required 50 sqm. at depot and all the stations having crossovers and for remaining stations 20 sqm. 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.

4.3.6 Maintenance Philosophy for Signalling 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 in the section/depot. 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.

4.4 TELECOMMUNICATION

4.4.1 Introduction

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

4.4.2 Overview

The Telecommunication facilities proposed are helpful in meeting the requirements for :

1. Supplementing the Signalling system for efficient train operation.
2. Exchange of managerial information
3. Crisis management during emergencies
4. Passenger information system

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
- Integrated Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralised Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving Cars and maintenance personnel.
- Data Channels for Signalling, SCADA, Automatic Fare Collection etc.
- E&M SCADA is not envisaged as part of Telecomm System as such, hence catered to separately in DPR
- Integrated Network Control System
- Access Control System

4.4.3 Telecommunication System and Transmission Media

4.4.3.1 Fibre Optic System (FOTS) - 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 minimum 96 Fibre optical fiber cable is proposed to be laid in ring configuration with path diversity.

SDH (minimum STM-4) based system shall be adopted with SDH nodes at every station, depot and OCC. Further small routers and switches shall be provided for LAN network at these locations. Alternatively a totally IP Based High Capacity, highly reliable and fault tolerant, Ethernet Network (MAN/LAN) can be provided in lieu of SDH backbone

4.4.3.2 Telephone Exchange

The System shall be IP Based with some of the extensions being Analog. For an optimized cost effective solution small exchanges of 30 port each shall be planned at each station and a 60 Port Exchange at the Terminal Stations and Depots shall be provided. The station exchanges will be connected to the Centre OCC main exchange. The Exchanges will serve the subscribers at all the stations and Central Control. The exchanges will be interconnected at the channel level on optical backbone. The exchanges shall be software partitioned for EPABX and Direct Line Communication from which the phones shall be extended to the stations. For the critical control communication, the Availability & Reliability should be high.

4.4.3.3 Mobile Radio Communication

Mobile Radio communication system having minimum 8 logical 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. All the stations, depots 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.

The frequency band for operation of the system will be in 400/800 MHz band, depending on frequency availability. 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.

To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 6 sites with rooftop towers with Base Stations shall be required along the proposed Andheri (E) – Dahisar (E) Corridor.

4.4.3.4 Passenger Announcement System

The system shall be capable of announcements from the local station as well as from OCC. Announcements from Station level will have over-riding priority in case of emergency announcements. The System shall be linked to Signalling System for automatic train actuated announcements. .

4.4.3.5 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. The System shall be integrated with the PA System and available from same MMI. For the Platform Area, high intensity LED Boards will be used in Evaluated Section. For all the concourses and Platform Area of underground Stations, HDLED Panels shall be used, which can also provide Audio/Visual Advertisements apart from Trains running status.

4.4.3.6 Centralized Clock System

This will ensure an accurate display of time through a synchronization system of slave clocks driven from the GPS Based Master Clock at the Operation Control Center. The Master Clock signal shall also be required for synchronization of FOTS, Exchanges, Radio, Signaling, etc. The System will ensure identical display of time at all locations. Clocks are to be provided at platforms, concourse, Station Master’s Room, Depots and other service establishments.

4.4.3.7 Closed Circuit Television (CCTV) System

The CCTV system shall provide video surveillance and recording function for the operations to monitor each station. The monitoring shall be possible both locally at each station and remotely from the OCC on the Video Wall.

The CCTV system shall be based on IP technology and shall consist of a mix of High Definition Fixed Cameras and Pan/Tilt/Zoom (PTZ) Cameras. Cameras shall be located at areas where monitoring for security, safety and crowd control purpose is necessary.

4.4.3.8 Access Control System

An Access Control System shall be provided for entering into important areas like SCR, SER, TER, OCC, DCC, TOM Rooms, etc. The System shall use the same AFC Smart Card as barring used for Travel on the system but giving Access to only the Authorised Personnel of the Metro. The System Shall be controlled and monitored centrally from the OCC.

4.4.3.9 Network Monitoring and Management

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide an Integrated Network Control System, 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, Telephone Exchange and summary alarms of PA/PIDS, CCTV and Clock System. The Integrated NMS will collect and monitor status and alarms from the individual NMS of the respective sub-systems and display on a common Work Station..

4.4.4 Technology

The Technologies proposed to be adopted for Telecommunication systems are shown in Table below:

Table 4.2

System	Standards
Transmission Media	Optical Fibre system as the main bearer for bulk of the Telecommunication network
Telephone Exchange	IP EPABX of minimum 30 ports is to be provided at all Stations, an Exchange of 60 Ports to be provided at Terminal Station
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel and central control.
Train Destination Indicator System	LED 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 synchronization system of slave clocks driven from a GPS master clock at the OCC and sub – master clock in station. This shall also be used for synchronization 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's in the Base Stations, 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.

4.4.5 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 Telecom equipment shall be generally 30 sqm each for Telecom Room and 50 sqm. for UPS Room (common for signal, Telecom and AFC). 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 equipment and network configuration keeping space for further expansion.

4.4.6 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 the existing 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 / equipment requiring major repairs as specified in suppliers documents shall be sent to manufacturer's workshop.

4.5 AUTOMATIC FARE COLLECTION SYSTEM:

4.5.1 Mass Rapid Transit System handles 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 less manpower. In view of the 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 of 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.

Seamless ticketing is now being thought of for Mumbai. This system is recommended to be adopted as this will enable the commuters to travel hastle free by different modes of transport viz. Metro, suburban trains, buses, water transport (whenever introduced) and even taxies without purchasing multiple tickets for each mode separately.

A. Manual fare collection systems have the following inherent disadvantages:

1. Large number of staff is required for issue and checking of tickets.
2. Change of fare structure is time consuming as it has to be done at each station.
3. Manipulation possible by jamming of mechanical parts.
4. Staff and passenger interaction leading to more chances of confrontation.
5. 100 % ticket checking at entry / exit impossible.

B. Automatic fare collection systems have the following advantages:

1. Less number of staff required.
2. Less possibility of leakages of revenue due to 100% ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.
4. Efficient and easy to operate.
5. System is amenable for quick fare changes.
6. Management information reports generation is easy.

7. System has multi operator capabilities. Same Smart Card can be used for other applications also.
8. AFC systems are the world wide 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 offices 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 Contactless 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 prone to dusty environment.

C. Choice of Control Gates:

Retractable flap type or Turnstile type Control Gates are proposed.

D. Passenger Operated Machines:

Space for provision of Passenger Operated Machines (Automatic Ticket Dispensing Machines) for future requirement has been provided at stations.

4.5.2 Standards:

The standard proposed for AFC system are as under:

Table 4.3

Standards	Description
Fare media	a) **Contactless Smart Token** – For single journey. Token are captured at the exit gate. b) **Contactless Smart Card** – For multiple journeys. Contactless readers shall be as per ISO 14443 standards.
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 diabled people.

Standards	Description
Station computer, central computer and AFC Network	All the **Fare Collection Equipment** shall be connected in a **local area network** with a station server controlling the activities of all the machines. The station servers will be linked to the AFC central computer situated in the operational control center through the optic fiber 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)	Manned **Ticked Office Machines** shall be installed in the station for selling cards / token to the passengers.
Ticket Readers	**Ticket Reader** shall be installed near EFO for passengers to check information stored in the token / cards.
UPS	**Common UPS of S&T system will be utilized.**
Maintenance philosophy	Being fully Contactless system, 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.

4.5.3 Integration of AFC with other Lines and Modes of Transport:

In Mumbai, different metro lines are being constructed and operated by different operators. In view of passenger convenience and operational efficiency, it is proposed that AFC 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 may be 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. This will facilitate the passengers as they need not carry different cards for different applications.

4.6 ROLLING STOCK

4.6.1 INTRODUCTION

The required transport demand forecast is the governing factor for the choice of the Rolling Stock. The forecasted Peak Hour Peak Direction Traffic calls for an Medium Rail Transit System (MRTS).

- **OPTIMIZATION OF COACH SIZE**

The following optimum size of the coach has been chosen for Standard Gauge (3.2 m wide stock) Cars

Table 4.4 - Size of the coach

	Length*	Width	Height
Driving Motor Car (DMC)	**21.84 m**	**3.2 m**	**3.9 m**
Trailer car (TC)/Motor Car (MC)	**21.74 m**	**3.2 m**	**3.9 m**

**Maximum length of coach over couplers/buffers = 22.6 m*

- **Passenger Carrying Capacity**

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibuled 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 and 6 persons in crush state of peak hour.

Therefore, for the Medium Rail Vehicles (MRV) with 3.2 m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 42 seated, 240 standing thus a total of 282 passengers for a Driving motor car and 50 seated, 248 standing thus a total of 298 for a trailer car/motor car is envisaged.

Following train composition is recommended:

6-car Train: DMC + TC + MC+MC+TC+DMC

Table 4.5 shows the carrying capacity of Medium Rail Vehicles.

Table 4.5 Carrying Capacity of Medium Rail Vehicles

	Driving Motor car		Trailer car/Motor car		6 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush
Seated	42	42	50	50	284	284
Standing	120	240	124	248	736	1472
Total	162	282	174	298	1020	1756

NORMAL-3 Person/sqm of standee area
CRUSH -6 Person/sqm of standee area

- **WEIGHT**

The weights of motorcar and trailer cars have been estimated as in Table 3, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg

Table 4.6 Weight of Light Rail Vehicles (TONNES)

	DMC	TC/MC	6 Car train
TARE (maximum)	42.69	41.61/41.98	252.56
Passenger			
(Normal)	10.48	11.29/11.29	66.13
(Crush @6p/sqm)	18.33	19.37/19.37	114.14
(Crush @8p/sqm)	23.4	24.7/24.7	145.6
Gross			
(Normal)	53.17	52.90/53.27	318.69
(Crush @6p/sqm)	61.02	60.98/61.35	366.7
(Crush @8p/sqm)	66.09	66.31/66.68	398.16
Axle Load @6 person/sqm	15.25	15.24/15.33	
Axle Load @8 person/sqm	16.52	16.57/16.67	

The axle load @ 6persons/sqm of standing area works out in the range of 15.25T to 15.33T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. 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.

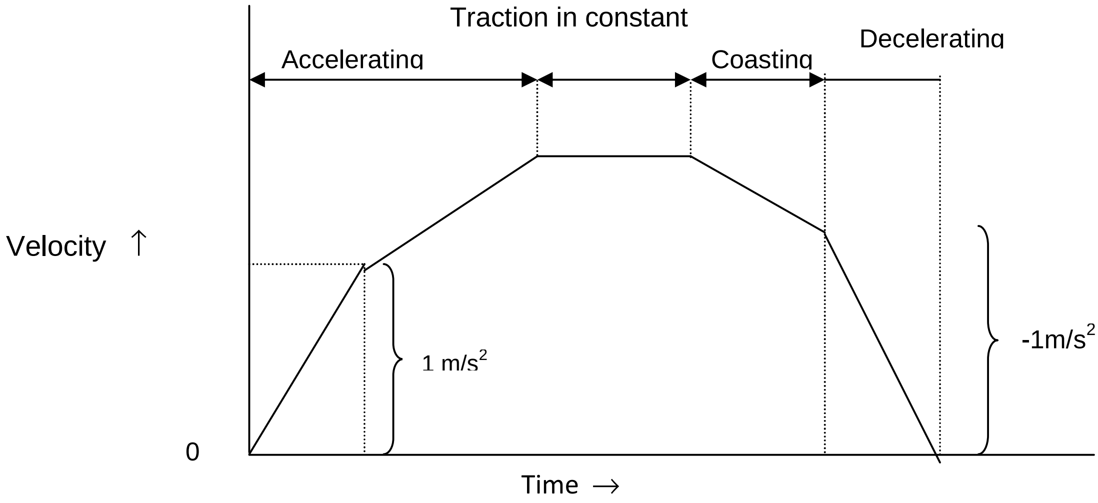
4.6.2 PERFORMANCE PARAMETERS

The recommended performance parameters are:

Traction Power Supply: 25Kv ac
Motoring capacity: 67%

Maximum Design Speed: 90 kmph
Maximum Operating Speed: 80 kmph
Max. Acceleration: 1 $m/s^2 \pm 5\%$
Max. Deceleration: 1.0 m/s^2 (Normal brake)

1.35m/s^2(Emergency Brake)



4.6.3 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) Optimized scheduled speed
(vi) Aesthetically pleasing Interior and Exterior
(vii) Low Life cycle cost
(viii) Flexibility to meet increase in traffic demand
(ix) Anti-telescopic

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

4.6.4 SELECTION OF TECHNOLOGY

- **Low life cycle cost**

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. Selection of following technologies has been recommended to ensure low life cycle cost-.

- **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 a standard practice to adopt stainless steel or aluminum for carbody.

The car bodies with aluminum require long and complex extruded sections which are still not manufactured in India. Therefore aluminum 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 their service life.

Stainless steel car body leads to energy saving due to its lightweight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti corrosive properties as well as on improvement of riding comfort and safety in case of a crash or fire.

- **Bogies**

Bolster less lightweight fabricated 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. 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. 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.

- **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, preferably a wheel disc brake.

4.6.5 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 this corridor, three phase a.c. traction drive that are self-ventilated, highly reliable, robust construction and back up by slip/slid control have been recommended for adoption.

The AC catenary voltage is stepped down through a transformer and converted to DC voltage through converter and supply voltage to DC link, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using Insulated Gate Bipolar Transistors (IGBT). Thus three-phase variable voltage variable frequency output drives the traction motors for propulsion.

Recently advanced IGBT has been developed for inverter units. 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 IGBT has internal protection from over current, short circuit, over temperature and low control voltage.

The inverter unit uses optical fiber cable to connect the control unit to the gate interface. This optical fiber cable transmits the gate signals to drive the advanced IGBT via the gate interface. This 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 MRTS.

4.6.6 INTERIOR AND GANGWAYS

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.

Interior View

4.6.7 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 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 Bi-parting Sliding Type as in the existing coaches of DMRC.

Passenger Doors

4.6.8 AIR–CONDITIONING

With heavy passenger loading of 6 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions 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.

4.6.9 CAB LAYOUT AND EMERGENCY DETRAINMENT DOOR

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.

Driving cab

In Standard Gauge (3.2 m wide stock) Cars, an emergency door for easy detrainment of the passenger on the track will be provided at the center of the front side of the each cabin which has a easy operation with one handle type master controller.

4.6.10 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.

4.6.11 NOISE AND VIBRATION

The trains will pass through heavily populated urban area .The noise and vibration for a metro railway become an important criteria from public acceptance view point. The source 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 has been achieved by provision of bolster less type bogies having secondary air spring.

4.6.12 PASSENGER SAFETY FEATURES

(i) ATP/ATO

The rolling stock is provided with Continuous Automatic Train Protection/Automatic Train operation to ensure absolute safety in the train operation. It is an accepted fact that 60-70% of the accidents take place on account of human error. Adoption of this system reduces the possibility of human error.

(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 smoke zero halogen type which ensures passenger safety in case of fire.

(iii) Emergency door

In Standard Gauge (3.2 m wide) Cars, the rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train.

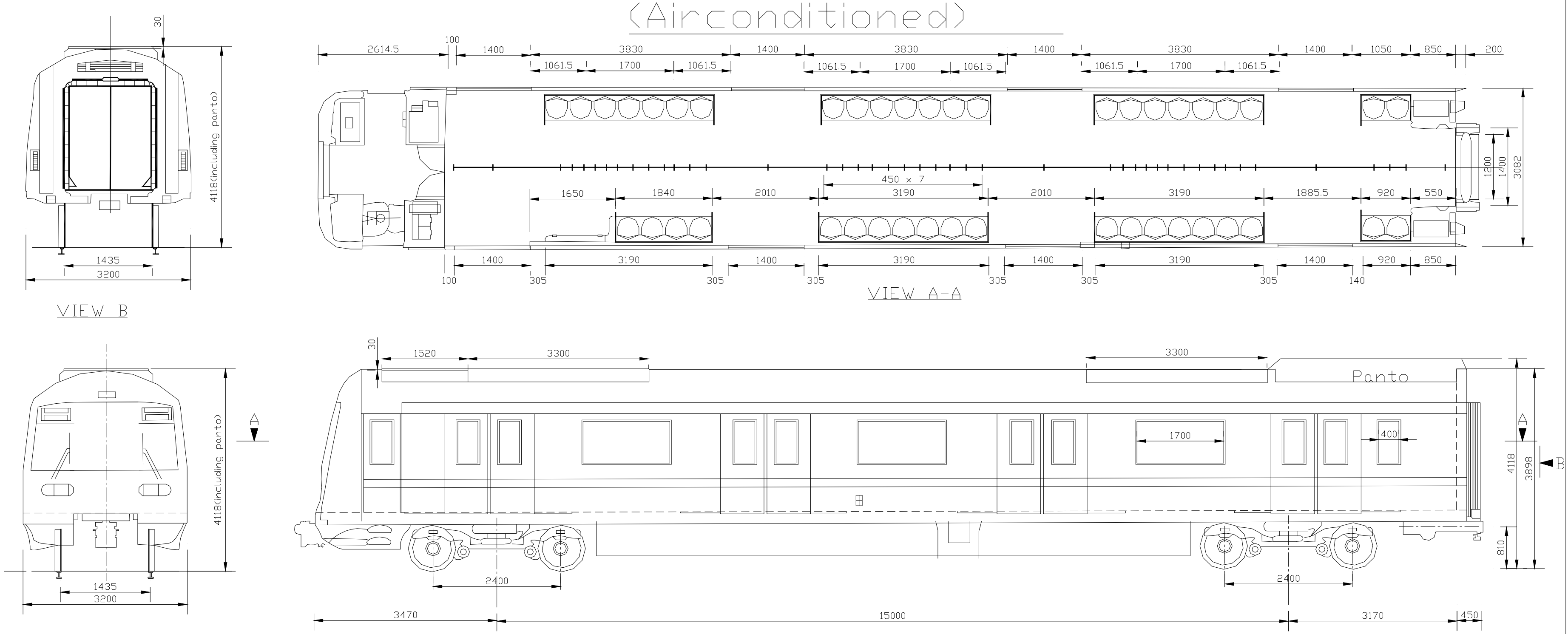
(iv) Crash worthiness features

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.

(v) Gangways

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

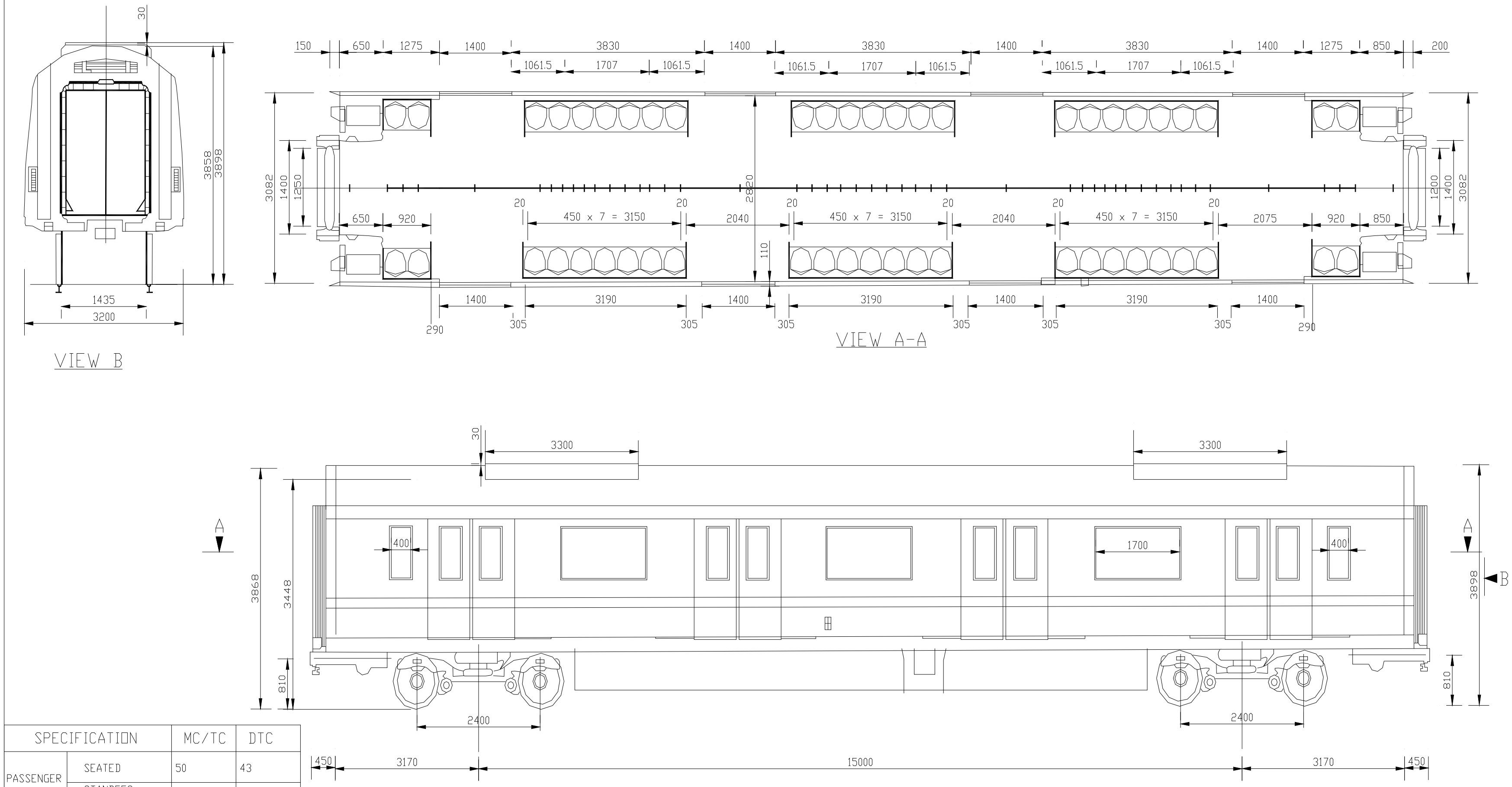
Mumbai Metro Driving Trailer Car (Airconditioned)



LAY OUT 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	

Mumbai Metro Motor Car
(Airconditioned)



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	

LAY OUT OF M-CAR

CHAPTER 5

CIVIL ENGINEERING

5.1 GEOMETRIC DESIGN NORMS:

5.1.1 General:

The alignment of this corridor has been designed based on the parameters already adopted and in use for Delhi Metro network. The parameters are time tested and metro services are being run successfully without any disruption. It has been decided that the alignment of this corridor has to be located on 5^{th} Lane of Western Express Highway (WEH) for the reason that all the flyovers in this stretch are of 3 lane each way and hence one additional lane will be available for the traffic in the stretches other than flyovers. The alignment by the side of flyover is planned in 6^{th} lane so as to leave 2 lane for the traffic plying on the slip road by the side of flyover.

As regards the type of alignment i.e. At-grade, Elevated and Underground depends upon the ROW. If ROW is 20 M or more, Elevated alignment is preferred over Underground as the cost of Underground alignment is 2 to 2½ times of Elevated alignment. The Merits and demerits of Elevated and Underground alignments are detailed at Annexure- 5.1

5.1.2 Horizontal Alignment:

Horizontal alignment of this corridor runs between Andheri and Dahisar. The alignment starts with Andheri(E) Station on right side (facing Dahisar) of flyover just by the side of L&T building. Alignment crosses to west side of Western Express Highway just after Andheri(E) Station and thereafter runs on the left side (facing Dahisar) of Western Express Highway. It is proposed that this corridor will be extended from rear end of Andheri(E) to Domestic Airport of Mumbai and integrate therein with Line-3.

For maximum permissible speed on curve with various radii Table 5.1.1 may be referred.

Horizontal Curves:

Elevated section

Minimum	:	200 m
Absolute minimum	:	120 m
Minimum curve radius at stations	:	1000 m

Maximum permissible cant	:	125 mm
Desirable maximum cant	:	110 mm
Maximum cant deficiency	:	85 mm

Transition Curves:

The service road and slip road along the express highway are not available throughout the stretch and also a number of flyovers are there along the corridor. A large number of curves are also there all along the alignment. Similar curves had to be introduced for the metro alignment also, which normally follows the Western Express Highway. However it is necessary to provide transition curves at both ends of the circular curves for comfort and safety of the passengers. Due to change in gradients at various locations in the corridor it is necessary to provide frequent vertical curves also. In case of ballastless track, it is prescribed 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 the 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.

5.1.3 Vertical Alignment:

a) Elevated sections:

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the ‘Box’ shaped or U shaped pre-stressed concrete girders, the rail level will be about 9.5 m above the road level. However, at stations, the rail level will be 13.5 m above the road level with concourse at the mezzanine floor. These levels will, however, vary marginally depending upon where the stations are located.

The track centers on the elevated section with twin U – Girders are kept at 5.0 m uniform throughout the corridor to standardize the superstructure, excepting at few locations as detailed below:

- On curves below 300 m radius but upto 120 m radius — 4.30 m (I- girder to be used)
- At scissors crossing — 4.50 m

b) Gradients:

Normally the stations shall be on level stretch. In limiting cases station may be on a grade of 0.1%. Between stations, generally the grades may not be steeper than 2.0%. However, where existing road gradients are steeper than 2%, gradients upto 4% (compensated) are proposed to be provided in short stretches on the main line.

c) Vertical curves:

Vertical curves are to be provided when change 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

5.1.4 Design Speed:

Design speed will be 90 km/h and the maximum sectional speed will be 80km/h.

Table 5.1.1

Cant, Permitted Speed and Minimum Transition Length for Various Curves

Radius (m)	Actual Cant (mm)	Permitted Speed(km/h)	Minimum Transition(m)
3000	15	80	10
2000	20	80	15
1000	45	80	20
800	55	80	25
500	85	80	40
400	105	80	50
300	110	70	50
200	110	55	50
150	110	50	50
120	110	45	50
100	110	40	50

5.1.5 Codes and Standards:

The codes, standards and specifications applicable for design of the components of the Rail System and for its operation and maintenance are:

i) NFPA 130 – 'Standard for Fixed Guide way Transit and Passenger Rail Systems'
ii) European Norms (EN):
iii) International Electro Technical Commission Standards (IEC):
iv) International Standards organization (ISO):
v) Japanese Industrial Standards (JIS):
vi) United States of America, AIS, AAR:
vii) British standards (BS):
viii) Indian Standards (IS)
ix) German Standards (DIN)
x) Indian Railway Standards (IRS):
xi) Indian Roads Congress (IRC): and
xii) Any other specified standards.

5.1.6 General technical requirements of the Rail System:

The rail system shall be designed to:

i) Handle the user demand efficiently;
ii) Minimize noise pollution;
iii) Provide adequate interchange facilities including pedestrian facilities;

The design of the Rail System shall also conform to:

i) Local building bye-laws;
ii) Relevant published standards of UIC;
iii) All statutory requirements, guidelines and directives; and
iv) Stipulations of fire service department.

5.2 ALIGNMENT:

5.2.1 Introduction:

5.2.1.1 Andheri (East) – Dahisar (East) corridor of Mumbai Metro Project is proposed to start at junction of Western Express Highway and MV Road in Andheri (East). The alignment stretches from Andheri (E) to Dahisar (E) via Jogeshwari, Goregaon, Malad, Kandivali, Thakur Village, Poisar and Borivali along and parallel to Western Express Highway (W.E.H.). Andheri(E) Metro Station on this corridor is proposed on Right Hand Side of WEH between L&T building and Flyover.

5.2.1.2 The chainage of Andheri(E) proposed station is taken as 0.0 and dead end chainage of this station as (-) 450 m.

5.2.1.3 Total length of the corridor from dead end to dead end is 16.475 km. The entire corridor proposed is elevated.

5.2.1.4 The corridor has been proposed on the East side of the flyover on W.E.H. to start with first station as Andheri(E). Just after station, the alignment crosses to West side of the WEH and thereafter it runs on West side only upto Dahisar.

5.2.1.5 Sixteen stations have been proposed on the corridor. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one Km. distance apart. The maximum and minimum inter station distances are 1727.7 m and 540.3 m respectively.

5.2.2 Station Locations:

5.2.2.1 Stations have been located so as to serve major passenger destinations and enable convenient integration with other modes of transport. Average spacing of stations is close to one km.

5.2.2.2 All stations will be two level stations except Dahisar Terminal Station. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. Dahisar station is proposed to have two towers one on either side

5.2.2.3 List of stations with chainages and inter station distances is given below in Table 5.2.1.

Table 5.2.1 List of Stations

Andheri To Dahisar Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G / ELEVATED**
0	DEAD END	(-) 450		
1	ANDHERI	0.0	450	ELEVATED
2	SHANKARWADI	1229.8	1229.8	ELEVATED
3	JVLR Jn.	2413.9	1184.1	ELEVATED
4	BOMBAY EXHIBITION	3781.5	1367.6	ELEVATED

5	HUB MALL	4580.0	798.5	ELEVATED
6	VISHVESHWAR NAGAR	5559.7	979.7	ELEVATED
7	AAREY ROAD Jn.	6100.0	540.3	ELEVATED
8	VITT BHATTI Jn.	7180.0	1080.0	ELEVATED
9	KURAR VILLAGE	8068.0	888.0	ELEVATED
10	BANDONGRI	9075.7	1007.7	ELEVATED
11	MAHINDRA & MAHINDRA	9700.0	624.3	ELEVATED
12	THAKUR COMPLEX	11427.7	1727.7	ELEVATED
13	BORIVALI BUS STOP	12250.0	822.3	ELEVATED
14	BORIVALI OMKARESHWAR	13376.5	1126.5	ELEVATED
15	SHRINATH NAGAR	14384.5	1008.0	ELEVATED
16	DAHISAR (E)	15524.9	1140.4	ELEVATED
	DEAD END	16025.7	500.8	

5.2.3 Terminals:

5.2.3.1 Andheri East Terminal:

Southern terminal of the corridor is proposed Andheri(E) with its centre line at Ch.0.0km. The station is located at junction of Western Express Highway and Mathurdas Vasanji Road on East side of the Andheri flyover on Western Express Highway. The station is elevated with rail level at about 14.0m above the road level. This terminal station is accessible from many residential and commercial establishments. Metro Line No.1 also crosses W.E.H. at this location and a station on this line is being constructed on the East of W.E.H. Rail level at this station of line no. 1 is about 21.50m above road level due to Andheri flyover on W.E.H. The two stations will be connected by an elevated walkway .Other side of WEH will be connected to this station by the help of walkway provided under the existing Andheri flyover as sufficient headway being available.

Dahisar Terminal:

The last station proposed on the corridor is Station No.16 (S.V & L.R. Junction) near junction of S.V. Road and Link Road at Dahisar(East), the centre line being at Ch.15.524. Station is in the midst of residential and commercial area of Dahisar.

Feasibility of connecting this corridor with Charkop-Dahisar Corridor has also been examined. It is possible to terminate D. N. Nagar-Charkop-

Dahisar Corridor on this terminal station of this corridor. The provision to extend this corridor to further North is also kept in view

5.2.4 Scissors Crossovers:

Scissors Crossovers will be provided at both the terminal stations viz. Andheri(E) and Dahisar (S.V. & L.R Junction). In between scissors crossovers are proposed at two stations for use in emergencies.

5.2.5 Description of Alignment:

5.2.5.1 Horizontal Alignment:

The proposed alignment starts from CH: (-) 450 m and Station No. 1 named as Andheri (E) is located at CH:00. Alignment starts on East side of WEH (R.H.S. of Western Express Highway when we go from Andheri East to Dahisar East), just after Andheri, alignment crosses to left side of WEH and runs all along the Western Express Highway. This alignment is integrated with Charkop-Dahisar Corridor at Dahisar(E) Station.

As far as possible, the alignment runs on the 5th Lane on West side of WEH and when the Alignment is taken by the side of flyover, then it runs in 6th Lane on West side of WEH. The minimum radius of curve provided is 210 m for which transition length provided is 55 m, maximum radius of curve provided is 9010 m for with transition length provided is 10 m.

From CH: (-) 450 m to CHP: 190 m alignment is on East side of Western Express Highway on Slip Road. After CH: 190 m, it turns West side of WEH with reverse curve radius as 320 m and 280 m up to CH: 325 m.

From CH: 325 m to CH: 2500 alignment runs on 5th Lane of WEH. In this stretch there are two curves with radii of 310 m and 260 m at CH: 700 m and CH; 1050 m. After curve of 260 m, Station named as Shankarwadi at CH: 1229.8 m is provided. Station No.3 named as JVLR Junction is proposed at CH:2413.9 m.

From CH: 2500 m alignment turns to LHS with curve radius of 360 m and runs in 6th Lane on West side of WEH up to CH: 3500 m.

From CH: 3500 m, alignment runs straight up to CH 6300 m. In this stretch there are four Stations namely Bombay Exhibition at CH: 3781.5 m , Hub Mall at CH: 4580 .0, Vishveshwar Nagar at CH: 5559.7 m and Array Road Junction at CH: 6100 m.

Thereafter from CH: 6300, alignment turns L.H.S. with radius of curve 510 m and alignment runs in 6th lane by the side of flyover. From there on, it takes right turn with curvature of 310 m. to align in the 5th lane of WEH..After this curve alignment runs in 5th lane up to Ch. 8170 m.

In this stretch there are two stations named as Vitt Bhatti Junction at CH: 7180 m and Kurar Village at CH: 8068. Thereafter, it turns R.H.S. after Kurar Village Station with radius 210 m. After 210 curve (radius) it turns L.H.S. with radius of curve 610 m and runs straight up to CH: 9300 m. Bandongri Station is located at CH: 9075.7 m. Thereafter, it turns R.H.S. with curve radius as 410 m. After turning R.H.S. goes straight up to CH: 10.200 m. Mahindra & Mahindra Station is located at CH: 9700 m in open area in front of Army area. From CH: 10200 alignment turns L.H.S. with radius of curve 670 m and goes straight up to CH: 12480 m. Borivali Bus Stop Station is located at CH: 12250 m. After CH: 12480 m alignment turns R.H.S. with radius of 610 m and goes straight up to CH 13530. Borivali Omkareshwar Station is located at CH: 13376.5 m and after CH: 13530 m alignment turns to R.H.S. and goes straight up to CH: 14800 m. Shri Nath Nagar Station is located at CH: 14384.5 m before Cross Road to Ashok Van Rwal Pada Road. After CH: 14800 alignment turns R.H.S. with curve radius of 660 m and goes straight up to last CH: 16025.7 m. Dahisar(E) Station is located at CH: 15524.9 m. This station is planned low height station just like tower type i.e. without concourse under platforms.
The details of curves are shown in Table No.5.2.5.

5.2.5.2 **Vertical Alignment:**

Vertical alignment has been designed with consideration of 5.5 m clear head room on the road. Minimum height difference from existing road level and proposed rail levels is about 13.5 m at station locations and 9.8 m other than station locations. Efforts have been made to maintain minimum radius of vertical curves of 2500 m. However it is not possible to maintain this at certain locations due to space constraints. At such locations minimum vertical curve radius is 1500m. Length of vertical curve provided is more than 20M. Overlap between transition curves and vertical curves are strictly avoided. All proposed stations are kept on level stretch. The maximum gradient is not steeper than 4.0%. Detailed description of vertical alignment is as follows:

Gradient details are given in Table 5.2.4

5.2.6 Road Junction Improvements:

Some road junctions need minor modifications. Details of junctions which need modifications are shown in Table No.5.2.2.

Table 5.2.2
Details of Junctions which need modifications

Sr. No.	Chainage	Type of Junction	Crossing leads to
1	500 M	4 Arm	Koyala compound Gajlaxmi Apartment & Mahakali & Boni Nagar
2	2230M	4 Arm	Jogeshwari Station to Megwadi & Mahakali
3	2617M	'T' - Junction	Vikhroli Link Road
4	2808M	'T' - Junction	State Reserve Police Force No.8 Mumbai
5	5500 M	5 Arm	Goregoan & Aarey Dairy
6	6394 M	4 Arm	Goregoan & Gokuldham
7	7070M	'T' - Junction	Pathanwadi
8	10194 M	4 Arm	Thakur Village & Thakur Complex
9	11147 M	4 Arm	Poisar & Thakur Village
10	12000 M	4 Arm	Borivali West & Magothane
11	12700 M	'T' - Junction	Kartar Road Raydoangri & Kulupwadi
12	13063 M	'T' - Junction	Borivali Station & Kulupwadi
13	13132 M	4 Arm	Borivali Station & Sanjay Gandhi National Park

5.2.7 Maintenance Depot:

5.2.7.1 It is proposed to provide the Car maintenance depot at Dahisar in the land of Airport Authority of India. The land parcel available is of 18. Ha but of irregular shape. Detailed planning of depot in this area has been done.

5.2.8 Existing road profile is shown in Table 5.2.3 and proposed rail levels in Table 5.2.4.

Table 5.2.3
Existing Road Profile(as Per Span's report)

S. No.	Chainage		Grade (%)	Road Level (Avg.)
	From	To		
1	0	0	0.00%	16.314
2	0	245	1.354%	19.631
3	245	610	-0.085%	19.322
4	610	750	-1.631%	17.038
5	750	870	0.153%	17.222
6	870	965	2.354%	19.458
7	965	1050	-1.084%	18.537
8	1050	1800	0.972%	25.825
9	1800	2235	-2.59%	14.558
10	2235	2584	0.64%	16.79
11	2584	3285	-0.234%	15.148
12	3285	3755	-0.492%	12.836
13	3755	4300	0.137%	13.581
14	4300	4977	0.061%	13.995
15	4977	5250	0.43%	15.169
16	5250	5955	1.374%	24.856
17	5955	6465	-0.543%	22.088
18	6465	7000	2.471%	35.306
19	7000	7270	1.608%	39.647
20	7270	7360	-13.962%	27.081
21	7360	7575	-2.387%	21.949
22	7575	7725	-6%	12.949
23	7725	8085	-1.359%	8.058
24	8085	8280	4.58%	16.989
25	8280	8325	21.793%	26.796
26	8325	8685	2.231%	34.829
27	8685	9045	-1.661%	28.85
28	9045	9500	-2.496%	17.493
29	9500	9710	1.597%	20.847
30	9710	9965	-1.826%	16.19
31	9965	10990	0.408%	20.37
32	10990	12390	0.186%	22.974
33	12390	12560	3.817%	29.463
34	12560	12840	-2.382%	22.794
35	12840	13315	-1.12%	17.473

S. No.	Chainage		Grade (%)	Road Level (Avg.)
	From	To		
36	13315	13715	-0.005%	17.454
37	13715	14050	-0.514%	15.733
38	14050	14825	-0.195%	14.222
39	14825	15290	-1.169%	8.787
40	15290	16223.173	-0.388%	5.164

Table 5.2.4

Proposed Gradients of Rail Track

Andheri to Dahisar Corridor (Vertical Curve Details)							
S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-450	420	870.0	34.3	34.3	0.000%	Level
2	420	540	120.0	34.3	32.7	-1.333%	Fall
3	540	800	260.0	32.7	31.5	-0.462%	Fall
4	800	1030	230.0	31.5	37.4	2.565%	Rise
5	1030	1390	360.0	37.4	37.4	0.000%	Level
6	1390	1800	410.0	37.4	36.1	-0.317%	Fall
7	1800	2280	480.0	36.1	31.7	-0.917%	Fall
8	2280	2650	370.0	31.7	31.7	0.000%	Level
9	2650	3080	430.0	31.7	26.7	-1.163%	Fall
10	3080	3660	580.0	26.7	27.7	0.172%	Rise
11	3660	3940	280.0	27.7	27.7	0.000%	Level
12	3940	4200	260.0	27.7	24.6	-1.192%	Fall
13	4200	4410	210.0	24.6	28.1	1.667%	Rise
14	4410	4780	370.0	28.1	28.1	0.000%	Level
15	4780	5160	380.0	28.1	25.6	-0.658%	Fall
16	5160	5440	280.0	25.6	35.1	3.393%	Rise
17	5440	5710	270.0	35.1	35.1	0.000%	Level
18	5710	5970	260.0	35.1	37.9	1.077%	Rise
19	5970	6360	390.0	37.9	37.9	0.000%	Level
20	6360	6610	250.0	37.9	36.7	-0.480%	Fall
21	6610	7040	430.0	36.7	50.5	3.209%	Rise
22	7040	7320	280.0	50.5	50.5	0.000%	Level
23	7320	7860	540.0	50.5	36.8	-2.537%	Fall
24	7860	8260	400.0	36.8	36.8	0.000%	Level
25	8260	8520	260.0	36.8	44.3	2.885%	Rise
26	8520	8820	300.0	44.3	38.5	-1.933%	Fall
27	8820	9220	400.0	38.5	38.5	0.000%	Level
28	9220	9440	220.0	38.5	35	-1.591%	Fall
29	9440	9880	440.0	35	35	0.000%	Level

30	9880	10180	300.0	35	27	-2.667%	Fall
31	10180	10540	360.0	27	29	0.556%	Rise
32	10540	10900	360.0	29	30.7	0.472%	Rise
33	10900	11150	250.0	30.7	36.4	2.280%	Rise
34	11150	11680	530.0	36.4	36.4	0.000%	Level
35	11680	11920	240.0	36.4	32.1	-1.792%	Fall
36	11920	12100	180.0	32.1	37.5	3.000%	Rise
37	12100	12410	310.0	37.5	37.5	0.000%	Level
38	12410	12600	190.0	37.5	42.1	2.421%	Rise
39	12600	12940	340.0	42.1	30.8	-3.324%	Fall
40	12940	13220	280.0	30.8	31.4	0.214%	Rise
41	13220	13560	340.0	31.4	31.4	0.000%	Level
42	13560	13960	400.0	31.4	26.6	-1.200%	Fall
43	13960	14220	260.0	26.6	30	1.308%	Rise
44	14220	14540	320.0	30	30	0.000%	Level
45	14540	14860	320.0	30	31.3	0.406%	Rise
46	14860	15360	500.0	31.3	18.7	-2.520%	Fall
47	15360	16025.7	665.7	18.7	18.7	0.000%	Level

5.2.9 Curvature:

There are many sharp turns and curves along the road. This necessitates provision of curves for metro alignment also. The radius of curves is kept as low as 260 m to reduce the property acquisition. Total 39 Nos. of curves have been provided in the entire length of Andheri(E) – Dahisar(E) Corridor. The details of curves are indicated in Table 5.2.5.

Table 5.2.5 Details of Curves

Andheri to Dahisar Corridor (Horizontal Curve Details)								
Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle	Tangent (m)	Straight Length (m)
				L1	L2	D M S		565.571
1	Left	320	25.735	50	50	04 36 28.063	12.874	0
2	Right	280	34.68	50	50	07 05 47.587	17.362	222.083
3	Left	310	179.045	55	55	33 05 31.108	92.097	45.744
4	Right	260	78.445	55	55	17 17 12.215	39.523	446.86
5	Left	4210	28.264	20	20	00 23 04.773	14.132	48.137
6	Left	4010	32.331	20	20	00 27 43.011	16.165	475.871
7	Left	4010	46.068	25	25	00 39 29.636	23.034	59.249
8	Right	9010	51.518	10	10	00 19 39.401	25.759	91.006
9	Right	360	72.034	55	55	11 27 52.695	36.138	257.778
10	Left	610	80.992	45	45	07 36 26.499	40.556	256.504
11	Right	3010	30.806	20	20	00 35 10.995	15.403	59.206

12	Left	3010	38.945	20	20	00 44 28.783	19.473	388.934
13	Right	1210	54.494	25	25	02 34 49.439	27.252	247.222
14	Left	4010	43.653	20	20	00 37 25.395	21.827	243.235
15	Left	2010	36.668	25	25	01 02 42.794	18.334	109.225
16	Right	2510	32.262	20	20	00 44 11.220	16.131	899.245
17	Left	1010	30.479	25	25	01 43 44.425	15.24	71.228
18	Right	1710	25.003	25	25	00 50 15.921	12.502	169.153
19	Left	510	123.096	50	50	13 49 45.061	61.849	64.886
20	Left	1010	73.879	25	25	04 11 27.695	36.956	0
21	Right	310	49.492	55	55	09 08 50.307	24.799	599.964
22	Left	4010	27.816	20	20	00 23 50.772	13.908	410.663
23	Left	1610	24.115	20	20	00 51 29.549	12.058	25.773
24	Right	1310	25.144	25	25	01 05 59.050	12.572	98.694
25	Right	210	59.235	55	55	16 09 40.949	29.815	97.047
26	Left	610	165.739	40	40	15 34 02.788	83.383	186.447
27	Left	2010	29.876	25	25	00 51 05.818	14.938	328.623
28	Right	410	179.837	55	55	25 07 53.217	91.388	31.341
29	Left	2210	30.053	25	25	00 46 44.966	15.027	53.498
30	Right	3010	31.194	25	25	00 35 37.584	15.597	420.216
31	Left	670	659.191	55	55	56 22 17.238	359.036	205.047
32	Right	1810	27.701	25	25	00 52 36.748	13.851	89.977
33	Left	1010	33.535	25	25	01 54 08.631	16.769	89.216
34	Right	1510	27.521	25	25	01 02 39.377	13.761	856.014
35	Right	610	143.282	45	45	13 27 29.139	71.972	607.563
36	Left	3010	37.082	25	25	00 42 21.093	18.541	84.488
37	Right	510	46.669	40	40	05 14 34.732	23.351	1146.31
38	Right	660	253.1	45	45	21 58 19.290	128.124	446.147
39	Left	2010	24.624	20	20	00 42 06.887	12.312	395.59

Table 5.2.5 (A) Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length (m)	% w. r. t. total curved length
1	>200m - 510m	10	848.268	28%
2	>510m - 1010m	8	1440.197	48%
3	>1010m - 1510m	3	107.159	4%
4	>1510m - 2010m	6	167.987	6%
5	>2010m - 5010m	11	378.474	13%
6	>5010m	1	51.518	2%
	Total	**39**	**2993.603**	**100.00%**

5.3 STATION PLANNING:

5.3.1 General:

5.3.1.1 Stations on the line:

The proposed Andheri (E) – Dahisar (E) Metro Corridor runs northwards from Andheri East to S.V & L.R Junction at Dahisar (E), parallel to Western Express Highway, covering a distance of 15.525 km from centre of Andheri(East) Station to Dahisar(East) station. A total of 16 stations have been planned along the proposed corridor. All stations are planned as elevated stations. Stations are generally located around 900 -1100 m apart, though the inter station distance varies from 540 m to 1728 m due to traffic and topographic reasons as well as design constraints.

The details of stations with rail level, inter station distances are given in the table 5.3.1.DP plan is given in Fig. 1.

Table 5.3.1Andheri To Dahisar Corridor (Mumbai)

S.No	Station Name	Chainage(m)	Inter Distance Between Two Stations.	Rail Level	Ground Level	Depth/ Height	U/G / ELEVATED
0	DEAD END	(-) 450					
1	ANDHERI	0.0	450	34.300	20.712	13.588	ELEVATED
2	SHANKARWADI	1229.8	1229.8	37.400	23.871	13.529	ELEVATED
3	JVLR Jn.	2413.9	1184.1	31.700	17.995	13.705	ELEVATED
4	BOMBAY EXHIBITION	3781.5	1367.6	27.700	13.857	13.843	ELEVATED
5	HUB MALL	4580.0	798.5	28.100	14.524	13.576	ELEVATED
6	V.NAGAR	5559.7	979.7	35.100	21.017	14.083	ELEVATED
7	AAREY ROAD Jn.	6100.0	540.3	37.900	24.476	13.424	ELEVATED
8	VITT BHATTI Jn.	7180.0	1080.0	50.500	37.500	13.000	ELEVATED
9	KURAR VILLAGE	8068.0	888.0	36.800	13.826	22.974	ELEVATED
10	BANDONGRI	9075.7	1007.7	38.500	24.784	13.716	ELEVATED
11	MAHINDRA & MAHINDRA	9700.0	624.3	35.000	21.500	13.500	ELEVATED
12	THAKUR COMPLEX	11427.7	1727.7	36.400	22.895	13.505	ELEVATED
13	BORIVALI BUS STOP	12250.0	822.3	37.500	22.969	14.531	ELEVATED
14	BORIVALI OMKARESHWAR	13376.5	1126.5	31.400	17.827	13.573	ELEVATED
15	SHRINATH NAGAR	14384.5	1008.0	30.000	16.205	13.795	ELEVATED
16	DAHISAR (E)	15524.9	1140.4	18.700	7.986	10.714	ELEVATED
	DEAD END	16025.7	500.8				

5.3.1.2 Rail Levels and Alignment:

Alignment is planned as elevated and is governed by a ground clearance of 5.50 m from road level. This in turn determines the level of the entire station structure on the elevated section. The alignment is planned to start on Eastern side of Western Express Highway but changes over to Western side and thereby runs in the 5^{th} line or 6^{th} line up to Dahisar (E). Entry/exit structures for the proposed stations have been planned on the East side for Andheri station and on west side thereafter. No space is available for entry/exit on median side of WEH due Western Express Highway and the flyovers.

5.3.1.3 Platforms:

All the elevated stations have two platforms. All stations are on straight stretch. The proposed stations along with their respective chainages, locations and catchment areas are given in Table 5.3.2.

Table 5.3.2
Station Location Characteristics

Andheri To Dahisar Corridor (Mumbai)					
S.No	**Station Name**		**Chainage(m)**	**Inter Distance Between Two Stations.**	
0	DEAD END		(-) 450		
1	ANDHERI	First Station near junction of W.E.H & M.V. Road	0.0	450	Chakala, Mota Nagar, Kanti Nagar, J.B Nagar,Netaji Subhash Nagar, Gundavli, WEH Station, Andheri Station.
2	SHANKARWADI	Natwar Nagar	1229.8	1229.8	Natwar Nagar,Janata Colony, Amboli, Jogeshwari (E), Hind Nagar, MHADA Colony, Sanjay Nagar.
3	JVLR Jn.	Near Jogeshwari-Vikroli link road	2413.9	1184.1	Momin Nagar,BR Nagar,Prabhat Nagar, Ram Nagar,Bandrekar Wadi, Gupha Tekdi,Majas Wadi,Squatters Colony, Laxmi Nagar, Jogeshwari caves, Poonam Nagar, Vaishali Nagar.

4	BOMBAY EXHIBITION	Bombay Exhibition Center	3781.5	1367.6	Shivshankar Nagar, Bombay Exhibition Center, Aarey Milk Colony, Konkan Krishi Vidyapith.
5	HUB MALL	Nearby Hub Mall	4580.0	798.5	Camawala Industrial Estate, Sonawala Industrial Estate, Aarey Milk Colony, Goregaon Station.
6	VISHVESHWAR NAGAR	Near Vishweshwar nagar	5559.7	979.7	Vishveshwar Nagar
7	AAREY ROAD Jn.	Junction of Aarey & Marol Roads	6100.0	540.3	Naik Wadi, Hanuman Tekdi, IITC, Vishveshwar Nagar, Jai Prakash Nagar, Aarey Milk Colony, Piramal Nagar, Goregaon Station.
8	VITT BHATTI Jn.	VITT Bhatti Junction.	7180.0	1080.0	IITC, VITT Bhatti, Dindoshipada, Upper Goving Nagar, Koyana Vasahat, Panchbawadi, Dindoshi, Hanuman Tekdi, Banjarpada, Mira Nagar, Yasho Dham, Gokul Dham, Pandurangwadi.
9	KURAR VILLAGE	Kurar Gaon	8068.0	888.0	Pathanwadi, Triveni Nagar, Parekh Nagar, Kurar Village, Malad (E), Raheja Township,, Dhanjiwadi, Malad Station.
10	BANDONGRI	Bandongri	9075.7	1007.7	Kurar Village, Hanuman Nagar, Raheja Estate, Pushpa Park, Malad Station.
11	MAHINDRA & MAHINDRA	Mahindra and Mahindra	9700.0	624.3	Hanuman Nagar, Samata Nagar, Kandivali Station, Lokhandwala Complex, Damu Nagar, Ashok Nagar, Mahindra & Mahindra Limited.
12	THAKUR COMPLEX	Thakur Complex	11427.7	1727.7	Chikhal Wadi, Asha Nagar, Thakur College, Saraf Chaudhary Nagar, Janata Nagar, Poisar, Magathane
13	BORIVALI BUS STOP	Near Magathane	12250.0	822.3	Magathane, Rajendra Nagar, Dattapada, Asara Colony, Tata Steel, Borivali Bus Depot.

14	BORIVALI OMKARESHWAR	Borivali Omkareshwar	13376.5	1126.5	Sukar Wadi, Krishna Nagar, Abhinav Nagar, Kajupada, Daulat Nagar, Raheja Complex, Borivali Station, Chinchpada, Sanjay Gandhi National Park, Nancy Colony.
15	SHRINATH NAGAR	Shrinath Nagar	14384.5	1008.0	Amba wadi, Ashokvan, Srinath Nagar, Daulat Nagar, Shankeshwar Nagar, Maruti Nagar, Dahisar Station, Mahavir Nagar, Shanti Nagar, Balaji Nagar, Maratha Colony, Ekta Nagar, Mandapeshwar, Nancy Colony, Mhatre Wadi, Ovaripada.
16	DAHISAR (E)	Near Vardhaman Industry	15524.9	1140.4	Avadhut Nagar,CS Complex,Shakti Nagar,Penkarpada, Dharkhadi, Ketkipada, Maratha Colony, N.I Complex.
	DEAD END		16025.7	500.8	

5.3.2 Station Locations:

Note: All Rail levels are w.r.t Global positioning system of WGS-84 datum.

5.3.2.1 **Station no.1 Andheri(E):**

Chainage	0.0
Inter station Distance	-
Rail Level	34.30m
Height of Rail Level from ground	13.588m
Location	Located on Western Express Highway surface Road by the side of L & T building on East side of the flyover
Entry / Exit	Entry and exit provided on East side on L & T Building side. Connection to WEH metro Station of Mumbai Line -1 is proposed by providing sky walk.
Catchment Area	Chakala, Mota Nagar, Kanti Nagar, J.B Nagar, Netaji Subhash Nagar, Gundavli, WEH Station, Andheri Station.

5.3.2.2 **Station no. 2 (Shankarwadi):**

Chainage	1229.8
Inter station Distance	1229.8 m
Rail Level	37.400m
Height of Rail Level from ground	13.529m
Location	Located on W.E.H 5^{th} lane on West side, station centerline passes through Andheri Mistry Coop. Housing Society
Entry / Exit	Entry and exits provided on West side, on acquired land .
Catchment Area	Natwar Nagar,Janata Colony, Amboli, Jogeshwari (E), Hind Nagar, MHADA Colony, Sanjay Nagar.

Service Road Near Flyover Underpass Below Flyover Roadside Local Shops Hutments

5.3.2.3 Station no. 3 (JVLR Junction):

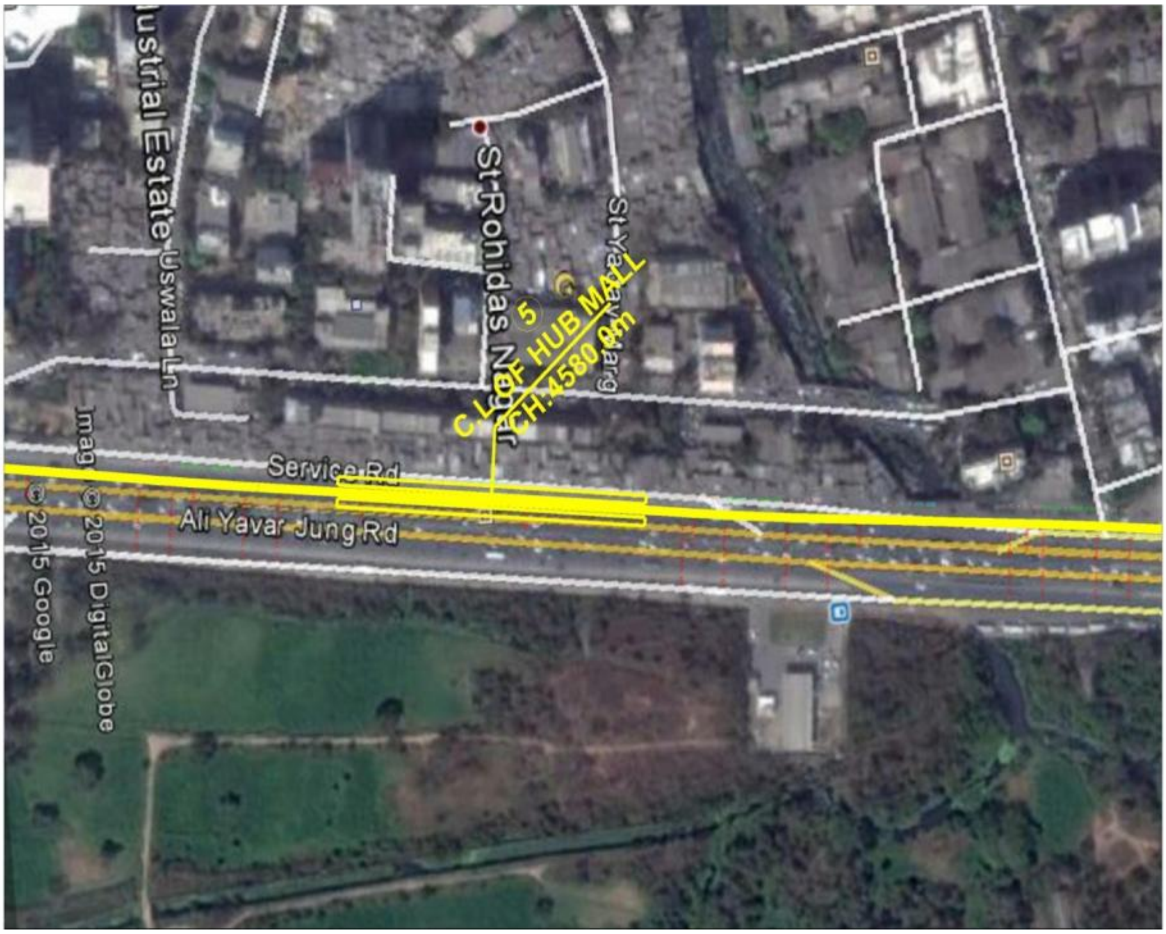
Chainage	2413.9
Inter station Distance	1184.1m
Rail Level	31.700m
Height of Rail Level from ground	13.705m
Location	Located on W.E.H 5th lane on west side, station centerline passes through the Hindustan gas Agency on West side of the alignment.
Entry / Exit	Entry and exit are proposed to be provided on West side on acquired land
Catchment Area	Momin Nagar, BR Nagar,Prabhat Nagar, Ram Nagar,Bandrekar Wadi, Gupha Tekdi,Majas Wadi,Squatters Colony, Laxmi Nagar, Jogeshwari Caves, Poonam Nagar, Vaishali Nagar.

5.3.2.4 Station no. 4 (Bombay Exhibition):

Chainage	3781.5
Inter station Distance	1367.6m
Rail Level	27.700m
Height of Rail Level from ground	13.843m
Location	Located on W.E.H 6th lane on west, station centerline passes through NESCO building on West side of the alignment.
Entry / Exit	Entry and exit provided on West side on Government land.
Catchment Area	Shivshankar Nagar, Bombay Exhibition Center, Aarey Milk Colony, Konkan Krishi Vidyapith.

5.3.2.5 Station no. 5(Hub Mall):

Chainage	4580
Inter station Distance	798.5m
Rail Level	28.100m
Height of Rail Level from ground	14.524m
Location	Located on WEH 5th lane on west side,Centre line passes through Krishna Tyre services on west side
Entry / Exit	Entry and exit provided on West side on the acquired land.
Catchment Area	Goregaon



5.3.2.5 Station no. 6 (V. Nagar):

Chainage	5559.7
Inter station Distance	979.7m
Rail Level	35.100m
Height of Rail Level from ground	14.083m
Location	Located on W.E.H surface road with station centerline passing through the land belonging to payas college..
Entry / Exit	Entry and exit provided on West side in the Government land
Catchment Area	Vishveshwar nagar, Sonawala Industrial Estate, Aarey Milk Colony, Goregaon Station.

5.3.2.7 **Station no. 7 (Aarey Road Junction):**

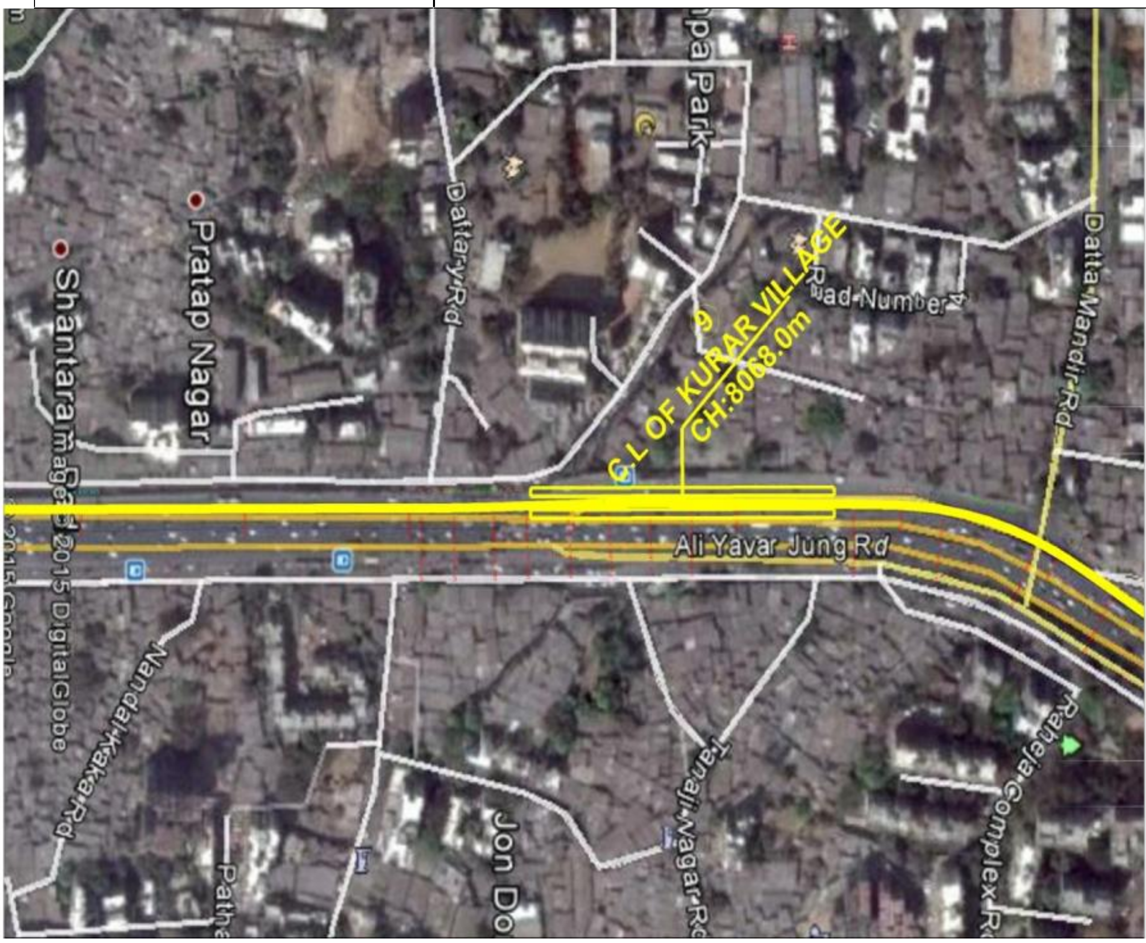
Chainage	6100
Inter station Distance	540.3m
Rail Level	37.900m
Height of Rail Level from ground	13.424m
Location	Located on W.E.H Service Road, station centerline passes raja Mobile centre near Virani Industrial Building
Entry / Exit	Entry and exit provided one on Government land and other on Private land
Catchment Area	Naik wadi, Hanuman Tekdi, IITC, Vishveshwar Nagar, Jai Prakash Nagar, Aarey Milk Colony, Piramal Nagar, Goregaon Station.

5.3.2.8 Station no. 8 (Vitt Bhatti Jn.):

Chainage	7180
Inter station Distance	1080m
Rail Level	50.500m
Height of Rail Level from ground	13.00m
Location	Located on W.E.H 5th lane, station centerline passes through Hutments and road side shops on West of the alignment.
Entry / Exit	Entry and exit provided on West side falls on Private shops.
Catchment Area	IITC, VITT Bhatti, Dindoshipada, Upper Goving Nagar, Koyana Vasahat, Panchbawadi, Dindoshi, Hanuman Tekdi, Banjarpada, Mira Nagar, Yasho Dham, Gokul Dham, Pandurangwadi.

5.3.2.9 Station no.9(Kurar Village):

Chainage	8068
Inter station Distance	888m
Rail Level	36.800m
Height of Rail Level from ground	22.974m
Location	Located on W.E.H 5th lane on west side, station centerline passes through hutments on West of the alignment.
Entry / Exit	Entry and exit provided on West side, on private land
Catchment Area	Pathanwadi, Triveni Nagar, Parekh Nagar, Kurar Village, Malad (E), Raheja Township,, Dhanjiwadi, Malad Station.



5.3.2.10 **Station no. 10 (Bandongri):**

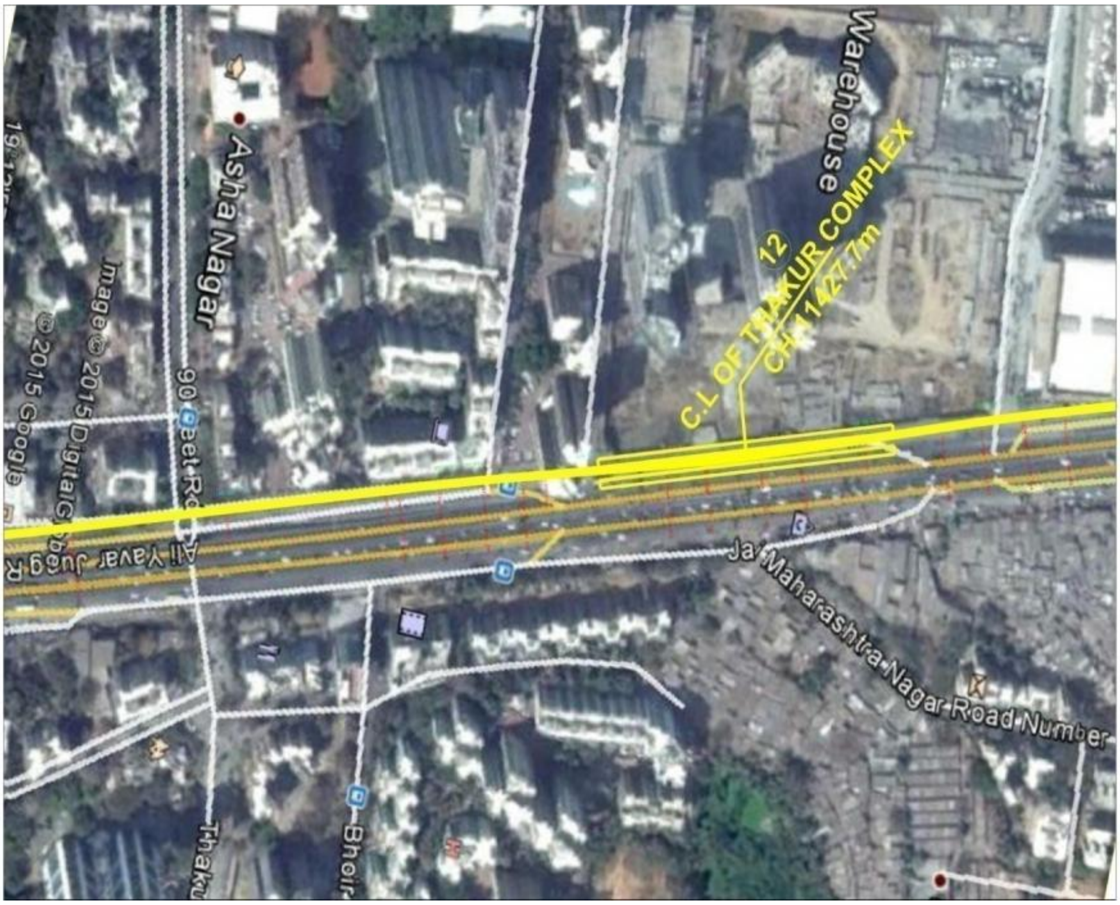
Chainage	9075.7
Inter station Distance	1007.7m
Rail Level	38.500m
Height of Rail Level from ground	13.716m
Location	Located on W.E.H 5th lane on west side, station centerline passes through Kohinoor marble shop
Entry / Exit	Entry and exit provided on West side, on acquired land of Bandongri Hutment and road side marble shops.
Catchment Area	Kurar Village, Hanuman Nagar, Raheja Estate, Pushpa Park, Malad Station.

5.3.2.11 Station no. 11 (Mahindra & Mahindra):

Chainage	9700
Inter station Distance	624.3m
Rail Level	35.000m
Height of Rail Level from ground	13.500m
Location	Located on W.E.H 5th lane on west side, station centerline passes through army open area
Entry / Exit	Entry and exit provided on West side, on open land
Catchment Area	Hanuman Nagar, Samata Nagar, Kandivali Station, Lokhandwala Complex, Damu Nagar, Ashok Nagar, Mahindra & Mahindra Limited

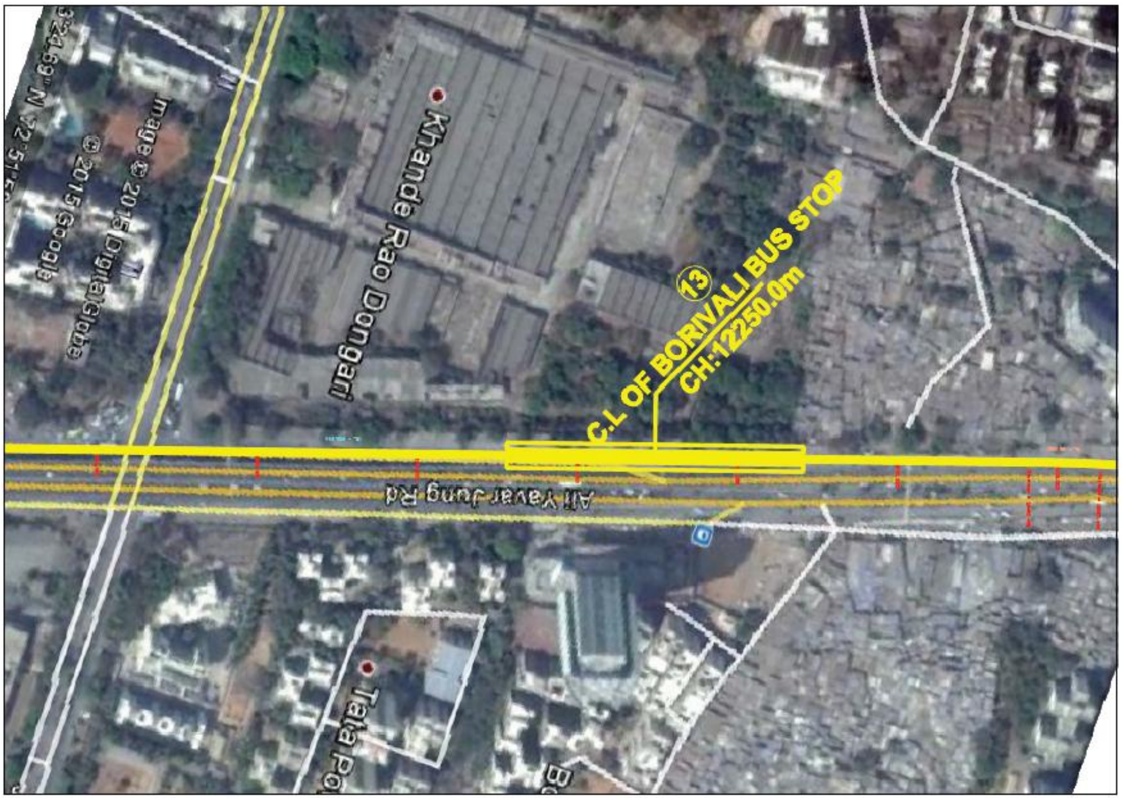
5.3.2.12 **Station no. 12 (Thakur Complex):**

Chainage	11427.7
Inter station Distance	1727.7m
Rail Level	36.400m
Height of Rail Level from ground	13.505m
Location	Located on W.E.H 5th lane, station centerline passes through open plot of Spectra Motor Limited
Entry / Exit	Entry and exit provided on West side, on vacant land
Catchment Area	Chikhal Wadi, Asha Nagar, Thakur College, Saraf Chaudhary Nagar, Janata Nagar, Poisar, Magathane



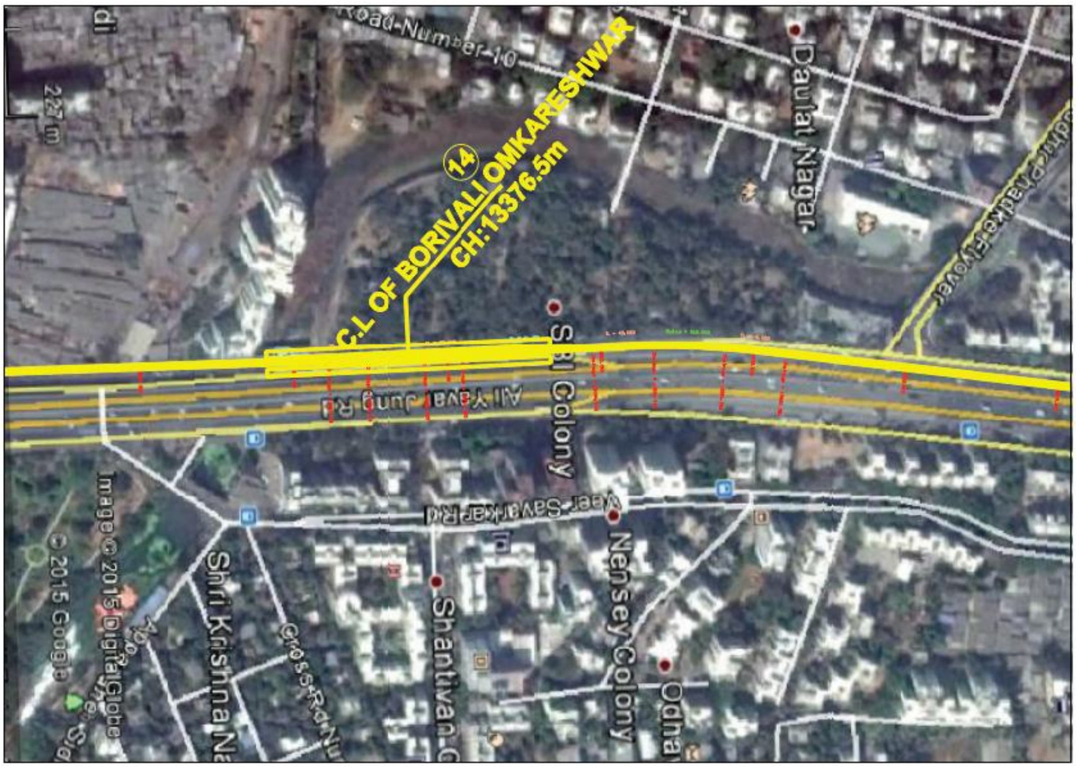
5.3.2.13 Station no. 13 (Borivali Bus Stop):

Chainage	12250
Inter station Distance	822.3m
Rail Level	37.500m
Height of Rail Level from ground	14.531m
Location	Located on W.E.H 5th lane on west side, station centerline passes through tata steel area
Entry / Exit	Entry and exit provided on West side, in front of Tata Steel Industrial bldg.
Catchment Area	Magathane, Rajendra Nagar, Dattapada, Asara Colony, Tata Steel, Borivali Bus Depot.



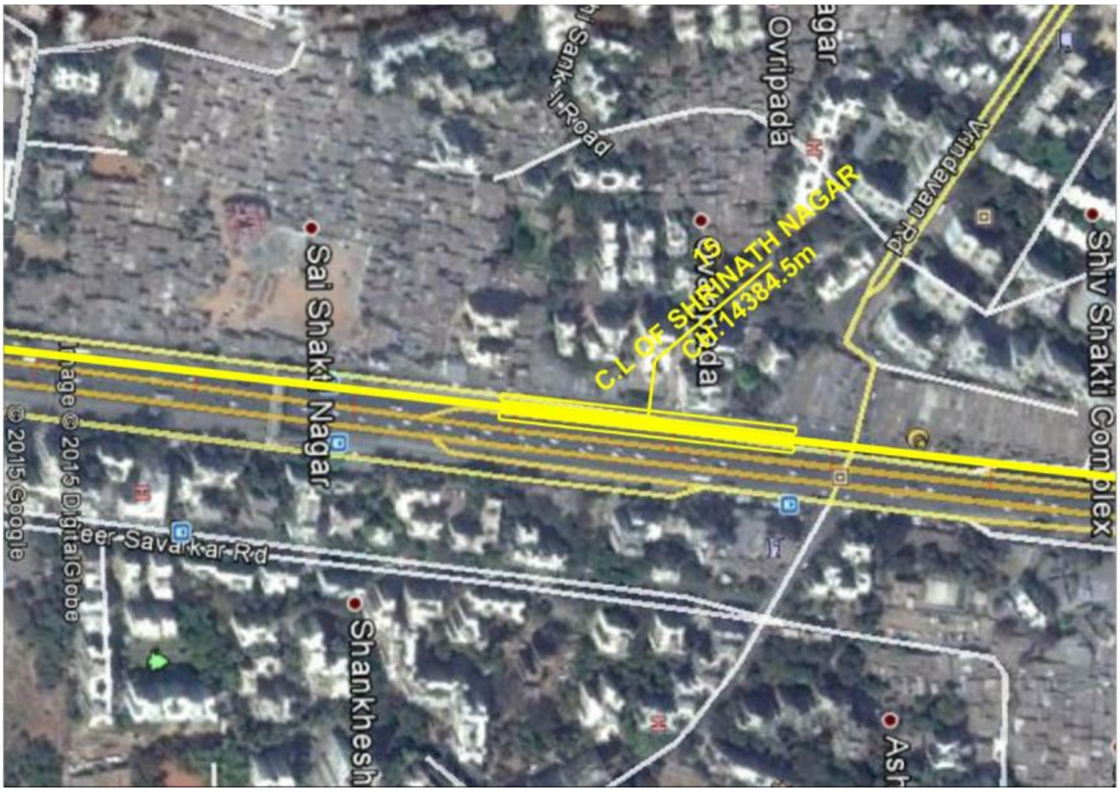
5.3.2.14 **Station no. 14 (Borivali Omkareshwar):**

Chainage	13376.5
Inter station Distance	1126.5m
Rail Level	31.400m
Height of Rail Level from ground	13.573m
Location	Located on W.E.H 5th lane on west side, station centerline passes through private shops
Entry / Exit	Entry and exit provided on West side, near krisna Complex Bus stop
Catchment Area	Sukar Wadi, Krishna Nagar, Abhinav Nagar, Kajupada, Daulat Nagar, Raheja Complex, Borivali Station, Chinchpada, Sanjay Gandhi National Park, Nancy Colony.



5.3.2.15 Station no. 15 (Shrinath Nagar):

Chainage	14384.5
Inter station Distance	1008m
Rail Level	30.000m
Height of Rail Level from ground	13.795m
Location	Located on W.E.H 5th lane on west side, station centerline passes through a building near Toyota Show room building.
Entry / Exit	Entry and exit provided on West side, on acquired land of Ovaripada roadside Marble and Granite shops.
Catchment Area	Amba wadi, Ashokvan, Srinath Nagar, Daulat Nagar, Shankeshwar Nagar, Maruti Nagar, Dahisar Station, Mahavir Nagar, Shanti Nagar, Balaji Nagar, Maratha Colony, Ekta Nagar, Mandapeshwar, Nancy Colony, Mhatre Wadi, Ovaripada.



5.3.2.16 **Station no. 16 (Dahisar(E)):**

Chainage	15524.9
Inter station Distance	1140.4m
Rail Level	18.700m
Height of Rail Level from ground	10.714m
Location	Located on W.E.H 5th lane on west side, station centerline passes through Karan marble. Station Block is proposed on the land of Tanvy Contractors Pvt. Limited.
Entry / Exit	Entry and exits provided on West side through station tower as above
Catchment Area	Avadhut Nagar,CS Complex,Shakti Nagar,Penkarpada, Dharkhadi, Ketkipada, Maratha Colony, N.I Complex.

5.3.3 Station Constraints:

5.3.3.1 At the location of all the stations the central station columns will intrude into current R.O.W. The space for station portal columns required throughout 185 m station length will be 1.5m to 2.5m wide

5.3.3.2 The station Concourse and platforms will necessarily be kept cantilevered for the half portion falling on the median side of the road.

5.3.3.3 Rail level at Vitt Bhatti junction is very high due to topography of the area.

5.3.3.4 At Dahisar station, there is need to acquire land for station building falling in the location having marble shops.

5.3.3.5 Due to narrow width of the station, Concourse will be in entire length of platform.

5.3.4 Proposed Station Configuration:

5.3.4.1 All stations are located on the Western Express Highway's West Side Service Road except Andheri (E)and are two level stations. Length of each station is 185 m. All the operating and passenger facilities are proposed in the concourse on the lower level while platforms are on the upper level of the stations. The concourse is of about 185m in length. Approaches to all stations are proposed from West side only. Station no1 (Andheri station) has been located on the Western Express Highway's East Side Service Road.

At station no. 10(BANDONGRI Station), an elevated walkway on the W.E.H already exists. It is proposed to connect this to the concourse of station no.10 to provide a direct access from East side of W.E.H.

At station no. 16 (DAHISAR (E) Station) an elevated walkway has been proposed to connect the concourse of the station no 16. to East side of W.E.H.

Station no 16 has two nos. of platform and the operational rooms and public facilities of station no. 16 has been planned on the off side of road.

For station number 1,2,3,4,5,6,7,8,9,10,11,12,13,14 and 15. layout proposed is with two unpaid and three paid area. Requirement of AFC gates at these stations is less than six except station no 1 (Andheri Station) At station no. 1, the number of passenger is quite large due to which one set of ticket counter and entry/exit gates will not be adequate. At this station, the number of gates required is 12, which can be accommodated in single width of the station.

Since the station is generally in the ROW, minimum vertical clearance of 5.5m has been provided under the concourse. Concourse floor level is about 8.5 m above the road. Platforms are at a height of about 13.5m from the road level. Commercial areas are provided in the concourse area.

The station structure is rested on the central columns of which have been placed on the 3.0m wide footpath. Road to concourse staircase and escalator has their independent columns.

5.3.4.2 First station of Andheri (E) – Dahisar (E) corridor near junction of Western Express Highway and M.V. Road is proposed to be connected to Andheri station of Versova – Ghatkopar Metro Corridor by an elevated walkway. The walkway will cross W.E.H. below the Andheri Flyover to East side footpath and will connect the concourse of Andheri station of Versova- Ghatkopar line.

5.3.4.3 Except station no. 1,10 and 16, all the rest of the thirteen stations are accessible from East side of W.E.H by nearby underground subways, flyover underpasses and foot over bridges for crossing of W.E.H. Existing underground subways, underpasses and F.O.B's are also considered while deciding station locations along with catchments areas.

5.3.4.4 **Drawings:**

Following drawings are enclosed:

1. Typical Elevated Proposed Metro Station no.1
   – Floor plans (Road, Concourse and Platform level)

2. Site plans of all stations with required land plan.

5.3.5 Salient features:

Salient features of a Metro Rail stations are as follows:

i. Most of the stations have two unpaid area. Station no. 16 only have been proposed with one unpaid area.
ii. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.

iii. The platform level at elevated stations is determined by a critical clearance of 5.50m above the road level, and 3.30m for the concourse height, about 1m for concourse floor and 2 m for structure of tracks above the concourse. Further, the platforms are 1.100 m above the rail level. This would make the platforms in an elevated situation at least 14.5 m above ground.
iv. At station no. 16, has two platform levels the rail level is 10.7 m above road
iv. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct 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.

v. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements.

vi. Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.

vii. Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way.

viii. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The requirements of such areas are given in Table 5.3.3 below:

ix. The DG set, bore well, pump house, underground water tank and refuge collection would be located at street level.

Table 5.3.3
Station Accommodation Requirements

Room No.	Description	Minimum Area(m^2)	Remarks
1	Station Control Room	50	
2	Station Manager	15	
3	Ticket Counter (2 nos.)		**2.5m deep x 1.7m per counter**
5	Security Room	9	
6	First Aid Room	10	
7	Female Toilet in paid area	25	**As per National Building Code**
8	Male Toilet in paid area	25	**As per National Building Code**
9	Handicap Toilet	9	**As per National Building Code**
10	Signaling Equipment Room	60	
11	Communication Room	40	
12	UPS Room (SIG/TEL)	60	
13	Mess room	25	
14	Staff Lockers (Gents)	9	
15	Staff Lockers (Ladies)	9	

Room No.	Description	Minimum Area(m^2)	Remarks
16	Tank / Pump Room		**At Street level as/requirement**
17	Excess Fare Collection (2 nos.)	6.25	**2.5mx2.5m**
18	Diesel Generator Room	29	**At Street level as/requirement**
19	ASS (Auxiliary Substation)	160	
20	Electrical Switch Room	40	
21	Electrical UPS room	25	
22	F.H.C		**As/requirement**
23	Cleaner Room	10	
24	Refuse Collection Room	5	**Street level**
25	Commercial Area		**As per space available at concourse**

x. The stations have been designed with following criteria in view:

- Minimum distance of travel to and from the platforms.
- Adequate capacity for passenger movements.
- Convenience, including good signages relating to circulation and orientation.
- Safety and security.
- To help visually impaired citizens, tactile tiles are laid in platform, concourse and road level to access metro rail.

xi. The number and sizes of staircases/escalators are determined by checking the capacity against morning and evening peak flow rates for both normal and emergency conditions.

In order to transfer passengers efficiently from street to platforms and vice versa, station planning has been based on established principles of pedestrian flow and arranged to minimise unnecessary walking distances and cross-flows between incoming and outgoing passengers.

Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to handle the peak traffic from street to platform and vice-versa (These facilities will also enable evacuation of the station under emergency conditions, within the specified time limit).

5.3.6 Station Standards:

5.3.6.1 Queuing Requirements are shown in Table 5.3.4

Table 5.3.4 Queuing Requirements

	Queuing:	Length
1	Ticket Operating Machines (TOM)	2.4m
2	Card readers	2.4m
3	Customer Service Centre	2.4m
4	Fare adjustment office	2.4m
5	Ticket Sales Windows	2.4m
6	Ticket Vending Machines	2.4m
7	Lift	2.4m
8	Stairs from working point	4.0m
9	Ticket Gates	6.0m
10	Escalators from working point	8.0m

5.3.6.1.1 **Table 5.3.5 shows the Station Planning Requirements:**

Table 5.3.5 Station Planning Requirements

Room No.	Description	Minimum Area(m^2)
1	Ticket Issuing Machines per 1 min.	10 passenger
2	Turnstile Gates per 1 min.	50 passengers
3	Side Platform Station (Normal Condition)	1.25 persons / sq.m
4	Side Platform Station (Emergency Condition)	5 persons / sq.m
5	Concourse	1 passenger / sq.m
6	Minimum Platform Width	4.0 m
7	Emergency Evacuation Time	6 min or less.
8	Maximum Travel Distance in Emergency	60 m
9	Walking Speed for Passenger	1 m / sec.
10	Escalator Carrying capacity in Emergency per minute. (1.2 m width, 30degree slope)	152 Passengers

Room No.	Description	Minimum Area(m^2)
11	Stairs Carrying Capacity in Emergency per minute. (From Platform Level to Concourse Level : 2 m width and 2 nos.)	229 Passengers
12	Stairs Carrying Capacity in Emergency per minute. (From Concourse Level to Ground Level: 3 m width and 2 nos.)	375 Passengers
13	a) No. of Passengers in 4 Coach Train with Dense Crush Loading	1486 Nos.
	b) No. of Passengers in 6 Coach Train with Dense Crush Loading	2222 Nos.

5.3.6.1.2 *Platform:*

Platform length must allow safe access to all doors of trains including door to the driver's cab and shall accommodate the longest train plus allowance for inaccurate stopping. Platform floor shall have durable, non slip and visually pleasing finish using heavy duty homogeneous tiles or some other material.

The maximum travel distance to an exit from any point on the platform shall not exceed about 90 m. Particular of the platform are:

- Length: 185 m
- 1.2 m security gate at each end of the platform to access viaduct walkway
- Level of platform above rail: 1.100 m.

5.3.6.1.3 **Platform Area Requirement:**

Station Passenger Density: (As per NFPA 130)

- Level of comfort : E (emergency situation) = 5 passenger / sq.m
- Level of comfort : C (peak hour normal operation) = 1.25 passenger / sq.m

Maximum passenger boarding at W.E.H station (Year 2031) =12501p/hour

No. of passengers per minute.= 12501 / 60 min. = 208 p / m

Considering, 3 min. Headway = 208 x 3 min. = 624 passengers. (Avg.)

In case of missed headway = 208 x 6 min. = 1248 passengers (Avg.)

Maximum passenger alighting at W.E.H station (Year 2031)= 18752 p / hour

No. of passengers per minute.= 18752/ 60 min. = 313 p / m

Considering, 3 min. Headway = 313 x 3 min. = 939 passengers. (Avg.)

In case of missed headway = 313 x 6 min. = 1878 passengers (Avg.)

Platform area provided = 1574 sq.m

In emergency, station passenger density = Platform area provided x E

= 1126 sq.mx 5 p/sq.m=5630 p

Normal operation, station passenger density= Platform area provided x C

=1126sq.mx1.25p/sq.m=1408 p

Thus, proposed station has capacity for 5630 passenger to hold in emergency situation and 1408 passenger in normal operation.

5.3.6.1.4 **Concourse Area Requirement:**

Passenger density at Concourse area = 1 passenger / sq.m (NFPA 130)

Concourse area provided = 1529 sq.m

Thus, concourse passenger capacity = 1529 passengers.

Maximum passenger boarding at W.E.H station = 12501 p/hr (Yr. 2031)

Maximum passenger alighting at W.E.H station = 18752 p/hr (Yr. 2031)

Total passengers alighting and boarding per hour=12501+18752=31253 p/hr

No. of passenger per minute: 31253/ 60 min. = 521 p / min.

Considering, 3 min. Headway = 521 x 3 min. = 1563 passengers. (Avg.)

5.3.6.1.5 **Sanitary Requirement for Stations:**

Table 5.3.6 shows Reference from National Building Code Part IX Plumbing Services, Section 2; Sanitation required at station:

Table 5.3.6

Place	WC for Males	WC for Females	Urinals
Station	3 for first 1000 persons and 1 for every subsequent 1000 persons.	4 for first 1000 persons and 1 for every additional 1000 persons.	4 for first 1000 persons and 1 for every additional 1000 persons.

5.3.6.2 Passenger Amenities:

5.3.6.2.1 Passenger amenities provided at the stations for the year 2016 are shown in Table 5.3.8. Passenger amenities which will be required in the year 2031 are shown in table 5.3.9. Adequate space has been provided for expansion as may be required in 2021 and 2031.

5.3.6.2.2 **Ticketing Gates:**

Ticketing gates' requirement has been calculated taking the gate capacity as 50 persons per minute per gate. Passenger forecast for the horizon year 2031 has been used to compute the maximum design capacity. At least two ticketing gates shall be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided in all stations where gates can be installed as and when required. One gate of 0.9 m clear width will be provided for physically challenged persons. This gate can also be used in emergencies.

5.3.6.2.3 **Ticket Counters and Passenger Operated Machines (POMs):**

It is proposed to deploy manual ticket issuing in the beginning of the operation of the line. At a later stage, automatic POMS would be used for which space provision has been made in the concourse. At present, ticket counters would be provided, which could be replaced with POMS in future. Capacity of manual ticket vending counters is taken to be 10 passengers per minute and it is assumed that only 50% of the commuters would purchase tickets at the stations while performing the journey. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

5.3.6.2.4 Fare Collection Gates:

- Fare collection gates, when deactivated, shall provide a minimum 508 mm clear unobstructed aisle.
- Minimum requirement at each access is 2 entry gates and 2 exit gates.
- At each access, entry gates will be on left side of EFO (Excess Fare Collection) and exit gates on right side of EFO.
- Capacity of Automatic Fare Collection (AFC) will be 50 ppm per gate.
- One Excess Fare Collection Office at each exit gate has been provided.

Table 5.3.8

PASSENGER TRAFFIC AND AMENITIES IN STATIONS (Projections for Year 2021)

Station	Peak Hour Boarding	Peak Hour Alighting	Ticketing Gates required (No.)	Ticket Counters Required (No.)	Stairs Width on Each platform (m)		Lifts Provided At Each Station (No.)		Escalators Provided At Each Station (No.)	
					G to C	C to P	G to C	C to P	G to C	C to P
STATION 16 (Dahisar.)	6851	5859	6	7	7	8.97	2	2	2	7
STATION 15 (Shrinath Nagar)	4867	4730	5	6	7	8.15	2	2	2	7
STATION 14 (Borivali Omkareshwar)	3348	2486	4	4	7	6.89	2	2	2	7
STATION 13 (Borivali Bus stop)	1851	1734	3	3	7	5.64	2	2	2	7
STATION 12 (Thakur Complex)	3682	2061	4	5	7	7.16	2	2	2	7
STATION 11 (M & M Ltd.)	3968	2530	4	5	7	7.40	2	2	2	7
STATION 10 (Bandongri)	1777	2210	3	2	7	5.58	2	2	2	7
STATION 9 (Kurar Village)	3530	2813	4	4	7	7.04	2	2	2	7
STATION 8 (Vitt Bhatti Jn)	2629	2042	3	3	7	6.29	2	2	2	7
STATION 7 (Aarey Road Jn)	1961	1350	2	2	7	5.23	2	2	2	7
STATION 6 (Vishveshwar nagar)	1851	1854	3	3	7	5.64	2	2	2	7
STATION 5 (Hub Mall)	171	490	1	1	7	4.51	2	2	2	7
STATION 4 (Bombay Exhibition.)	2311	2784	3	4	7	6.42	2	2	2	7
STATION 3 (JVLR Jn.)	7237	10167	7	8	7	10.12	2	2	2	7
STATION 2 (Shankarwadi)	2547	1206	3	3	7	6.22	2	2	2	7
STATION 1 (Andheri)	4289	8553	8	10	7	11.21	2	2	2	7

Table 5.3.9

PASSENGER TRAFFIC AND AMENITIES IN STATIONS (Projections for Year 2031)

Station	Peak Hour Boarding	Peak Hour Alighting	Ticketing Gates required (No.)	Ticket Counters Required (No.)	Stairs Width on Each platform (m)		Lifts Provided At Each Station (No.)		Escalators Provided At Each Station (No.)	
					G to C	**C to P**	**G to C**	**C to P**	**G to C**	**C to P**
STATION 16 (Dahisar.)	7541	8817	9	10	7	9.60	2	2	2	7
STATION 15 (Shrinath Nagar)	8961	8680	9	10	7	9.69	2	2	2	7
STATION 14 (Borivali Omkareshwar)	7649	3620	8	9	7	8.87	2	2	2	7
STATION 13 (Borivali Bus stop)	1681	2928	4	4	7	5.93	2	2	2	7
STATION 12 (Thakur Complex)	4660	3257	5	6	7	7.01	2	2	2	7
STATION 11 (M & M Ltd.)	4504	3020	5	5	7	6.91	2	2	2	7
STATION 10 (Bandongri)	1816	2821	3	4	7	5.86	2	2	2	7
STATION 9 (Kurar Village)	3278	3710	4	4	7	6.15	2	2	2	7
STATION 8 (Vitt Bhatti Jn)	2979	2439	4	4	7	5.96	2	2	2	7
STATION 7 (Aarey Road Jn)	2127	1525	2	2	7	5.05	2	2	2	7
STATION 6 (Vishveshwar nagar)	1936	2138	3	3	7	5.44	2	2	2	7
STATION 5 (Hub Mall)	182	467	1	1	7	4.39	2	2	2	7
STATION 4 (Bombay Exhibition.)	2339	2773	3	4	7	5.83	2	2	2	7
STATION 3 (JVLR Jn.)	9679	11894	9	11	7	10.14	2	2	2	7
STATION 2 (Shankarwadi)	2750	1377	3	4	7	5.82	2	2	2	7
STATION 1 (Andheri)	4688	7306	7	9	7	8.66	2	2	2	7

Note: G- ground/ street level, C- concourse level, P- platform level

Peak hour boarding and alighting is taken from, Peak Hour Ridership Source: CTS- 2016 & 2031 morning peak hour ridership flows for Andheri (E)- Dahisar (E) Metro.

1. Minimum requirement at each access: 2 entry Gates, 2 Exit Gates, 1 EFO and 2 Ticket Counters.
2. At each access, EFO will be in centre, entry Gates on left side of EFO and exit Gates on right side of EFO.
3. Maximum Gate throughput: 45 passengers per minute. With passenger behavior coefficient of 1.5 second it becomes 30 passengers.
4. Maximum TOM throughput: 10 passengers per minute, with 50% of passengers purchasing single ride ticket.
5. Considered Queue length: Minimum 1 and Maximum 3 passengers in a queue.
6. Sufficient space shall be provided in station concourse area for future expansion of Gates and Ticket counters.

5.3.6.3 **Number and Capacity of Exits:**

5.3.6.3.1 Following standards are prescribed in NFPA 130

i. There shall be sufficient exit lanes to evacuate the station occupant load as defined in NFPA 130 (2-5.2) from the station platforms to concourse in 4 minutes or less. The maximum travel distance to an exit from any point on the platform shall not exceed 800 ft (91.4m).

The station also shall be designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less.

ii. Exit Lanes, Doors, and Gates.

The capacity in persons per inch per minute (pim), passenger travel speeds in feet per minute (fpm), and for gates in people per minute (ppm) shall be as follows:

iii. Platforms, Corridors, and Ramps of 4 Percent Slope or Less.

Exit corridors and ramps shall be a minimum of 5ft 8in. (1.73m) wide. In computing the capacity available, 1ft 0in. (304.8mm) shall be deducted at each side wall and 1ft 6in. (457.2mm) at platform edges.

Capacity – 2.27 pim

Travel Speed – 200 fpm (61m / min)

iv. Stairs, Stopped Escalators, and Ramps of Over 4 Percent Slope.

Exit stairs shall be a minimum of 44in. (1.12m) wide. Stopped escalators shall be permitted to be considered as emergency exits.

Escalators shall not account for more than half of the units of exit at any one level.

Capacity – 1.59 pim
Travel Speed – 50 fpm (15.24m / min)
(indicates vertical component of travel speed)
(Per Exit Lane Down Direction)
Capacity – 1.82 pim
Travel Speed – 60 fpm (18.3m / min)
(indicates vertical component of travel speed)

v. Doors and Gates

Exit doors and gates shall be a minimum of 36in. (914.4 mm) wide.
Capacity – 2.27 pim

vi. Ticket Vending

Vending rate of ticket office:	10 tickets/min.
Vending rate of POM:	5 tickets/min.

5.3.6.4 Information Displays:

Signage shall provide important information to users, causing a sense of reassurance, security and orientation when entering, exiting or transferring. It shall be guide to various station areas, provide information of the station and its services and provide information on train services.

User information will comprise of:

i) Static signage such as station name, destination of train services, platform number, way finding signs, direction, entry and exit.
ii) Maps and long term changeable information on scheduled services.
iii) Emergency exit.
iv) Signage shall be placed at suitable points, and perpendicular to the line of Sight.
v) Public telephones to be provided.

5.3.6.5 Advertisement:

i) Advertisement boards may be installed in public areas and in station premises.

ii) Advertisement installation should not adversely impact metro operations, station circulation pathways or create safety hazards and shall be compatible with station design including signage and art installations.

iii) The installation shall be of standard sizes with fire resistance/ non-combustible materials.

5.4 CIVIL STRUCTURE AND CONSTRUCTION METHODOLOGY:

5.4.1 Viaduct – Elevated Structure:

5.4.1.1 Choice of Superstructure

The choice of superstructure has been made keeping in view of the factors like ease in construction, standardization of formwork, Optimum utilization of form work for wide spans etc.

The segmental construction has been proposed, since it has the following advantages:

- It is an efficient and economical method for the structures, having spans of larger lengths. Structures with sharp curves and variable super elevation can easily be accommodated.
- It reduces the construction time considerably as both manufacturing of segments as well as sub- structure work proceed simultaneously; and assembling can be done thereafter.
- It reduces the space requirement and protects the environment at the site of construction since minimum space is only required for foundation and sub-structure.
- Minimum hindrance to the traffic as well as reduces the pollution at the site, as the superstructure is manufactured at a place away from busy areas and placement/erection is done by mechanical means.
- Less space is required at casting/ stacking yard, as the segments can be stacked in layers.
- Easier for transportation of smaller segments on city roads.
- Easy to affect the changes in span configuration depending on the site conditions.
- Interference to the traffic during construction is significantly reduced.
- Segmental construction ensures aesthetical & pleasant look with good finishings.
- The overall labour requirement is less than that of conventional methods.
- Better quality control in the overall construction.
- Higher safety during construction.

5.4.2 Types of Superstructure for Elevated Section

Normally in metro elevated section, following two types of segmental superstructure are adopted;

(A) Pre-cast segmental box girder using external unbounded tendon.

(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.

(C) Precast segment Twin U girders

The Comparative advantages/disadvantages of above two types are as follows:

A. Pre-cast Segmental Box Girder using External Unbounded Tendons.

This essentially consists of precast segmental construction with external pre-stressing with proper jointing technique and hence considered most preferred technique in fast track projects. In this construction, the pre-stressing tendons are placed outside the structural concrete (inside the box section) and protected with high density polyethylene tubes, which are grouted with special wax or cement. The match-cast joints at the interface of two segments are provided with shear keys.

The main advantages of externally pre-stressed precast segmental construction are as follows:-

- Simplification of all post-tensioning operations, especially in installation of tendons.
- Reduction in the thickness of structural concrete, as no space is occupied by the tendons inside the concrete.
- Good protection from the corrosion, as the tendons are covered with polyethylene ducts. The grout inspection is easier and leaks if any, can be identified during the grouting process.
- Simplified segment casting, as there is no concern about alignment of tendons.
- Increased speed of construction.
- Replacement of tendons can be done in safe and convenient manner in case of distress.
- Possible for inspection and monitoring of tendons, throughout the life of structure.

However, there are few disadvantages also, in this type of construction, like;

i) Parapets are to provided separately after launching of box guider is completed. This takes some extra time in the construction.

ii) Rail level is about 1 m higher as compared to U-girder.

B. Precast Segmental U-Channel Superstructure with Internal Pre-stressing.

The single 'U' type of viaduct structure is also a precast segmental construction with external pre-stressing and requires gluing and temporary pre-stressing of segments.

Joints at the interface of two segments are also provided with shear keys. The main advantages for this type of structural configuration of superstructure are:

1. Built in sound barrier.
2. Possibility to lower the longitudinal profile by approximately 1mtr compared to box girder.
3. Built in structural elements are capable to maintain the trains on the bridge in case of derailment (a standard barrier design allow this)
4. Built in maintenance and evacuation path on either side of the track.

This type of construction has a major disadvantage as compared to box girders that the width of pier cap required is substantially more and also does not look aesthetically as good as box girder construction.

Considering ''pros and cons'' of the two type of superstructures as described above, the segmental box girder is recommended for Visakhapatnam metro.

C. Precast , pre- tensioned U-girder with Internal Pre-stressing

Girders of various spans (19 m, 22 m, 25m and 30 m) are cast in casting yard, pre-stressed internally. These girders are transported to site in trailors and launched in position by using double cranes of suitable capacity one on either end. Great advantage of these girders is launching being done in the night without disturbing the normal traffic. It will have better quality control due to the fact that all the girders are shop manufactured. Twin U Girders are normally economical as compared to segmental U girders and box girders.

In view of the above Twin U girder is recommended for adoption.

5.4.3 STRUCTURAL SYSTEM OF VIADUCT

5.4.3.1. Superstructure

The superstructure of a large part of the viaduct comprises of simply supported spans. However at major crossing over or along existing bridge, special steel or continuous unit will be provided.

A Box Girder having a soffit width of about 4 mts (approx) normally accommodates the two tracks situated at 4.2m center to center (c/c). The superstructure with Box Girder for all simply supported standard spans will be constructed by ‘precast pre-stressed segmental construction method’ with epoxy bonded joints.

The standard Spans with center to center piers of simply supported spans constructed by precast segmental construction technique has been proposed as 28.0m. The usual segments shall be 3.0m in length except the Diaphragm segments, which shall be 2.0m each. The other spans (c/c of pier) comprises of 31.0 m, 25.0 m, 22.0 m, 19.0 m & 16.0 m, which shall be made by removing/adding usual segments of 3.0 m each from the center of the span.

The pier segment will be finalized based on simply supported span of 31.0m and the same will also be kept for all standard spans of simply supported. For major crossing having spans greater than 31.0m, special continuous units of normally 3 m span construction or steel girders are envisaged. All these continuous units (in case provided at obligatory location) will be constructed cast-in-situ by ‘balanced cantilever construction technique’.

5.4.3.2 Substructure

The superstructure of the viaduct will be supported on single cast-in-place RC pier. The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs. At the preliminary design stage, the size of pier is found to be limited to 1.8m to 2.0 m diameter of circular shape for most of its height, so that it occupies the minimum space at ground level where the alignment often follows the central verge of existing roads.

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0 m height above existing road level has been provided all around the pier. A gap of 25 mm has also been provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that a required clearance of 5.5 m is always available on road side beyond vertical plane drawn on outer face of crash barrier. In such case, the minimum height of rail above the existing road is 8.4 m.

The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8 m. The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will be provided at pier top for the drainage due to spilling of rainwater, if any.

The transverse spacing between bearings would be about 3.2 m. However, exact spacing to be determined at the stage of detailed design.

The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be carefully selected to ensure minimum occupation at ground level traffic. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

5.4.4 CONSTRUCTION OF STATIONS

At almost all locations, it is proposed to construct 'the elevated stations' with elevated concourse over the road to minimize the land acquisition. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus, a separate structural configuration is required to be proposed, although this may necessitate a break in the launching operations at each station location.

Sub-structure for the station portion will also be similar to that of viaduct and will be carried out in the similar manner. However, in the x –section there will be single viaduct column in the station area, which will be located on the median and supports the concourse girders by a cantilever arm to eliminate the columns in the right of way.

5.4.4 Grade of Concrete

It is proposed to carry out construction work with 'Design mix concrete' through computerized automatic Batching Plants with following grades of concrete for various members considering the design requirements and durability.

i) Piles - M -35
ii) Pile cap and open foundation - M -35
iii) Piers - M -40
iv) All precast element for viaduct and station - M -45
v) Cantilever piers and portals - M -45/M -60
vi) Other miscellaneous structures - M -30

Permeability test on concrete sample is recommended for all main structures to ensure im-permeable concrete.

5.4.6 Reinforcement and pre-stressed Steel

It is proposed to use HYSD 500 or TMT steel as reinforcement bars. For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 K 15 and or 19 K 15 is recommended (confirming to IS:14268).

5.4.7 Road width required during construction

As most of the construction is to be carried out in the middle of the road, central two lanes including median will be required for construction activities. During piling and open foundation work, a width of about 9 m will be required for construction and the same will be barricaded. It is proposed that two lanes are provided for traffic on either side during construction by widening of roads, if necessary. In certain cases, one way traffic may be resorted to.

All these actions will require a minimum period of about 4 to 6 months. During this period, the implementing agency can go ahead with the following preliminary works:

i) Preliminary action for diversion of utility and preparation of estimates thereof.

ii) Reservation of land along the corridor, identification and survey for acquisition.

5.5 GEO-TECHNICAL INVESTIGATION:

5.5.1 The detailed report on Geotechnical Investigation has been submitted separately. The summary of the same is necessary to get idea of availability of rock for foundation and its depth. The water table is generally 4.0 m below ground / road level.

5.5.2 Climate:

The ground level varies between 2.8 to 6.0 m above sea level. The highest temperature in this city is around 35^0 C and the minimum temperature is around 15^0 C. The period between January to May and October to December is the dry period in this region. The Southwest monsoon period, between June and September, is the main rainy season. The average annual rainfall is about 2400mm for the suburbs.

5.5.3 General 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.

5.5.4 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.

5.5.5 Seismicity:

Mumbai lies in seismic zone IV. However seismic coefficient of zone III may be adopted in the design of structures to commensurate with the Indian Standard seismic zoning of the country IS.1893-1984 as well as IRC:6-2002.

5.5.6 Details of Boreholes:

A total of 18 boreholes were taken at different locations as shown in the enclosed sheet. Details of strata in different boreholes are shown in Table 5.5.1

Table 5.5.1

Borehole Number	Chainage (in m)	Ground R.L. (m)	Depth of Investigation (in m)		
			In Soil	In Rock (soft/hard)	Total
BH 12	16200.00	5.28	6.0	7.4	13.4
BH 13	15800.00	7.00	6.5	6.0	12.5
BH 14	14500.00	15.25	6.3	9.0	15.3
BH 15	13500.00	17.36	6.6	5.0	11.6
BH 16	12300.00	22.42	7.8	6.0	13.8
BH 17	11475.00	21.43	7.15	6.0	13.15
BH 18	10480.00	17.74	8.4	6.4	14.8
BH 19	9700.00	20.91	6.5	6.7	13.2

Borehole Number	Chainage (in m)	Ground R.L. (m)	Depth of Investigation (in m)		
			In Soil	In Rock (soft/hard)	Total
BH 20	8800.00	33.43	5.5	7.0	12.5
BH 21	7820.00	21.90	6.5	8.85	15.35
BH 22	7100.00	36.60	8.6	6.0	14.6
BH 23	6550.00	23.60	6.0	6.2	12.2
BH 24	5650.00	21.25	7.0	6.0	13.0
BH 25	4520.00	14.43	6.5	5.5	12.0
BH 26	3700.00	13.00	5.95	6.25	12.2
BH 27	2780.00	16.47	6.5	8.5	15.0
BH 28	1400.00	23.60	6.5	7.0	13.5
BH 29	100.00	17.26	8.0	6.0	14.0

5.5.8 The proposed foundation levels for 1.2 m diameter RCC bored cast-in-situ piles are tabulated below based on the investigation carried out.

Table 5.5.2

Bore hole no.	Chainage	Over burden depth	Weathered rock	Brecie or Basalt	Proposed foundation level (1.8 m in rock)	Depth of 1.2 m of pile
12	16200.00	6.0	2.0	5.4	9.8	8.2
13	15800.00	6.5	1.0	5.0	9.3	7.7
14	14500.00	6.3	6.0	3.0	14.1	12.5
15	13500.00	6.6	1.0	4.0	9.4	7.8
16	12300.00	7.8	2.0	4.0	12.6	11.0
17	11475.00	7.15	3.0	3.0	12.0	10.4
18	10480.00	8.4	3.0	3.4	13.2	11.6
19	9700.00	6.5	2.0	4.7	10.3	8.7
20	8800.00	5.5	4.0	3.0	11.3	9.7
21	7820.00	6.5	-	8.85	15.8	14.2
22	7100.00	8.6	2.0	4.0	12.4	10.8
23	6550.00	6.0	1.2	5.0	9.0	7.4
24	5650.00	7.0	1.0	5.0	9.8	8.2
25	4520.00	6.5	2.5	3.0	10.8	9.2
26	3700.00	5.95	2.25	4.0	10.0	8.4
27	2780.00	6.5	5.0	3.5	15.0	13.4
28	1400.00	6.5	4.0	3.0	12.3	10.7
29	100.00	8.0	3.0	3.0	12.8	11.2

5.5.9 It is proposed to adopt the safe bearing capacity of the foundation strata as 115 T / sq.m as recommended by Geotechnical expert. All the piles will be designed as end bearing piles without considering any friction.

5.6 UTILITIES ALONG ALIGNMENT:

5.6.1 Introduction:

Besides the details of various aspects, e.g. transport demand analysis, route alignment, station locations, system design, viaduct structure, geotechnical investigations, etc., there are a number of engineering issues which are required to be considered in sufficient detail before really deciding on taking up any infrastructure project of such a magnitude. Locating the existing utilities and planning for their diversion is one of them.

5.6.2 Utility Services:

The proposed corridor starts about 50m North of Metro Line No.1, (Versova –Ghatkopar) which is under operation. The alignment runs via Goregaon, Malad, Kandivali, Borivali and ends at Dahisar. Large number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, O.H. electrical transmission lines, electric poles, traffic signals, etc., are existing along the proposed alignment. These utility services are essential and have to be maintained in proper working order during different stages of construction and operation of Metro. Some of the utilities are to be diverted temporarily for the construction phase while some have to be diverted / shifted permanently. Since these may affect construction, project implementation and time schedule / costs, necessary planning / action needs to be initiated in advance.

Organizations/Departments concerned with utility services in the area are given in Table 5.6.1.

Table 5.6.1 Utility Services and Concerned Departments

Sr. No.	Organization/ Department	Utility Services
1	Municipal Corporation of Greater Mumbai (MCGM)	Roads, surface water drains, nallahs, sewerage and drainage conduits, sewerage treatment plants, pumping stations, water mains and their service lines including hydrants, water treatment plants, pumping stations, gardens, etc.

Sr. No.	Organization/ Department	Utility Services
2	Public Works Department (PWD)	Construction and maintenance of State Highways and Expressways
3	Irrigation and Flood Department, MCGM	Nallahs/flood water drains, etc.
4	BEST (Brihanmumbai Electric Supply & Transport) Undertaking	Power cables and their appurtenances, H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc.
5	Mahanagar Telephone Nigam Ltd. (MTNL)	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
6	Mumbai Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
7	Mahanagar Gas Ltd.	Gas lines
8	Reliance Energy / Tata Power	Power cables and their appurtenances, H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc.
9	MMRDA & MHADA	Land development and Housing, etc.
10	Tata Tele Services	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
11	Reliance Info. Ltd.	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.

Assessment of the type and location of underground utilities running along and across the proposed route alignment between Andheri and Dahisar 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, overhead and underground electric cables, telecom cables, etc. are given below.

5.6.3 Diversion of Underground Services:

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

- Utility services have to be kept operational during the entire construction period and after completion of the project. All proposals have, therefore, to ensure their uninterrupted functioning.
- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.
- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout

of piles in the foundation may be suitably adjusted to ensure that no foundation needs to be constructed at the location, where a utility is crossing the proposed alignment.

5.6.3.1 **Sewer Lines, Storm Water Drains and Water Lines:**

The major sewer/drainage lines and water mains running across the alignment and likely to be affected due to location of pier foundations are proposed to be taken care of by relocating the column supports of viaduct by change in span or by suitably adjusting the layout of pile foundations. Where this is not feasible, lines will be suitably diverted. Provision shall be made in the project cost towards utility service lines.

Table 5.6.2 DETAILS OF AFFECTED SEWER LINES

Sr. No.	Chainage		Side	Affected Length (m)	DIA(MM)	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	100	677	LEFT	577	230	Along	A
2	840			17	600	Across	B
3	3000	4250	LEFT	1250	450	Along	A
4	4960	5345	LEFT	385	230	Along	A
5	5900	6300	LEFT	400	300	Along	A
6	6370			17	300	Across	B
7	6370	6850	LEFT	480	300	Along	A
8	8550	8960	LEFT	410	230	Along	A
9	9410			17	300	Across	B
10	11100			17	1000	Across	B
11	11958			17	450	Across	B
12	11958	12450	LEFT	492	350	Along	A
13	13380			16	230	Across	B
14	13720			17	500	Across	B

Note:

a. The depth of sewer lines was reported between 2 to 3m. (app.) below ground.
b. “A” – To be shifted / diverted.
c. “B” – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.3 DETAILS OF AFFECTED WATER LINES

Sr. No.	Chainage		Side	Affected Length (m)	DIA(MM)	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	0	195	Left	195	600	Along	A
2	0	195	Left	195	300	Along	A
3	195	880	Left	685	600	Along	A
4	195	890	Left	685	300	Along	A
5	870			40	450	Across	B
6	880			30	600	Across	B
7	890			30	300	Across	B

Sr. No.	Chainage FROM	Chainage TO	Side	Affected Length (m)	DIA(MM)	Position w.r.t. Alignment	Diversion Proposals
8	895			35	250	Across	B
9	870	1060	Left	190	450	Along	A
10	1060			14	450	Along	A
11	1070	1350	Left	230	150	Across	B
12	1345	1620	Right	275	150	Along	A
13	1345	1590	Right	245	300	Along	A
14	1355			11	450	Across	B
15	1350			12	150	Across	B
16	1620			13	150	Across	B
17	1625			15	450	Across	B
18	1620	2232	Left	612	150	Along	A
19	1625	2050	Left	625	450	Along	A
20	1700	2250	Right	550	300	Along	A
21	2225			30	600	Across	B
22	2235			30	600	Across	B
23	2300			25	300	Across	B
24	2640			40	1200	Across	B
25	2700	2810	Left	110	600	Along	A
26	2810	3015	Left	205	600	Along	A
27	3015	3050	Left	35	600	Along	A
28	3050			30	300	Across	B
29	3050	3200	Left	150	600	Along	A
30	3320			40	600	Across	B
31	3600	3745	Left	145	600	Along	A
32	3745	3950	Left	205	600	Along	A
33	4100	4300	Left	200	150	Along	A
34	4170			23	150	Across	B
35	4265			26	150	Across	B
36	4300			20	150	Across	B
37	4445	4650	Right	205	600	Along	A
38	4650	5525	Left	875	600	Along	A
39	5525	5730	Left	205	900	Along	A
40	5730	5840	Left	110	900	Across	B
41	5955			40	1200	Along	A
42	5970			35	900	Across	B
43	6130	6335	Right	205	900	Along	A
44	6335	6400	Right	65	900	Along	A
45	6385			12	600	Across	B
46	6400			15	450	Across	B
47	6410			12	600	Across	B
48	6670	6780	Right	110	900	Along	A
49	6730			55	600	Across	B
50	6770			55	900	Across	B
51	7050			75	1200	Across	B
52	7150				600	Across	B
53	7175			80	600	Across	B
54	7295	7500	Right	205	900	Along	A
55	7580			60	900	Across	B
56	7720			60	300	Across	B

Sr. No.	Chainage		Side	Affected Length (m)	DIA(MM)	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
57	7730			60	300	Across	B
58	7970			60	600	Across	B
59	8000	8265	Left	265	600	Along	A
60	8265			60	600	Across	B
61	8390			60	300	Across	B
62	8775	8980	Right	205	600	Along	A
63	9010			60	600	Across	B
64	9460			65	250	Across	B
65	9465			65	300	Across	B
66	9470			65	600	Across	B
67	9615			55	300	Across	B
68	10180			90	900	Across	B
69	10315			60	900	Across	B
70	10590	10680	Left	90	900	Along	A
71	11150			26	300	Across	B
72	11130	11350	Left	220	1200	Along	A
73	11330			12	1200	Across	B
74	11700	13140	Right	1440	1200	Along	A
75	11970			15	600	Across	B
76	11600	13080	Left	1480	900	Along	A
77	13080			40	900	Across	B
78	13145			35	1050	Across	B
79	13150			36	1050	Across	B
80	13150	13400	Left	250	1050	Along	B
81	13200			12	1050	Across	B
82	13200	13320	Left	120	450	Along	A
83	13400	13500	Centre	100	750	Along	A
84	13700	14480	Centre	780	751	Along	A
85	13920			11	300	Across	B
86	13940			15	150	Across	B
87	13980			10	80	Across	B
88	14480			15	750	Across	A
89	14480	14665	Centre	185	900	Along	A
90	14590			20	900	Across	A
91	15110			10	30	Across	A
92	15120			15	300	Across	A
93	15300			10	301	Across	A
94	15300	15400	Left	100	302	Along	A
95	15500	15700	Centre	200	303	Along	A

5.6.3.2 **Gas Pipe Lines:**

A few gas pipelines with varying diameters belonging to Mahanagar Gas Limited, Mumbai are running along and across the road along which the metro alignment is proposed. A few pipelines running along and across the alignment are likely to be affected.

Table 5.6.4 DETAILS OF AFFECTED GAS (MAHANAGAR) PIPELINES

Sr. No.	Chainage		Side	Affected Length (m)	DIA(MM)	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	2600	4300	Left	1700	304	Along	A
2	5060				125	Across	B
3	5060	6150	Left	1090	152	Along	A
4	6150				152	Across	B
5	6150	7180	Left	1030	20	Along	A
6	6150	7200	Left	1030	304	Along	A
7	6400				125	Across	B
8	7950				20	Across	B
9	8020				51	Across	A
10	8400	9500	Left	1100	304	Along	A
11	8580				20	Across	A
12	9500				20	Across	A
13	9500				90	Across	A
14	9500	14600	Center	5100	20	Along	A
15	10180				20	Across	B
16	10820				20	Across	A
17	11170				63	Across	A
18	11400				203	Across	A
19	12000				63	Across	A
20	12020				63	Across	A
21	13040				20	Across	A
22	14580				20	Across	B
23	14600	15800	Left	1200	304	Along	A
24	16000	16200	Left	200	20	Along	A

Note:

1. "A" – To be shifted / diverted.
2. "B" – Suitably locate the pier/change the pile layout to avoid diversion.

5.6.4 Above Ground Utilities:

Above ground utilities, viz. street light poles, traffic signal posts, telecommunication posts, junction boxes, etc., are also required to be shifted and relocated suitably during construction since these will be interfering with the proposed alignment. Approximate number of affected trees / lamp / telecom / electrical posts and boxes are indicated in Table 4.3 below.

Table 5.6.5 DETAILS OF AFFECTED ABOVEGROUND SERVICES

Sr. No.	Name of Utility	Numbers	Remarks
1.	Light Post	212	-
2.	Electric Post	Nil	-
3.	Traffic Signal Post	14	-
4.	Telephone Post	2	-
5.	Transformer / DP	Nil	-
6.	Electrical Junction Box	43	-
7.	Telephone Junction Box	Nil	-

8.	Trees	107	-
9.	H.T. Pylon	Nil	-

5.6.4.1 HT Electric Cables along the Corridor (Underground Position):

At several places, 11kv/22kv/33kv/66kv power cables belonging to Reliance Energy and TATA Power in the entire stretch of corridor are running along and across the proposed alignment in underground position and a few of them are likely to be affected.

Table 5.6.6 DETAILS OF AFFECTED TATA POWER CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FORM	TO					
1	880			12	22 KV CABLES	ACROSS	B
2	947	987	LEFT	40	22 KV CABLES	ALONG	A
3	1051			14	22 KV CABLES	ACROSS	B
4	1345	1550	RIGHT	205	22 KV CABLES	ALONG	A
5	2329	2364	LEFT	35	22 KV CABLES	ALONG	A
6	2647			17	33 KV CABLES	ACROSS	B
7	3745	3950	LEFT	205	22 KV CABLES	ALONG	A
8	5082	5400	LEFT	318	33 KV CABLES	ALONG	A
9	5525	5730	LEFT	205	33 KV CABLES	ALONG	A
10	6130	6335	LEFT	205	33 KV CABLES	ALONG	A
11	9466			16	11 KV CABLES	ACROSS	B
12	10943			17	11 KV CABLES	ACROSS	B
13	11155	11360	LEFT	205	22 KV CABLES	ALONG	A
14	12025			17.5	22 KV CABLES	ACROSS	B
15	12029			17.5	33 KV CABLES	ACROSS	B
16	12029	12283	LEFT	254	22 KV CABLES	ALONG	A
17	13207	14585	LEFT	1378	33 KV CABLES	ALONG	A
18	15110	15400	LEFT	290	33 KV CABLES	ALONG	A
19	15500	15715	LEFT	215	33 KV CABLES	ALONG	A

Note:

1) The depth of Tata Power Cables was reported between 1m. (app.) below ground.
2) “A” – To be shifted / diverted.
3) “B” – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.7

DETAILS OF AFFECTED RELIANCE ENERGY CABLES & H.T. LINE CROSSINGS

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	1313	1800	LEFT	487	Cable Duct	Along	A
2	3138	3220	LEFT	82	Cable Duct	Along	A
3	3656			133	H.T. Line (220kv) Crossing	Across	A
4	3745	3950	LEFT	205	Cable Duct	Along	A
5	5010	5729	LEFT	719	Cable Duct	Along	A
6	6328	6463	LEFT	135	Cable Duct	Along	A

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
7	6904	7539	LEFT	635	Cable Duct	Along	A
8	10587			151	H.T. Line (220kv) Crossing	Across	A
9	11036			90	H.T. Line (220kv) Crossing	Across	A
10	11226			25	Cable Duct	Across	B
11	11987			120	H.T. Line (220kv) Crossing	Across	A
12	12014			22	Cable Duct	Across	B
13	12079	12282	LEFT	203	Cable Duct	Along	A
14	12190			12	Cable Duct	Across	B
15	12190	12282	LEFT	92	Cable Duct	Along	A
16	12385			14	Cable Duct	Across	B
17	12400			13	Cable Duct	Across	B
18	12420			13	Cable Duct	Across	B
19	12850	13610	LEFT	760	Cable Duct	Along	A
20	12850	13610	RIGHT	760	Cable Duct	Along	A
21	13564			8	Cable Duct	Across	B
22	13753	14673	LEFT	920	Cable Duct	Along	A
23	13753			1	Cable Duct	Across	B
24	14356	14673	LEFT	317	Cable Duct	Along	A
25	14215			3.5	Cable Duct	Across	B
26	14845	14955	LEFT	110	Cable Duct	Along	A
27	15280			15	Cable Duct	Across	B
28	15409	15712	LEFT	303	Cable Duct	Along	A
29	15507	15712	LEFT	205	Cable Duct	Along	A

Note:

1) The depth of Reliance Energy Cables was reported between 1m. (app.) below ground.
2) “A” – To be shifted / diverted.
3) “B” – Suitably locate the pier/change the pile layout to avoid diversion.

5.6.4.2 **Telecom Cables:**

Telecom cables of MTNL are running along and across the proposed alignment in underground position at many places and a few of them are likely to be affected. Detailed proposals for tackling these lines need to be prepared in consultation with the concerned agencies.

Table 4.8

DETAILS OF AFFECTED INFOMAGIC PVT (RELIANCE) CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	1056			21		ACROSS	B
2	1066			16		ACROSS	B
3	2225			15		ACROSS	B
4	2650			17		ACROSS	B

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
5	2810	3015	LEFT	205		ALONG	A
6	3040			17		ACROSS	B
7	3114			14		ACROSS	B
8	3176	3244	LEFT	68		ALONG	A
9	3745	3950	LEFT	205		ALONG	A
10	3788			27		ACROSS	B
11	3819			26		ACROSS	B
12	4193	4269	CENTER	76		ALONG	A
13	5490			17.5		ACROSS	B
14	5525	5730	LEFT	205		ALONG	A
15	6077			35		ACROSS	B
16	6903	7056	CENTER	153		ALONG	A
17	7054			12		ACROSS	B
18	7077			22		ACROSS	B
19	7718			11		ACROSS	B
20	7727			11		ACROSS	B
21	7974			8.5		ACROSS	B
22	7978			14		ACROSS	B
23	12017			57		ACROSS	B
24	15286			20		ACROSS	B

Note:

1)The depth of Power Cables was reported between 1m. (app.) below ground.
2)“A” – To be shifted / diverted.
3)“B” – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.9 DETAILS OF AFFECTED M.T.N.L CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FORM	TO					
1	0	195	LEFT	195	CABLE DUCT	ALONG	A
2	520	880	LEFT	360	CABLE DUCT	ALONG	A
3	880			17.5	CABLE DUCT	ACROSS	B
4	1000	1045	CENTER	45	CABLE DUCT	ALONG	A
5	1095	1550	LEFT	455	CABLE DUCT	ALONG	A
6	1345	1550	RIGHT	205	CABLE DUCT	ALONG	A
7	1609	2187	LEFT	578	CABLE DUCT	ALONG	A
8	2810	3016	LEFT	206	CABLE DUCT	ALONG	A
9	3745	3950	LEFT	205	CABLE DUCT	ALONG	A
10	4077			17.5	CABLE DUCT	ACROSS	B
11	4992			22	CABLE DUCT	ACROSS	B
12	5525	5730	LEFT	205	CABLE DUCT	ALONG	A
13	6130	6379	LEFT	249	CABLE DUCT	ALONG	A

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FORM	TO					
14	9468	9600	LEFT	132	CABLE DUCT	ALONG	A
15	9800	10178	LEFT	378	CABLE DUCT	ALONG	A
16	10178			18.5	CABLE DUCT	ACROSS	B
17	11155	11360	LEFT	205	CABLE DUCT	ALONG	A
18	12080	12285	LEFT	205	CABLE DUCT	ALONG	A
19	12600	12800	LEFT	200	CABLE DUCT	ALONG	A

Note:

1) The depth of MTNL Cables was reported between 1m. (app.) below ground.
2) "A" – To be s shifted / diverted.
3) "B" – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.10 DETAILS OF AFFECTED TATA COMMUNICATION CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	605			8.5	TATA OFC	Across	B
2	1322	1807	LEFT	485	TATA OFC	Along	A
3	2811	3016	LEFT	205	TATA OFC	Along	A
4	3176	3241	LEFT	65	TATA OFC	Along	A
5	3363	3485	CENTER	122	TATA OFC	Along	A
6	3745	3950	LEFT	205	TATA OFC	Along	A
7	4444	4680	RIGHT	236	TATA OFC	Along	A
8	5145	5400	LEFT	255	TATA OFC	Along	A
9	5493			17	TATA OFC	Across	B
10	11139			16	TATA OFC	Across	B
11	11154	11359	LEFT	205	TATA OFC	Along	A
12	12079	12282	LEFT	203	TATA OFC	Along	A
13	12364	12431	LEFT	67	TATA OFC	Along	A
14	12623	12693	LEFT	70	TATA OFC	Along	A

Note:

1) The depth of Telephone Cables was reported between 1m. (app.) below ground.
2) "A" – To be shifted / diverted.
3) "B" – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.11 DETAILS OF AFFECTED REWMAX TELECOM CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	0	185	LEFT	185	Cable duct	Along	A
2	974	1641	LEFT	667	Cable duct	Along	A
3	1641			7	Cable duct	Across	B
4	2810	3015	LEFT	205	Cable duct	Along	A
5	3040	3248	LEFT	208	Cable duct	Along	A
6	3745	3950	LEFT	205	Cable duct	Along	A
7	3804			26	Cable duct	Across	B
8	4293	5391	LEFT	1098	Cable duct	Along	A
9	5524	5729	LEFT	205	Cable duct	Along	A
10	6087			23	Cable duct	Across	B
11	6130	6335	LEFT	205	Cable duct	Along	A
12	6907	7043	LEFT	136	Cable duct	Along	A
13	7163	7600	LEFT	437	Cable duct	Along	A
14	8458	9287	LEFT	829	Cable duct	Along	A
15	9267			26	Cable duct	Across	B
16	9983	10188	LEFT	205	Cable duct	Along	A
17	11154	11359	LEFT	205	Cable duct	Along	A
18	12079	12693	LEFT	614	Cable duct	Along	A
19	12725			27	Cable duct	Across	B
20	13208	13752	LEFT	544	Cable duct	Along	A
21	14356	14562	LEFT	212	Cable duct	Along	A
22	14956	15286	LEFT	330	Cable duct	Along	A
23	15305	15712	LEFT	407	Cable duct	Along	A

Note:

1) The depth of REVMAX Cables was reported between 1m. (app.) below ground.
2) “A” – To be shifted / diverted.
3) “B” – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.12

DETAILS OF AFFECTED BHARATI AIRTEL CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	0	195	LEFT	195	Cable duct	ALONG	A
2	650	740	LEFT	90	Cable duct	ALONG	A
3	881			12	Cable duct	ACROSS	B
4	916	983	LEFT	67	Cable duct	ALONG	A
5	1125	1200	LEFT	75	Cable duct	ALONG	A

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
6	1345	1680	LEFT	335	Cable duct	ALONG	A
7	2224			13.5	Cable duct	ACROSS	B
8	2810	3015	LEFT	205	Cable duct	ALONG	A
9	3151			16	Cable duct	ACROSS	B
10	3175	3269	LEFT	94	Cable duct	ALONG	A
11	3745	3950	LEFT	205	Cable duct	ALONG	A
12	4292	4662		370	Cable duct	ALONG	A
13	5010	5417	LEFT	407	Cable duct	ALONG	A
14	5468			16	Cable duct	ACROSS	B
15	6116	6335	LEFT	219	Cable duct	ALONG	A
16	6116	6335	RIGHT	219	Cable duct	ALONG	A
17	7083			14	Cable duct	ACROSS	B
18	7638			15	Cable duct	ACROSS	B
19	6467			15	Cable duct	ACROSS	B
20	9973			16	Cable duct	ACROSS	B
21	10938			15	Cable duct	ACROSS	B
22	11155	11360	LEFT	205	Cable duct	ALONG	A
23	113902			7	Cable duct	ACROSS	B
24	11958			17	Cable duct	ACROSS	B

Note:

1) The depth of Bharati Airtel Cables was reported between 1m. (app.) below ground.
2) “A” – To be shifted / diverted.
3) “B” – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.6.13

DETAILS OF AFFECTED VODAFONE CABLES

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
1	830			12	OFC CABLE	ACROSS	B
2	1024	1200	LEFT	176	OFC CABLE	ALONG	A
3	1236	2150	LEFT	914	OFC CABLE	ALONG	A
4	2220	2300	LEFT	70	OFC CABLE	ALONG	A
5	2649			17	OFC CABLE	ACROSS	B
6	2800	3016	LEFT	216	OFC CABLE	ALONG	A
7	3710	3890	LEFT	180	OFC CABLE	ALONG	A
8	4240	4652	LEFT	412	OFC CABLE	ALONG	A
9	5220	5300	LEFT	80	OFC CABLE	ALONG	A

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	FROM	TO					
10	5472	5683	LEFT	211	OFC CABLE	ALONG	A
11	6080	6380	LEFT	300	OFC CABLE	ALONG	A
12	6380			13	OFC CABLE	ACROSS	B
13	11158	11349	LEFT	201	OFC CABLE	ALONG	A
14	11300			6.7	OFC CABLE	ACROSS	B
15	12078	12283	LEFT	205	OFC CABLE	ALONG	A
16	12560	12613	LEFT	133	OFC CABLE	ALONG	A
17	13207	13334	LEFT	127	OFC CABLE	ALONG	A
18	13350	13555	LEFT	205	OFC CABLE	ALONG	A
19	14356	14624	LEFT	268	OFC CABLE	ALONG	A
20	15261	15400	LEFT	139	OFC CABLE	ALONG	A
21	15507	15712	LEFT	205	OFC CABLE	ALONG	A

Note:

1) The depth of Vodafone Cables was reported between 1m. (app.) below ground.
2) "A" – To be shifted / diverted.
3) "B" – Suitably locate the pier/change the pile layout to avoid diversion.

A fresh Utility survey is being done by DMRC as all the above utilities were identified as per the old alignment by SPAN. Separate report on the utilities will be made available. However the provision in the cost for handling utilities have been made on per kilometer basis.

5.7 LAND ACQUISITION:

5.7.1 Land:

5.7.1.1 Alignment and Profile:

As discussed in the previous chapters, the proposed corridor runs from Andheri to Dahisar via Jogeshwari, Goregaon, Malad, Kandivali, Poisar & Borivali.

5.7.2 Land Requirement:

The full corridor including stations is proposed to be elevated. As such land will be required for the following only.

- Entry/Exit Structures
- Station utilities like Diesel generator room, underground water tank, etc.
- Traffic integration facilities
- Depot

- Traction Receiving Substations
- Mid section for viaduct

5.7.3 Elevated Corridor:

While designing the alignment, entire corridor is broadly divided in four parts.

Alignment through slip road of W.E.H.:

Wherever service road is not available, the alignment is planned through slip road. If width of slip road is more than 15m, alignment is planned through center of slip road so that by providing median at the center, corridor can be taken on single pier. If width of slip road is less, the alignment has been taken through center line of slip road on portal structure.

At station locations on slip road, the alignment is designed in such a way that the portal foundation and flyover foundation will not infringe. In such cases land acquisition is required.

Alignment through median in between slip road and service road of W.E.H.:

If service road and slip road are available, alignment is planned through median between service road and slip road of W.E.H. In this case generally land acquisition is not required except for station locations.

Alignment through median of service road:

At some locations the existing service road is four lane with central median and footpath on either side. In this case the alignment is designed through median of service road and mostly land acquisition is not required.

Alignment close to RE wall of existing W.E.H. Flyover:

At some locations where service road is not available and due to site constraints the alignment is designed close to the RE wall of flyover, minimum 3.5 m distance is kept in between alignment and RE wall so that foundations of both should not infringe. In this case land acquisition is not required.

The whole alignment is planned through slip road or service road of W.E.H. except for short length of 150 m where alignment is on W.E.H. as neither slip nor service road is available. For elevated section, single pier as well as portal structure supporting the viaduct will be located on slip road and on service road. Necessary permission for using such right of way will have to be obtained from the concerned authorities. All stations are proposed with elevated concourse so that minimum land is required. Traffic integration facilities are provided wherever the same are required.

The normal viaduct structure of elevated Metro is about 10.5 m (edge to edge) wide. However, for reasons of safety a clean marginal distance/set back of about 5 m is necessary from either edge of the viaduct (or 10 m on both sides of the centre line) wherein no structures are to be located. This is necessary as the traction system as proposed is overhead 25 KV AC system with masts fixed on the parapets. Also, it ensures road access and working space all along the viaduct for working of emergency equipment and fire brigade.

In view of the constraints on space on ground, it is proposed to provide the concourse area on the mezzanine level. All the stations in elevated stretch including terminal station are planned with single side discharge platforms. Normally, the width required for stations is 20.4 m. The staircases giving access to concourse area from ground have been proposed as per site conditions and constraints.

5.7.4 Land for Traffic Integration:

As indicated no land acquisition is proposed for traffic integration purpose. It is expected that the public parking policy of MCGM will be taking care of parking generated near metro stations. No parking space has been catered for.

5.7.5 Land for Depot:

Car Maintenance Depot for Andheri (E)-Dahisar (E) Corridor has been proposed in Airport Authorities land in Dahisar.

5.7.6 Land Requirement for Stations and Running Section:

Entire corridor is planned along slip road and service road of Western Expressway on the West side. In many sections service road is not available and in some section width of slip road is reduced due to less ROW and encroachments by shops, hutments, etc. As such adequate land is not available in many stretches and requisite land has to be acquired.

Details of land acquisition required along the running line are shown in Table 5.7.1.

Table 5.7.1

Land Requirement on Permanent basis						
A. Stations						
	Stations	East side Entry/exit		West Side Entry/exit		Total
		Govt. Land		Private Land		
		West	East	West	East	
1	ANDHERI	240	0	0	620	860
2	SHANKARWADI	0	0	590	240	830
3	JVLR Jn.	0	0	620	240	860
4	BOMBAY EXHIBITION	620	0	0	240	860
5	HUB MALL	0	240	630	0	870
6	V. NAGAR	0	240	800	0	1040
7	AAREY ROAD Jn.	357	240	273	0	870
8	VITT BHATTI Jn.	0	0	620	340	960
9	KURAR VILLAGE	0	0	630	240	870
10	BANDONGRI	0	240	675	0	915
11	MAHINDRA & MAHINDRA	610	0	0	240	850
12	THAKUR COMPLEX	0	0	590	240	830
13	BORIVALI BUS STOP	0	0	665	240	905
14	BORIVALI OMKARESHWAR	0	0	615	240	855
15	SHRINATH NAGAR	0	0	705	240	945
16	DAHISAR	0	0	1600	240	1840
		1827	**960**	**9013**	**3360**	**15160**

B. Running Section

No land is is required for Viaduct (Running Section) as the alignment will run within the ROW.

B. Depot

		Govt Land
1	DAHISAR Depot (AAI Land) including land for One Receiving Sub Station in Depot area	**150000**

C. Receiving Sub Station (RSS)		
		Govt Land
1	DAHISAR Depot	5000 (included in Depot Land)
2	Mumbai exhibition Centre	5000

Summary of Permanent Land Requirement				
		Govt	Private	Total
1	Stations	2787	12373	15160
2	Depot including one RSS	150000	0	150000
3	Receiving Sub stations (RSS)	5000	0	5000
	Total	157787	12373	170160

5.7.8 Temporary Construction Depot:

It is proposed to provide the Government land to the civil Contractors for developing their construction depot at two locations one each with the area of 4 Ha.

5.8 SAFETY & SECURITY SYSTEMS:

5.8.1 General:

5.8.1.1 This chapter lays down the standards and requirements for safety & security, arising out of fire and unauthorized entry into premises. The system will be designed and installed for safe transportation of passengers & premises safety in Metro Railway System.

5.8.1.2 **Requirements:**

i. The System shall protect the passengers against the fire in train services and at the premises of Metro Railway.
ii. The system shall protect vulnerable premises from fire.
iii. The system shall be able to detect the unauthorized entry and exit at nominated places.
iv. The system shall include
   - Fire alarm system.
   - Fire Hydrant and Sprinkler System.
   - Fire Extinguishers.
   - Closed circuit television with video analytics.
   - Security Gates – Metal Detector.
   - Baggage Scanner.

5.8.2 Fire Alarm System:

5.8.2.1 **General:**

The Fire Alarm System is a fully integrated, Fire Detection & Alarm System. It includes alarm initiating devices, alarm notification appliances, control panels, auxiliary control devices, power supplies, and wiring. Its installation is restricted to designated areas. In Metro railway this system shall be provided at the following locations:

i. At Station Control Room (SCR).
ii. Station security services centre.
iii. At Operational Control Centre.
iv. At Depot, in depot controller room.

v. Escalator landing and inside elevators.
vi. Evacuation routes.
vii. Cash transfer routes on the station.
viii. Equipment room.
ix. Store room.
x. Any other place required.

5.8.2.2 **Scope:**

The system comprises of Main Addressable Intelligent fire alarm panel, smoke sensors, and smoke laser sensors, smoke optical sensors, heat sensors, audio visual indicators, isolator modules, monitor control and relay modules connected by interconnecting with Fire Retardant Low Smoke (FRLS) copper armored cable.

The main panel shall be located in security / control room. All the sensors and devices shall be connected to main panel. The panel shall operate with UPS power, 210 AC and shall have its in-built battery backup with battery charger.

A smoke detector is a device that detects the presence of smoke. It will be provided in commercial, industrial, and residential complexes and also closed and limited open space areas. Provision of smoke detector at equipment / store room shall be mandatory.

5.8.2.3 **System Components:**

Fire Alarm Control Panel:

The main Fire alarm control panel, forms the heart of the fire detection system which gives command to peripheral device like detectors & to sub-systems. It shall consist of microprocessor based Central Processing Unit (CPU).

The CPU communicates with control panel installed, for the system to function effectively. The system comprises of:

i. Addressable pull stations – Manual Call Point.
ii. Intelligent photo electric smoke, thermal detector.
iii. Addressable control model.
iv. Isolated modules.

5.8.2.4 **Addressable Pull Stations (Manual Call Point):**

An addressable pull station is an active fire protection device, usually wall-mounted. When activated, it initiates an alarm on a fire alarm system. In its simplest form, the user activates the alarm by pulling the handle down, which completes a circuit and locks the handle in the activated position, sending an alarm to the fire alarm control panel. After operation, fire alarm pull station must be restored to the ready position using a special tool or key in order to de-activate the alarm sequence and return the system to normal.

5.8.2.5 **Intelligent Photo - Electric Smoke Detector:**

This Smoke detector works on photoelectric (light-scattering) principal to measure smoke density and on command, from the control panel, sends data to the panel representing the analog level of smoke density. However the detectors do not respond to refrigerant gas.

5.8.2.6 **Addressable Control Module:**

Addressable control modules will be used to operate dry contacts for door holders, air handling unit, shut down or other similar functions. Optionally the module can be used to supervise wiring of the output load power supply. If the monitored voltage falls below threshold, then a fault condition shall be displayed.

5.8.2.7 **Isolator Module:**

The fault isolator module to be connected placed between groups of sensors on the loop wiring, to protect the loop, if a fault occurs in the event of short circuit. The two isolators located on either side of the short circuit fault, shall automatically sense the voltage drop, open their switches and remove the devices from the rest of the loop. If the line voltage rises above a fixed threshold, indicating that the short circuit fault is removed, then the isolator module shall automatically restore the power, to the isolated group of devices. The smooth functioning again shall be continued.

5.8.3 Fire Hydrant System:

5.8.3.1 General:

Fire Hydrant System is a semi-automatic water based system. In this system a network of pipes is laid out, depending upon the risk, with hydrant valves placed at strategic places.

5.8.3.2 Scope:

The entire pipeline shall be kept pressurized with water. When any of the hydrant valve opens, the pressure in the pipeline reduces drastically. Jockey pump set shall normally keep the complete system pressurized, and enables it to cope up with the system demand, which results in further fall in pressure. The fall in pressure is sensed by the designated pressure switch, which automatically starts the main fire pump set.

Depending upon the type and sensitivity of the risk, diesel-engine power pump set should be installed having 100% standby capacity.

Fire Hydrant System comprises of the following:

- Sufficiently large water reservoir
- Fire pump sets (Main and Standby)
- Jockey pump set
- Hydrant valves
- Fire fighting hoses
- Branch pipe with nozzles

Hydrant System is proposed to be installed at following Places

i. Building Stair Case area.
ii. Basement Area of Building.
iii. Restricted area of Yard / Car shed / Depot.

5.8.3.3 System Component:

- Landing Valves
- Hoses
- Couplings
- Hose Reels
- Fire Brigade Connectors
- Branch Pipes & Nozzles

5.8.3.4 **Landing Valve:**

It's a simple valve like water tap, whenever it is open, after connecting hose to that valve, water flow is targeted to extinguish fire.

5.8.3.5 **Hoses:**

Hose is a flexible tube used to carry water

5.8.3.6 **Hose Reel:**

A Hose Reel is a cylindrical spindle made of either metal, fiberglass, or plastic used for storing a hose. The most common style of hose reels are spring driven, hand crank, or motor driven. Hose reels are categorized by the diameter and length of the hose they hold, the pressure rating and the rewind method.

5.8.3.7 **Coupling:**

Coupling is a short length of pipe or tube with a socket at both ends that allows two pipes or tubes to be connected together temporarily.

5.8.3.8 **Fire Brigade Connector:**

Approved fire brigade connection, shall consist of 4 nos. of 63 mm instantaneous inlets, in a glass fronted wall box, at a suitable position on the street at convenient location to make inlets accessible. The size of the wall box shall be adequate to allow hose to connect to the inlets, after breaking glass cover if need be.

5.8.4 Sprinkler System:

5.8.4.1 A **fire sprinkler system** is an active fire protection measure, consisting of a water supply system, with adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected.

Each closed-head sprinkler is held by either a heat-sensitive glass bulb or a two-part metal link held together with fusible alloy. The glass bulb or link, applies pressure to a pipe cap which acts as a plug. This prevents water from flowing, until the ambient temperature around the sprinkler reaches the designed activation temperature of the individual sprinkler head. Each sprinkler activates independently, when the predetermined heat level is reached. The number of sprinklers that operate are limited to only those near the fire, thereby maximising the available water pressure over the point of fire origin.

Sprinkler System is proposed to be installed at following places

i. Building Passages.
ii. Basement Area.
iii. OCC room.
iv. Equipment room.
v. Store room.

5.8.5 Fire Extinguishers:

5.8.5.1 **General**:

Fire extinguishers form a **first aid action** against small and incipient fire before it develops into a major hazard.

5.8.5.2 **Scope:**

Types of Extinguishers:

i. Carbon-di-oxide of 4.5 kg.
ii. ABC Type 5Kg.
iii. Water Container 9 ltr. capacity.

These extinguishers shall be installed in the entire public, as well as service areas where the security is necessary. These appliances should be distributed, over the entire area, so that its users do not have to travel more than 15 m to reach the appliance. These appliances can be mounted or hanged on the wall at desired location.

5.8.5.3 **Description:**

Carbon Di Oxide (CO2) Fire Extinguishers

The cylinder filled with carbon dioxide (CO2), when operated extinguishes fire without any residue. Carbon-di-oxide Extinguishers are recommended, as these have inert gas with no residue, which is electrically non-conductive and ideal to be used over electronics and electric appliances.

5.8.5.4 **ABC Dry Powder - Fire Extinguishers:**

ABC Extinguishers are proposed for Class 'A' fire. These extinguishers are portable & can be handled by anyone / common person. These when operated, protect against the fire to flammable material, such as wooden articles, curtains etc.

- Type 'A' extinguisher shall be used for ordinary combustible articles such as cloth, wood, paper.

- Type 'B' extinguisher shall be used for flammable liquid fires, such as oil, gasoline, paints, lacquers, grease, and solvents.
- Type 'C' extinguisher shall be used for electrical fires, such as wiring, fuse boxes, energized electrical equipments and other electrical sources.
- Type 'D' extinguisher shall be used for metal fires such as magnesium, titanium and sodium.

5.8.5.5 **Water Type Fire Extinguishers:**

Water Type Fire Extinguishers are recommended for all Class "A" type of Fires where unskilled staff / personnel exist and can operate these without much difficulty.

5.8.5.6 **Glow Signs:**

Different types of signs like Exit, Fire and Emergency shall be provided to ensure passengers guidance and safety. The signs can glow in the dark specially. Exit Fire and Emergency Signs help passengers to find exit and help fire fighters to locate emergency equipment.

5.8.6 Closed Circuit Television:

5.8.6.1 **General:**

The objective of CCTV System is to provide High degree of Electronic surveillance system to the entire premises. It is essential to have recorded images to be stored at least for 30 days of all critical area's to facilitate investigations of reported cases. CCTV provision facilitates effective management.

Strategically placed video surveillance cameras help to enhance security by providing motion based / continuous monitoring of all corners / areas of premises.

CCTV monitoring shall cover the following areas:

i. Station Control Room (SCR)
ii. Station security services
iii. Platform Supervisor Booth
iv. Operational Control Centre and Traffic Controller (TC)
v. Depot controller (DC) in Depot
vi. Escalator landing and inside elevators
vii. Evacuation routes
viii. Cash transfer routes at the station

5.8.6.2 **Description:**

CCTV comprises of the following components:
i. Integrated Port Camera (IP Cameras)
ii. Computer
ii. Software

5.8.6.3 **Integrated Port Cameras:**

For operation of IP Cameras, no external supply connection is needed. However, Power Over Ethernet (PoE) shall be attached to an Uninterruptible Power Supply (UPS) and sized to maintain camera operations. PoE technology, enables a system to pass electrical power, along with data, on Ethernet cabling. Standard version of PoE specify Category 5 cable or higher to be used for the system.

Two types of IP Cameras Shall be used:

*Fix Camera– Use of this camera is restricted to 20 m range.
*PTZ Camera– Pan/Tilt/Zoom Camera is used for range from 20 m to 100 m.

5.8.6.4 **Computer:**

Images, when recorded by cameras, are transmitted to computer. When computer is on, images are displayed on its monitor instantly. These images are also stored in memory device.

Storing of images occurs automatically, even when computer is in off position.

5.8.6.5 **Software:**

Software installed in computer enables coding & decoding of data for functioning of the system enforced.

5.8.6.6 **Server Software:**

Software covers MS-SQL 2005, or better based Main Archive Server for audio and video, Main directory, Failover directory, Failover recording, Digital Virtual Matrix, Incident Reports, Alarm Management, Network Management System and Watchdog modules.

Server maintains a catalog of settings for all clients. It also encodes & decodes of stored information through I P cameras.
Software enables the client to dynamically create connections between Cameras and workstations and view live or recorded video on the digital monitors (Audio, video, serial ports and digital I/Os)

5.8.6.7 **Client Software:**

Client software includes of Administrator Tool application, Monitoring application, Archive Player application, Sync archive player application, Map creation application etc. All the relevant software licenses work on concurrent basis and no restriction of its use for specific work station is classified.

Client software performs the following applications simultaneously without interfering with any of the Archive Server operations (Recording, Alarms, etc.):

- Live display of cameras and audio
- Live display of camera sequences, panoramic camera views
- Playback of archived video
- Instant replays of Video and Audio
- Display and control of Maps
- Audio announcements
- Alarm management

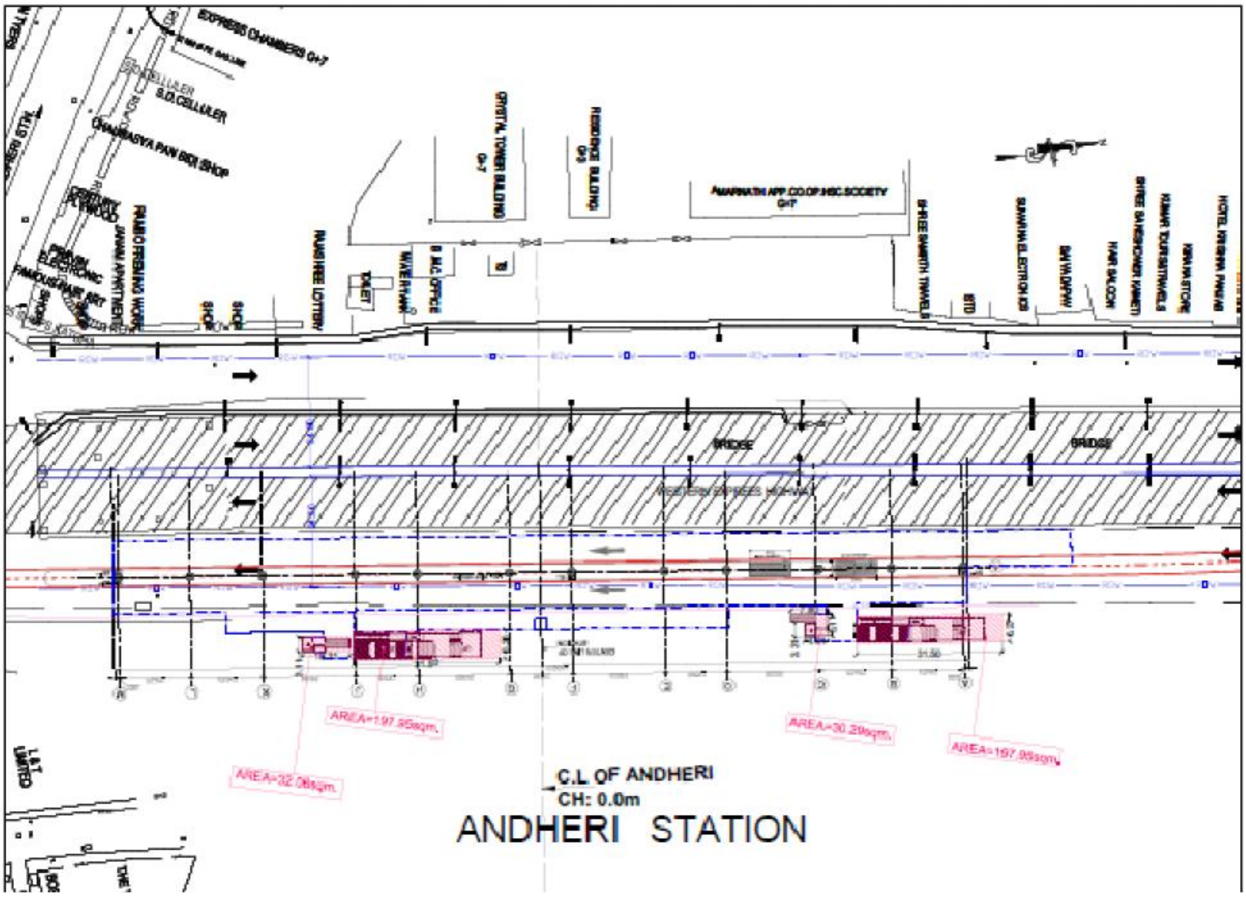
Client application provides, management and control over the system, using a standard PC mouse, keyboard or CCTV keyboard. Standard scroll mouse moves the camera by merely clicking on the extremes of the picture, in all directions and zoom function by scroll button, to avoid the use of joystick keyboard while maintaining easiness of the control.

Client application is to control pan-tilt-zoom, iris, focus, presets and dome patterns of the PTZ camera for correct functioning of the system.

Software provides utility to play multiple exported clips simultaneously. It also provides the ability to play multiple clips in time sync with each other to understand the sequence of events occurred during an emergency.

5.8.6.8 Security in general has gained great importance during the last few years. It is a prime concern at the stations due to the large number of commuters who congregate there daily. Any short coming or lapse at the stations can cause a disaster. Security arrangement has been catered for at the stations and in the coaches. Cost of the same is included in the estimate.

The estimate for security may, however, need revision after level and quantum of security to be provided are known in greater detail.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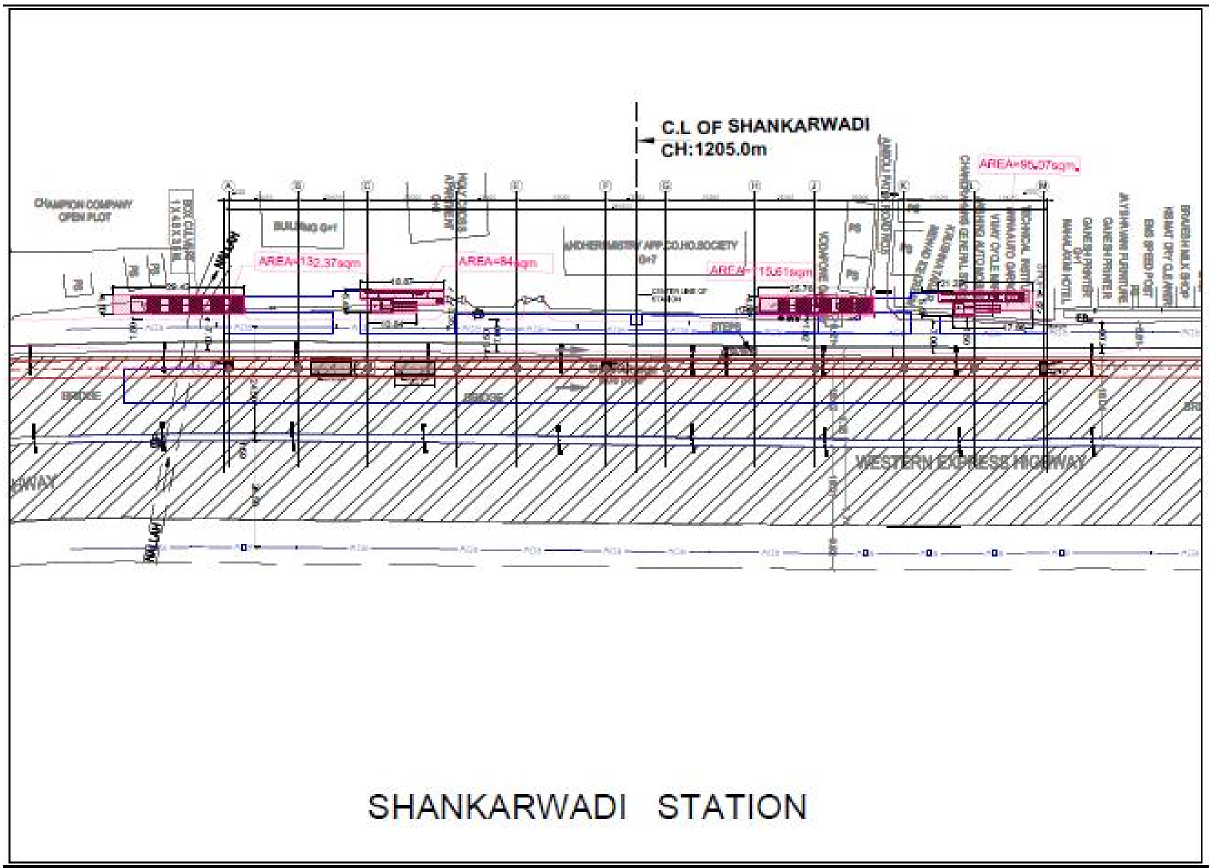
AREA=197.95sqm.
AREA=32.08sqm.
C.L OF ANDHERI
CH: 0.0m
ANDHERI STATION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OPEN PLOT
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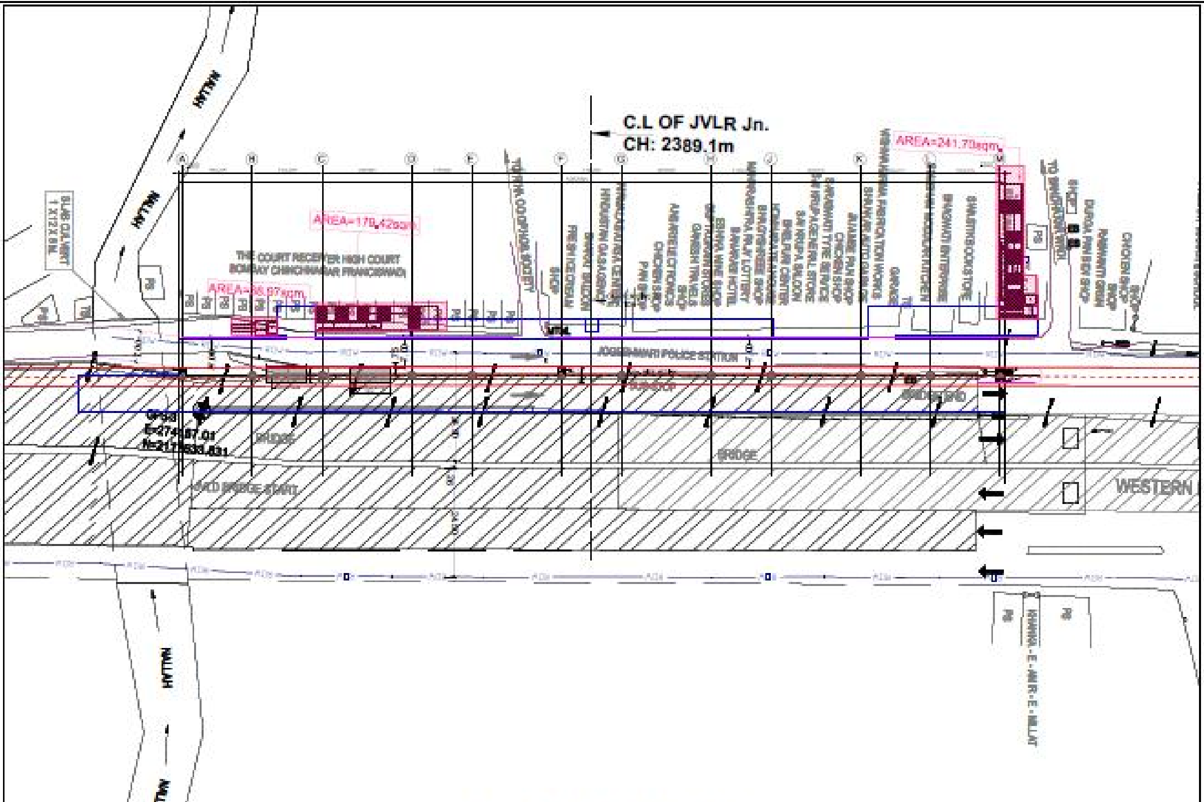
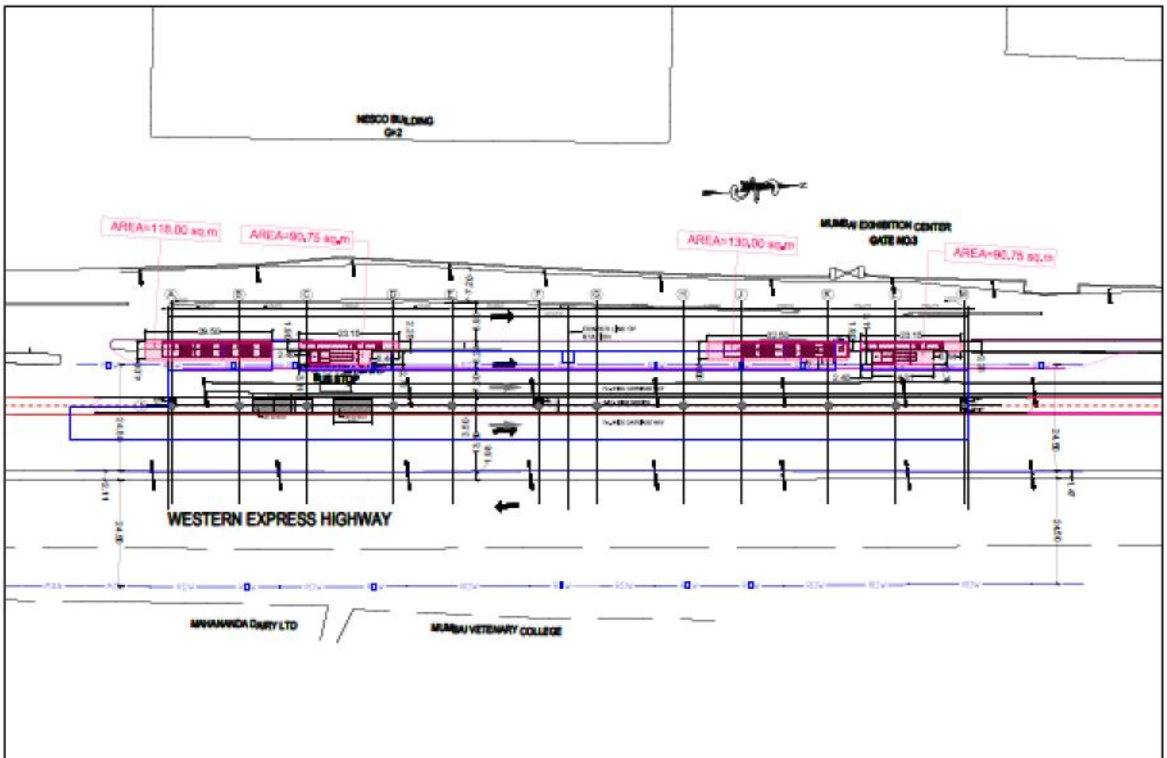
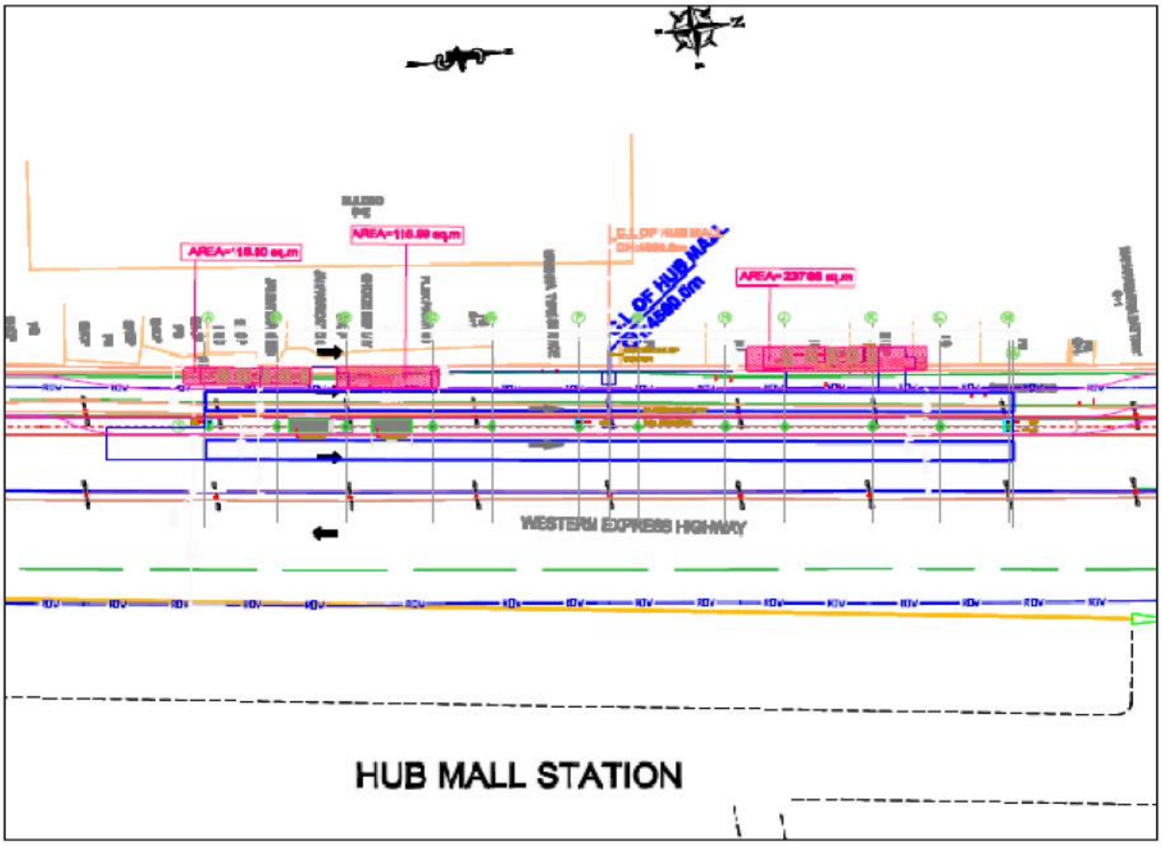
AREA=115.61sqm
WESTERN EXPRESS HIGHWAY
SHANKARWADI STATION



JVLR Jn. STATION



BOMBAY EXHIBITION STATION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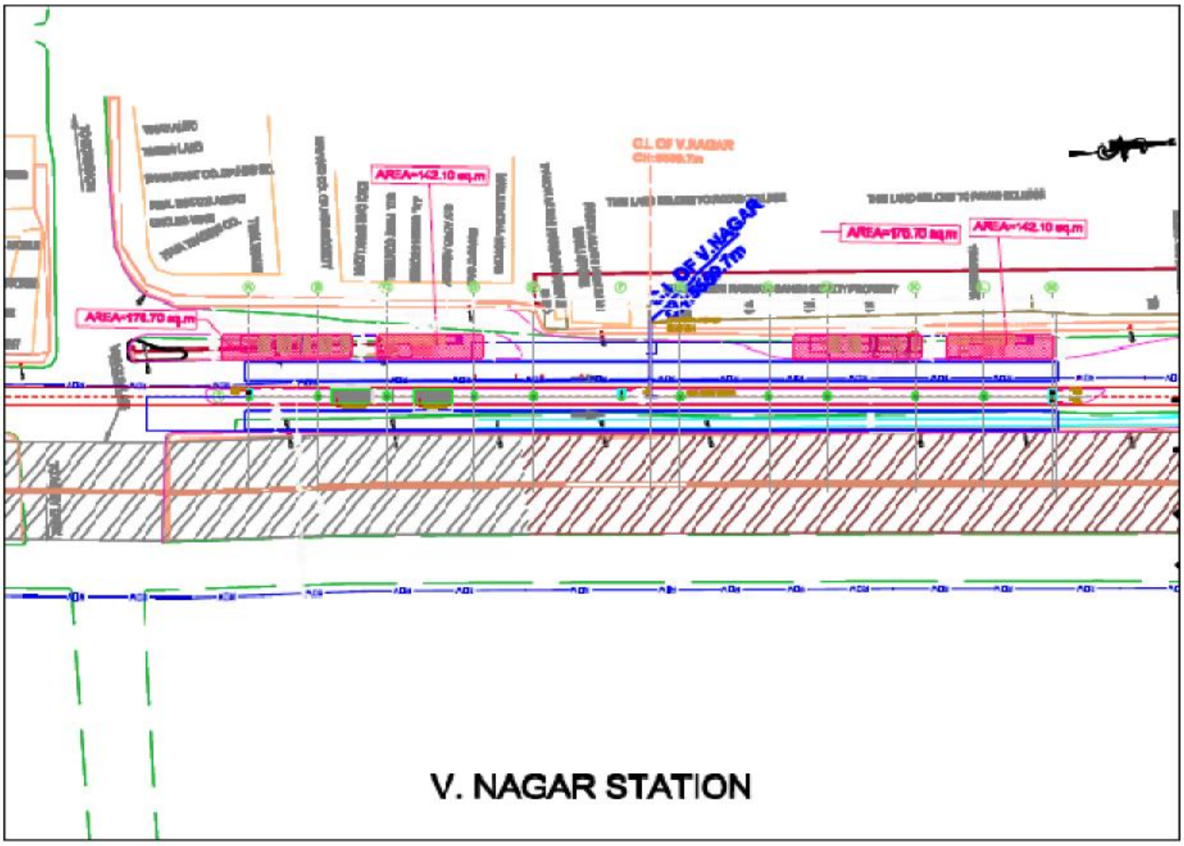
HUB MALL STATION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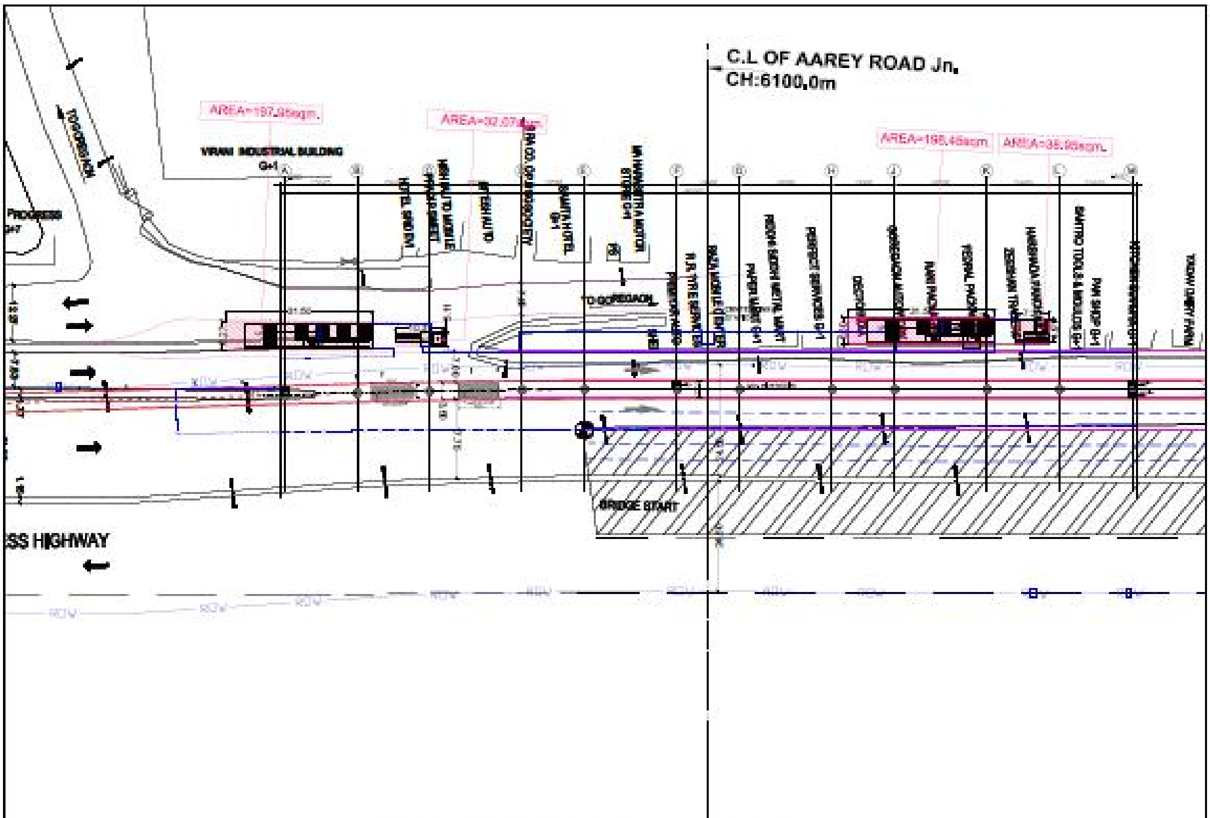
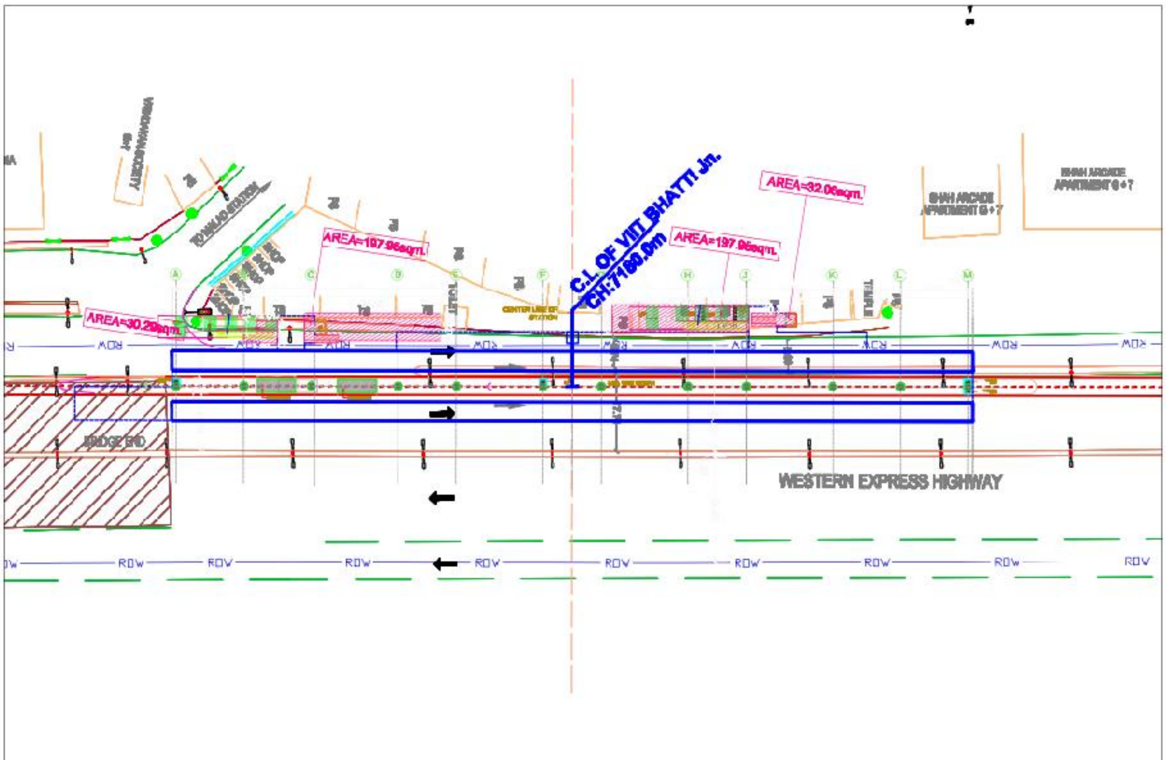
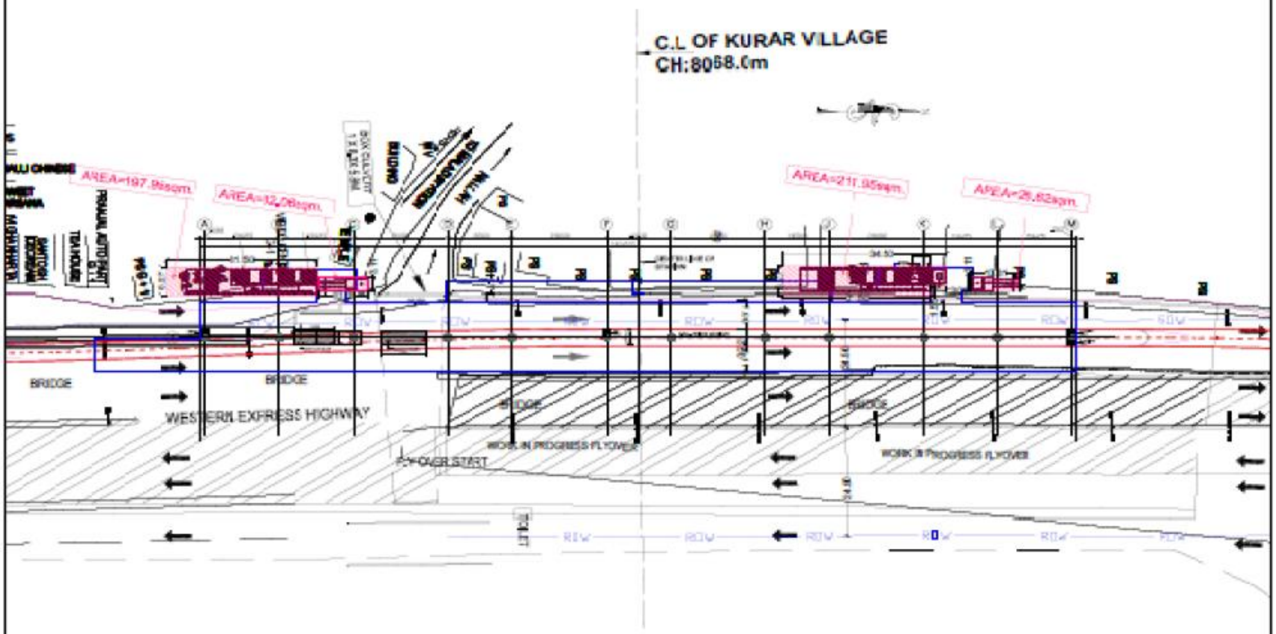
V. NAGAR STATION



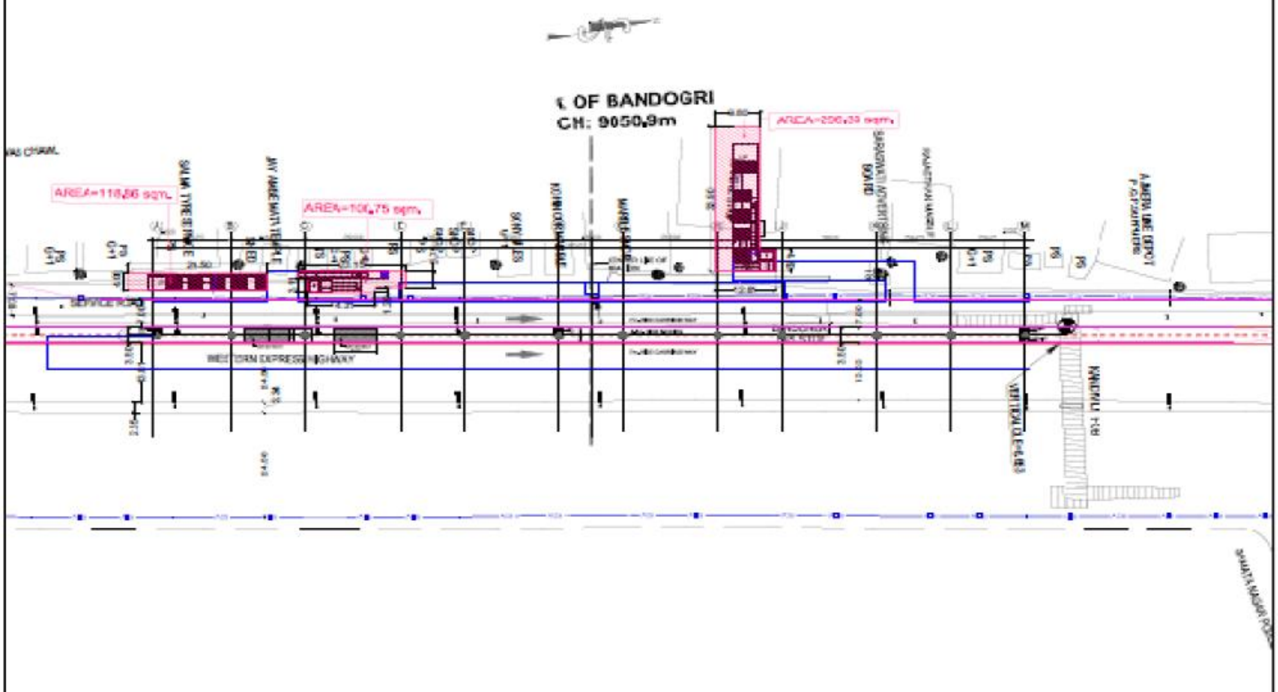
AAREY ROAD Jn. STATION



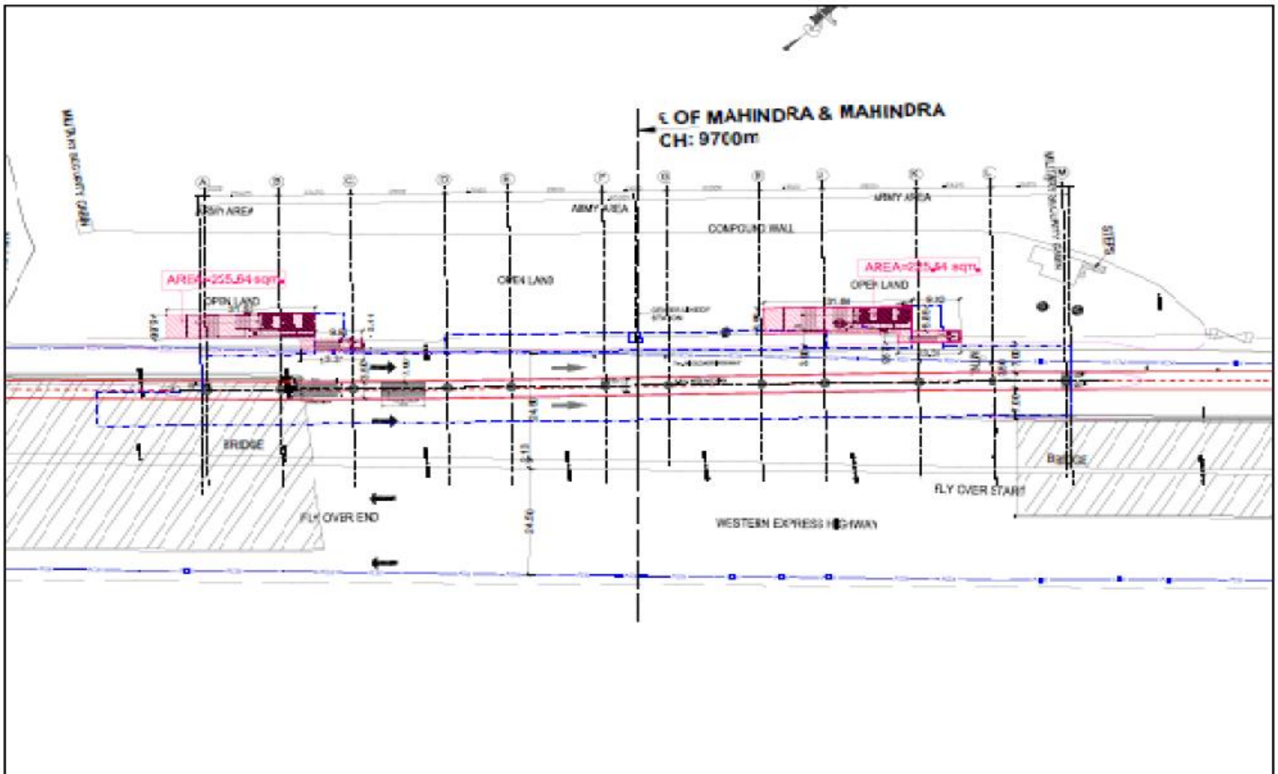
VITT BHATTI Jn. STATION



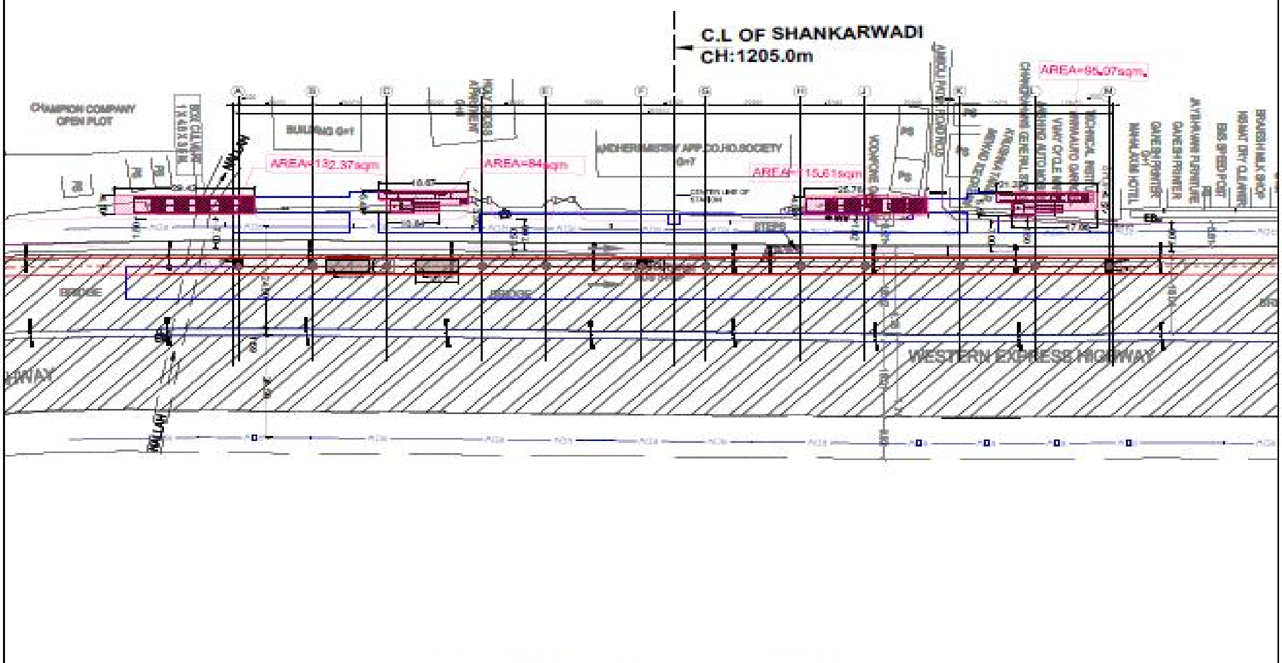
KURAR VILLAGE STATION



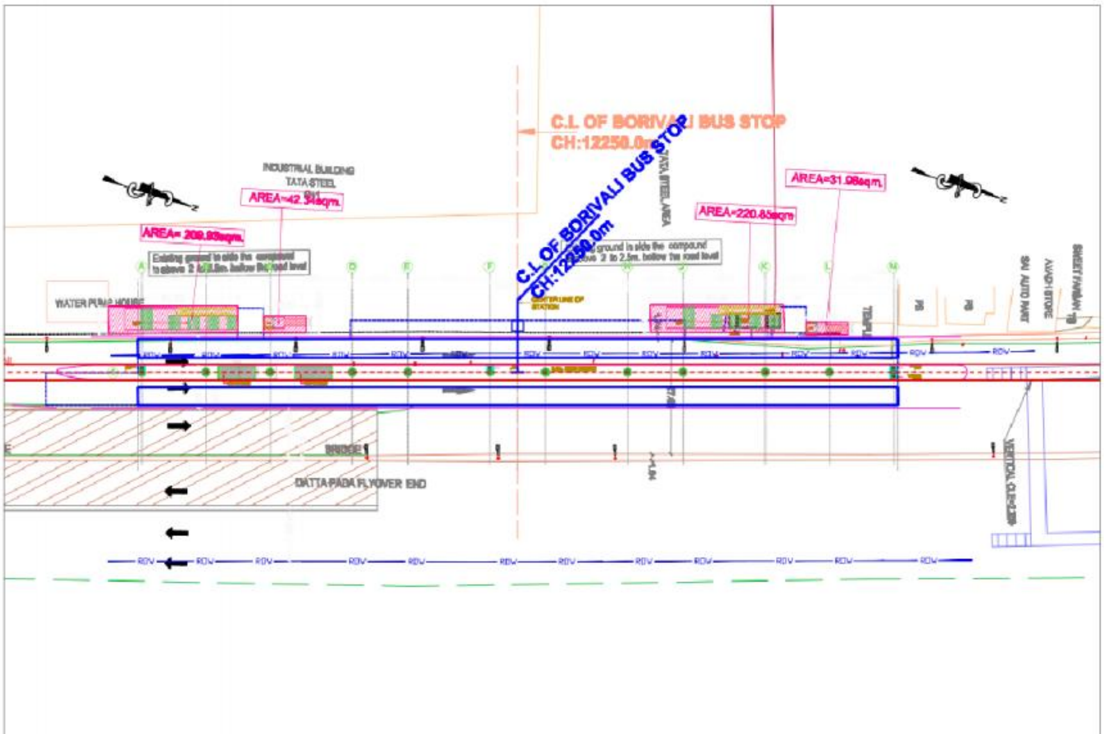
BANDONGRI STATION



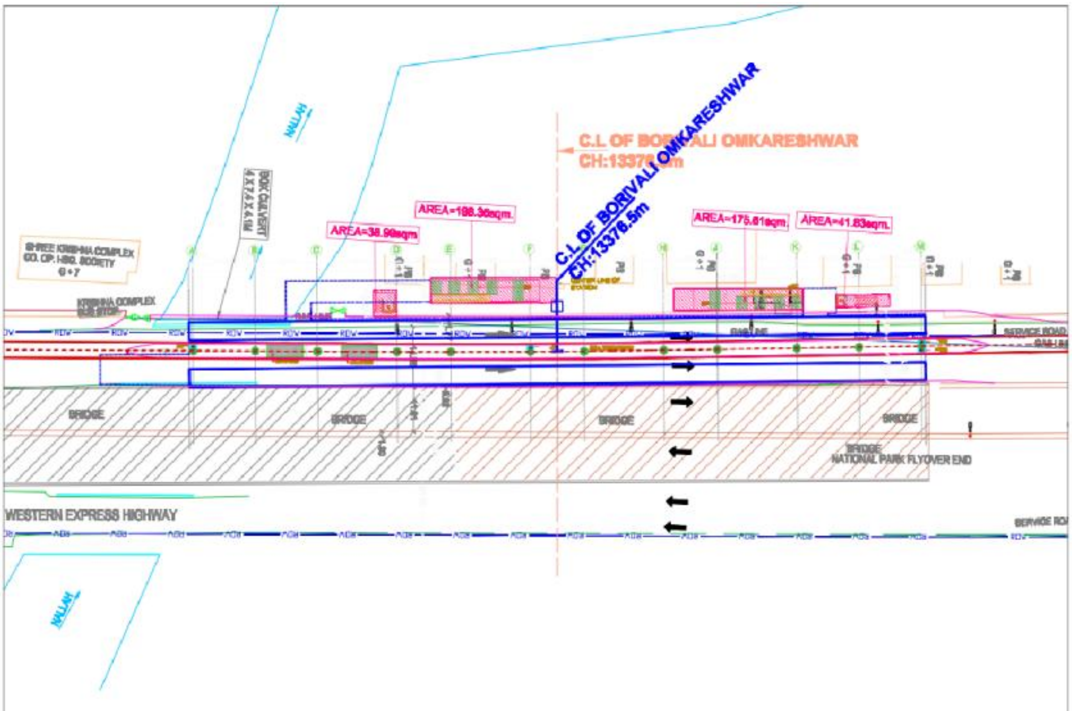
MAHINDRA & MAHINDRA STATION



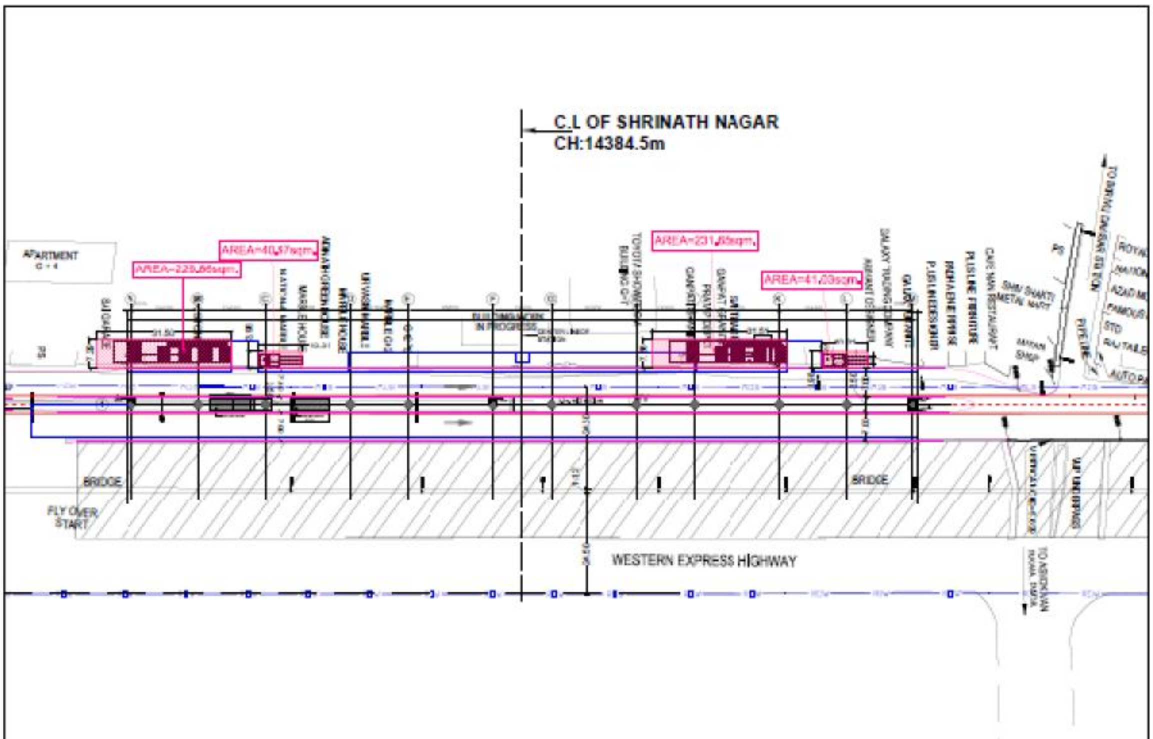
SHANKARWADI STATION



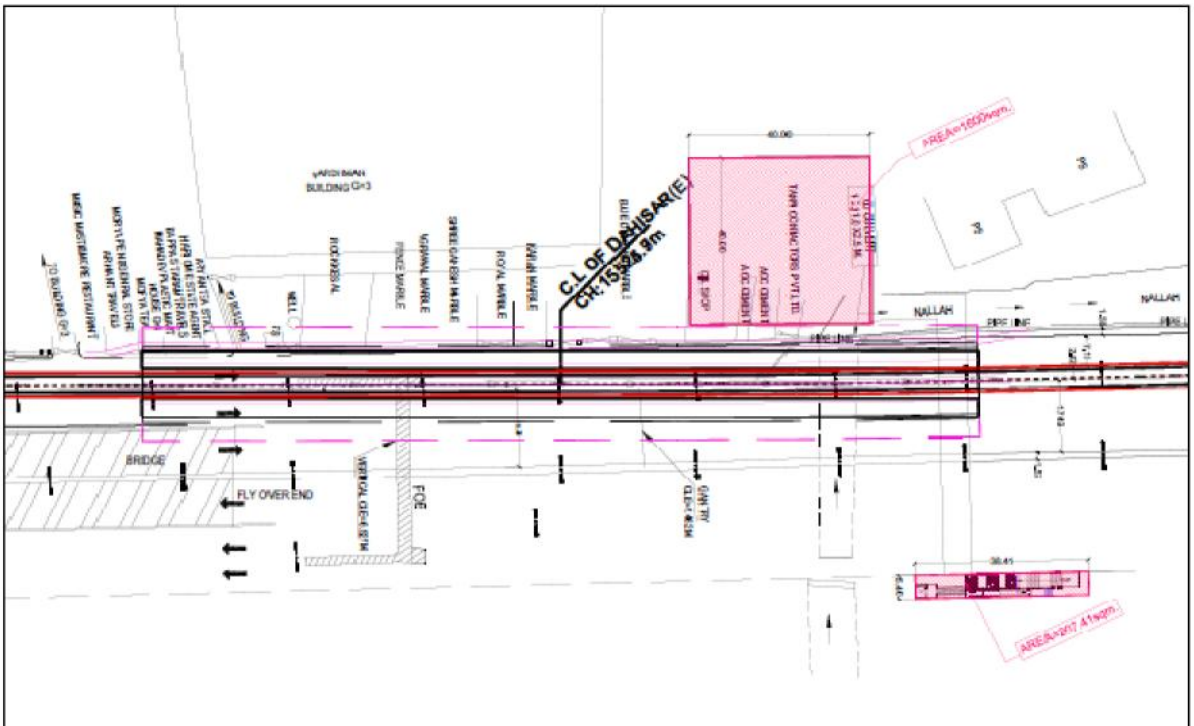
BORIVALI BUS STOP STATION



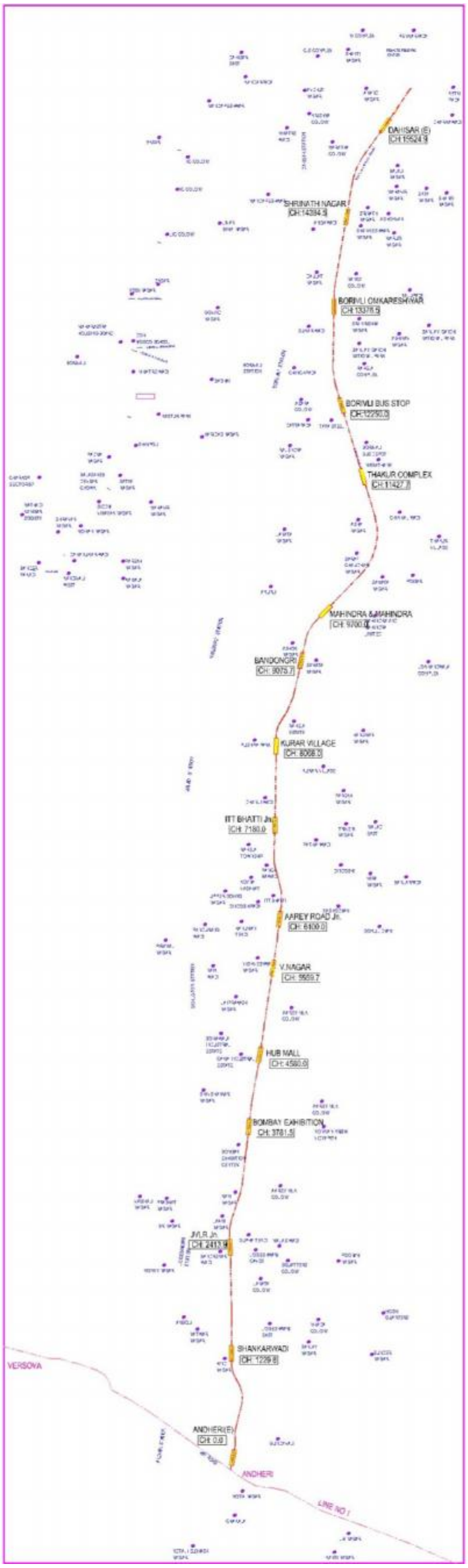
BORIVALI OMKARESHWAR STATION



SHRINATH NAGAR STATION



DAHISAR STATION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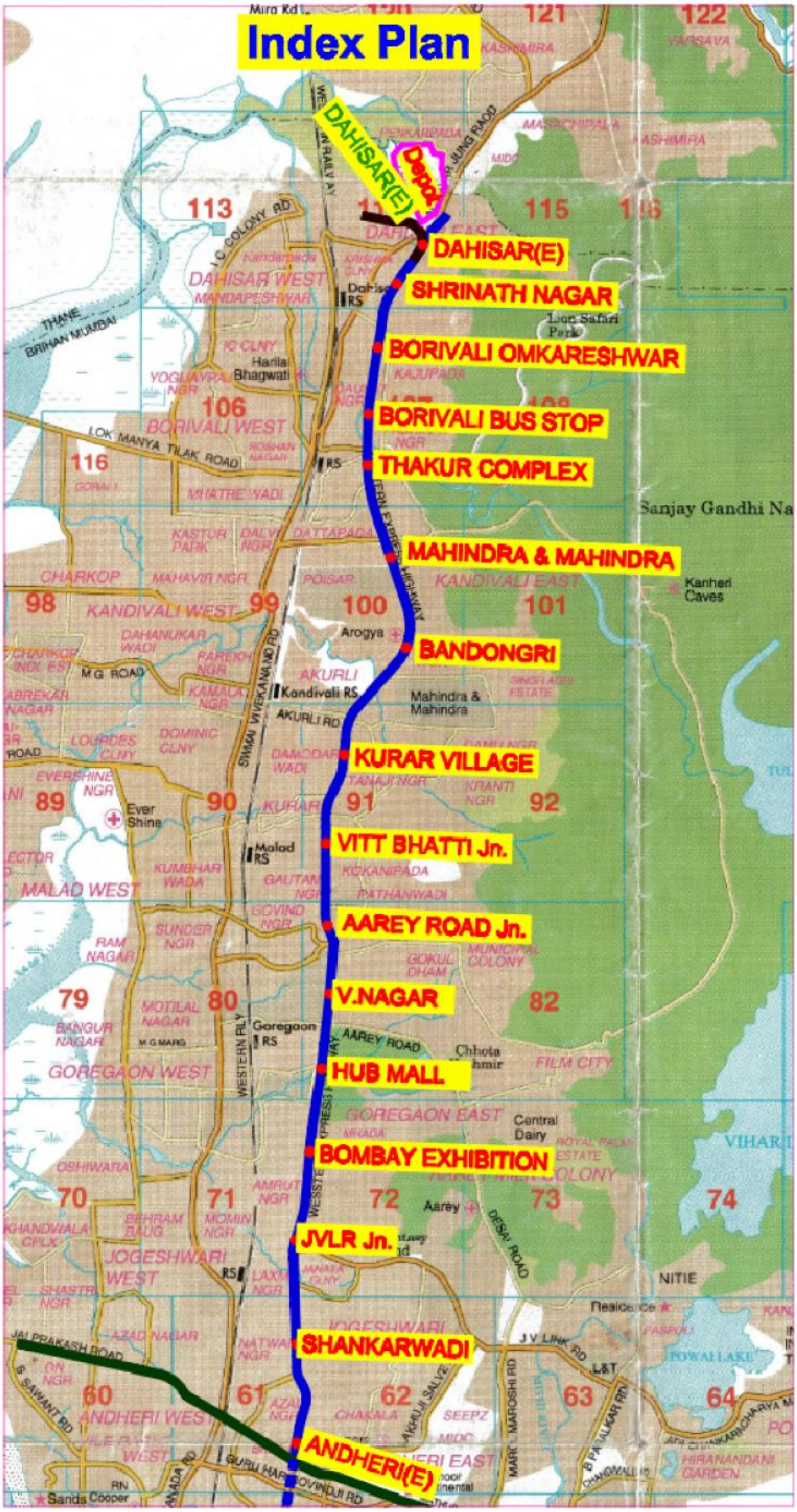
SHRINATH NAGAR
CH 14384.9
BORIVLI OMKARESHWAR
CH 13076.9
BORIVLI BUS STOP
CH 12290.0
THAKUR COMPLEX
CH 11427.0
MAHINDRA & MAHINDRA
BANDONGRI
KURAR VILLAGE
ITT BHATTI Jn.
CH. 7180.0
AAREY ROAD Jn.
V.NAGAR
HUB MALL
BOMBAY EXHIBITION
JVLR Jn.
SHANKARWADI
VERSOVA
ANDHERI (E)
CH 0.0
ANDHERI
LINE NO 1

Fig. 1. DP plan


Index Plan
DAHISAR(E)
Depot
DAHISAR(E)
SHRINATH NAGAR
BORIVALI OMKARESHWAR
BORIVALI BUS STOP
THAKUR COMPLEX
MAHINDRA & MAHINDRA
BANDONGRI
KURAR VILLAGE
VITT BHATTI Jn.
AAREY ROAD Jn.
V.NAGAR
HUB MALL
BOMBAY EXHIBITION
JVLR Jn.
SHANKARWADI
ANDHERI(E)

Appendix-I

SELECTION OF TYPE OF ALIGNMENT

The metro network may have the under-mentioned three types of alignments:

1. At-Grade
2. Elevated
3. Under-ground

1. At Grade - At-Grade type of alignment is technically feasible only in the areas where vacant land is available or a dedicated corridor of 14 meters width is provided in the mid of the road. However, the main limitation of providing At-Grade corridor is that city is divided in two parts and any crossing from one side to other side of At-Grade corridor has to be provided by grade separation i.e., either foot-over bridge or under passes. This alternative is the most economical. However, it should be noted that cost saving is only in Civil Engineering cost which is arrived if the land cost requirement for at grade alignment is taken into account and cost per km. may come even more than elevated. Therefore, At-Grade type of alignment for metro systems in cities is normally ruled out.

2. Elevated – Elevated alignment is generally provided in the cities for metro network, but the pre-requisite is the right of way (ROW) of road should minimum be 20 meters. It will enable to provide a median of about 2.8 to 3.0 meters wide road, two lane each way (7 meters width) and foot-path 1.5 meter each way. The land requirement for elevated alignment is mainly for the exit and entries for the station. As the alignment pillars located on median of the roads, a rough estimate of land requirement is about 240 sq. meters on either side of the road, wherein even underground water tank and generator rooms can be accommodated under the staircase. Construction of elevated station is much easier, 8 meter wide strip for the platform length (say 185 meters) will be required temporarily for putting the pillars on the median. Small area of about 400 sq. meters is needed for execution of the work of exit and entries on either side of the road.

4. Under-ground – This type of alignment is adopted only in case when ROW is less than 20 meters and alignment has to necessarily pass through the area where no roads are available. In this case only station locations where metro stations can conveniently located are identified and these are joined by under-ground tunnels. However, under-ground station need much ground surface area than elevated station for the reasons that in case of under-ground station, there is a space requirement for chiller plants in addition to exit and entries, which may be almost same as required for elevated station. Normally, the construction of under-ground stations require the area with 240 meters length and 24 meters width which need to be cut open. Finding out such a big space for construction of under-ground station in a congested city and even on passenger roads is very difficult if not impossible. For construction of under-ground station, the traffic is necessarily required to be diverted. Advantages and dis-advantages of these two types of alignments are given in the table below:

S.No.	Item name	Under-ground alignment	Elevated alignment
1.	Permanent land	More area required	Comparatively less area required
2.	Land requirement for construction	Much more area required. At least twice of what required for elevated station	Area requirement is much less than under-ground
3.	Construction time	At least 5 years	At least 3 and 1/2 years
4.	Cost of construction	2.25 to 2.50 times of elevated cost.	Much cheaper compared to underground
5.	Operation cost	1.25 to 1.5 times of elevated operation cost	Much cheaper compared to underground
6.	Security concern	Under-ground metro stations are more prone to terrorist attacks.	Less prone to terrorist attacks.
7.	Risk	More risk to the passengers during the disruption	Less risk compared to underground.
8.	Drainage Arrangement	Very exhaustive drainage arrangement needed	Very simple arrangement
9.	Ramp	In case of under-ground, when alignment is changes from under-ground to elevated, 11 meters width and 650 meters long land portion is needed for providing the ramp with physical barrier between 2 sides of the city.	There is no requirement of such ramp and land.

The rough estimate of under-ground and elevated alignments for 20 kms length has been made at the price level of March, 2015. The cost (without land and Taxes) of under-ground alignment comes to Rs. 412 crores and elevated Rs. 176 crores. It indicates that per kilometre of under-ground alignment replacing elevated alignment, the cost to the tune of 2.3 times has to be incurred

In view of the above, the decision for opting a particular type of alignment has to be taken on techno-economic basis. For country like India, a balance has to be kept in two types of alignments for the reasons that we are already short of funds for our infrastructure projects. It is also recommended that underground alignment be opted only in the stretches where elevated alignment is not possible to provide.

To appreciate the magnitude of land requirement, Ground Level Plans of one Typical elevated station and underground station are put up at Figure-1 & Figure-2 to this appendix.

*****

Figure -1 Typical Elevated Station Layout

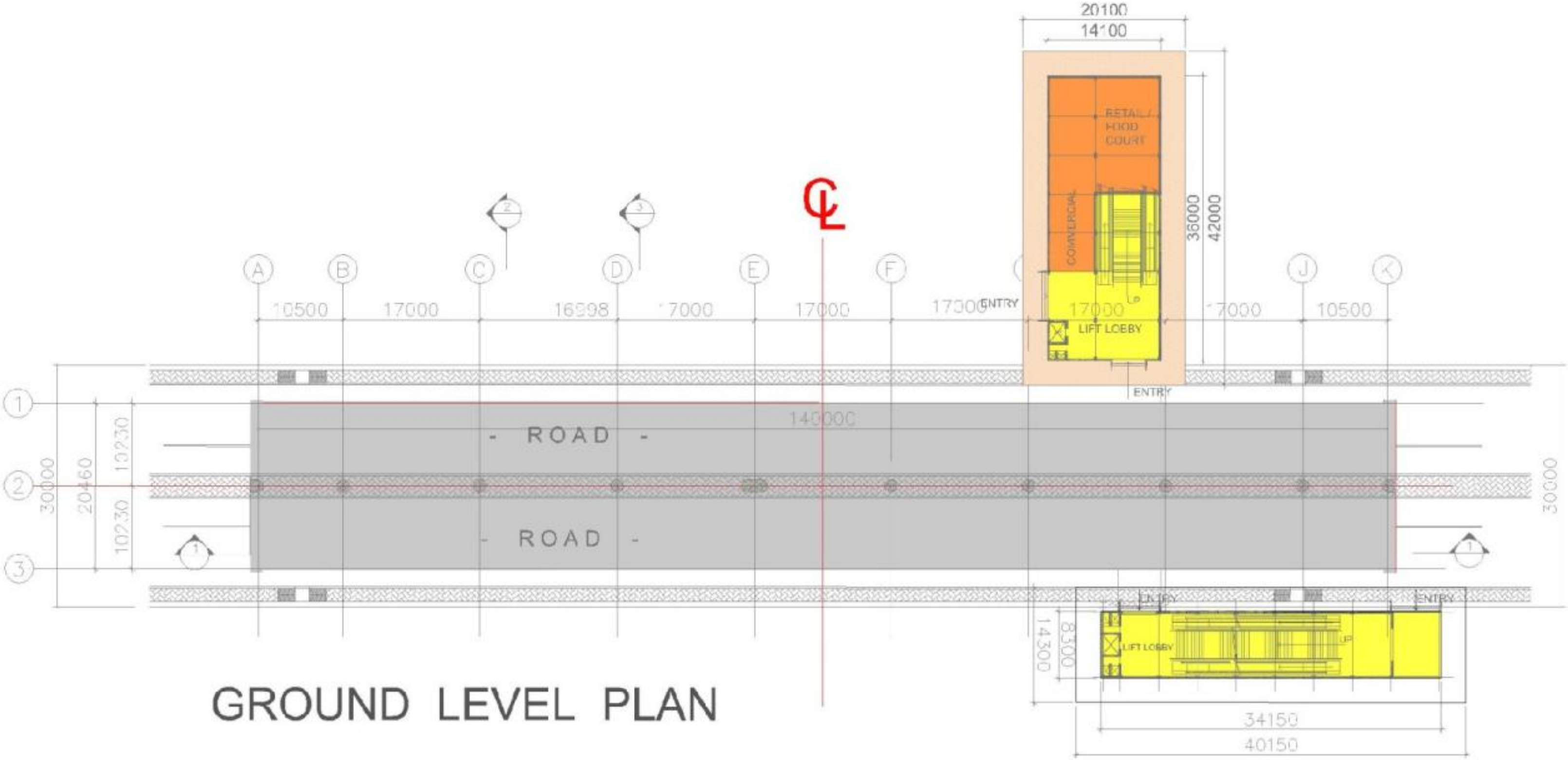
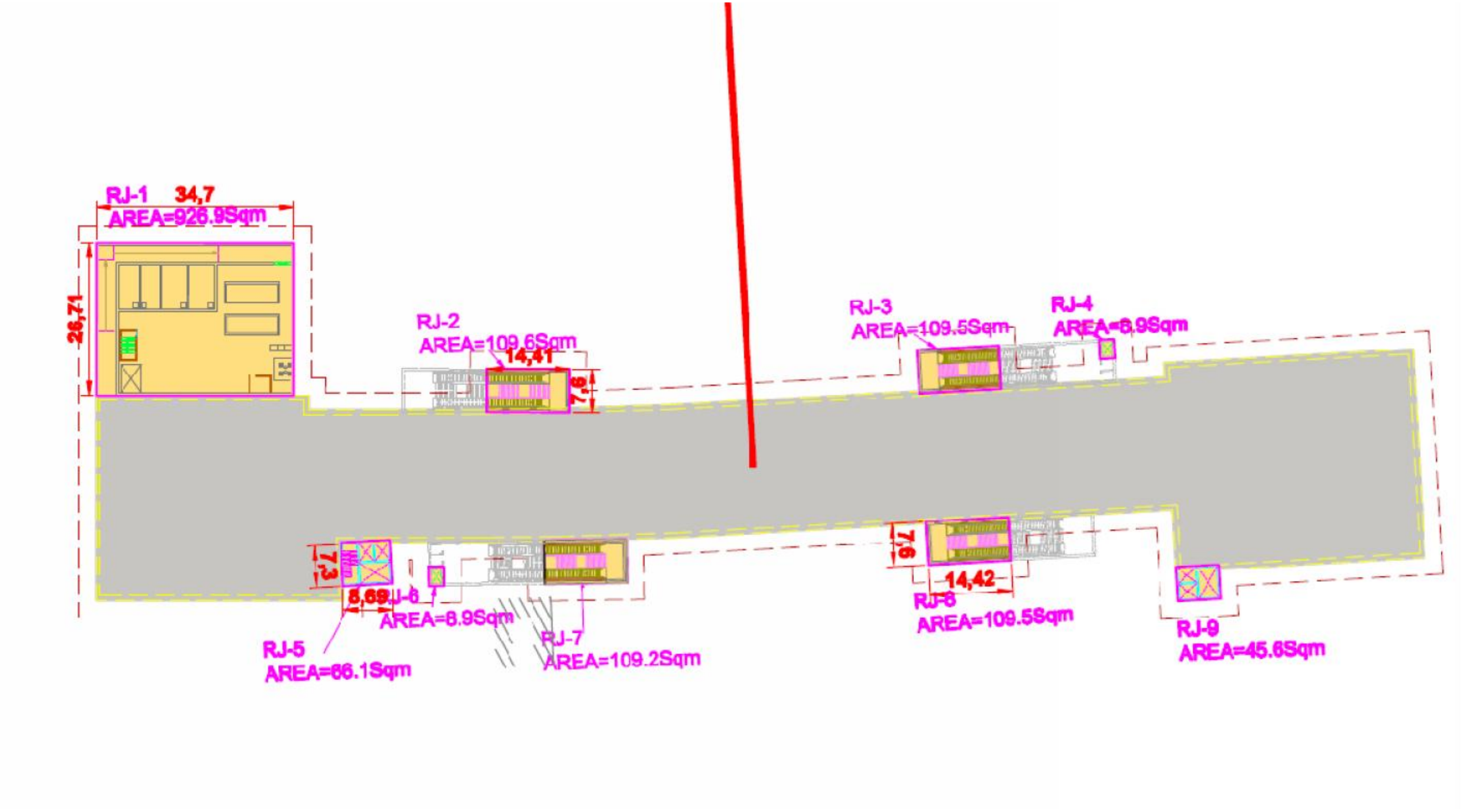


Figure 2 Typical Underground Station Layout

Ground Level Plan



CHAPTER 6

TRAIN OPERATION PLAN AND ROLLING STOCK

6.1. OPERATION PHILOSOPHY

The underlying operation philosophy is to make the Metro System more attractive and economical, the main features being:

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- Multi-tasking of train operation and maintenance staff.

6.2 STATIONS

Details of stations for Mumbai Metro (Andheri- Dahisar corridor) are given in table 6.1:

Table 6.1 Details of Stations

Mumbai Metro(Andheri- Dahisar corridor)			
Sl.No	Station Name	Chainage(m)	Inter Distance between two Stations
0	Dead End	(-) 450	
1	ANDHERI	0.0	450
2	SHANKARWADI	1229.8	1229.8
3	JVLR Jn.	2413.9	1184.1
4	BOMBAY EXHIBITION	3781.5	1367.6
5	HUB MALL	4580.0	798.5
6	V.NAGAR	5559.7	979.7
7	AAREY ROAD Jn.	6100.0	540.3
8	VITT BHATTI Jn.	7180.0	1080.0
9	KURAR VILLAGE	8068.0	888.0
10	BANDONGRI	9075.7	1007.7
11	MAHINDRA & MAHINDRA	9700.0	624.3
12	THAKUR COMPLEX	11427.7	1727.7
13	BORIVALI BUS STOP	12250.0	822.3
14	BORIVALI OMKARESHWAR	13376.5	1126.5
15	SHRINATH NAGAR	14384.5	1008.0
16	DAHISAR (E)	15524.9	1140.4
	Dead End	16025.7	500.8

6.3 TRAIN OPERATION PLAN

6.3.1 Salient Features:

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for this corridor has been taken as 35 Kmph.

6.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Andheri- Dahisar for the year 2016, 2019,2021 and 2031 for the purpose of planning are indicated in Attachment I/A, I/B,I/C and I/D respectively and has been taken as the maximum of the PHPDT in the forward & reverse directions.

6.3.3 Train Formation

To meet the above projected traffic demand, the possibility of running trains with composition of 6 Car trains with different headways have been examined.

Composition

DMC : Driving Motor Car

MC : Motor Car

TC : Trailer Car

6-car train composition: DMC+TC+MC+ MC+TC+DMC

Capacity@ 6 passengers per square meter of standee area

DMC : 282 passengers (Sitting-42, Standing-240)

MC : 298 passengers (Sitting-50, Standing-248)

TC : 298 passengers (Sitting-50, Standing-248)

6 Car Train : 1756 Passengers (Sitting-284, Standing-1472)

6.3.4 Train Operation Plan

Based on the projected PHPDT demand, train operation has been planned for Mumbai Metro (Andheri- Dahisar corridor) for the year 2016, 2019,2021 and 2031 as detailed below:

Train operation plan for Andheri- Dahisar with train carrying **capacity @ 6 persons per square meter of standee area** on Mumbai Metro (Andheri- Dahisar corridor) is given below:

- **Year 2016** (Refer **Attachment I /A**)

Train operation with **6 car Trains** with headway of **8 min** between Andheri-Dahisar is planned in the first year of operation i.e. **2016** with Peak Hour Peak Direction Capacity of **13170 @ 6 persons per square meter of standee area (Capacity of 16830 @ 8 persons per square meter of standee area under dense loading conditions)**.

The maximum PHPDT demand of 12800 is in the Section between Andheri and Shankarwadi. The planned capacity of 13170 (16830 under dense loading) is more than the PHPDT demand. Traffic demand and train capacity for this corridor in the year 2016 is tabulated and represented on a chart enclosed as Attachment I /A.

- **Year 2019** (Refer **Attachment I /B**)

Train operation with **6 car Trains** with headway of 6.75 **min** between Andheri-Dahisar is planned in the first year of operation i.e. **2019** with Peak Hour Peak Direction Capacity of **15609 @ 6 persons per square meter of standee area (Capacity of 19947 @ 8 persons per square meter of standee area under dense loading conditions)**.

The maximum PHPDT demand of 15602 is in the Section between Andheri and Shankarwadi. The planned capacity of 15609 (19947 under dense loading) is more than the PHPDT demand. Traffic demand and train capacity for this corridor in the year 2019 is tabulated and represented on a chart enclosed as Attachment I /B.

- **Year 2021** (Refer **Attachment I/C**)

Train operation with **6 car Trains** with headway of **5.5 min** between Andheri-Dahisar is planned in the year **2021** with Peak Hour Peak Direction Capacity of **19156 @ 6 persons per square meter of standee area (Capacity of 24480 @ 8 persons per square meter of standee area under dense loading conditions)**.

The maximum PHPDT demand of 18860 is in the Section between Andheri and Shankarwadi. The planned capacity of 19156 (24480 under dense loading) is more than the PHPDT demand. Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I /C.

- **Year 2031** (Refer **Attachment I/D**)

  Train operation with **6 car Trains** with headway of **5.5 min** between Andheri-Dahisar is planned in the year **2031** with Peak Hour Peak Direction Capacity of **19156 @ 6 persons per square meter of standee area (Capacity of 24480 @ 8 persons per square meter of standee area under dense loading conditions)**.

The maximum PHPDT demand of 18752 is in the Section between Andheri and Shankarwadi. The planned capacity of 19156 (24480 under dense loading) is more than the PHPDT demand. Traffic demand and train capacity for this corridor in the year 2031 is tabulated and represented on a chart enclosed as Attachment I /D.

The PHPDT capacity provided on this corridor in different years of operation is given in Table 6.2 :

Table 6.2 PHPDT Capacity Provided

	YEAR			
	2016	**2019**	**2021**	**2031**
Cars/trains	**6**	**6**	**6**	**6**
Head way (Minutes)	**8**	**6.75**	**5.5**	**5.5**
Max. PHPDT Demand	**12800**	**15602**	**18860**	**18752**
PHPDT Capacity Available	**13170* (16830**)**	**15609* (19947**)**	**19156* (24480**)**	**19156* (24480**)**

* @ 6 persons per square meter of standee area
** @ 8 persons per square meter of standee area

6.3.5 TRAIN FREQUENCY

Mumbai Metro (Andheri- Dahisar corridor)

The train operation Andheri- Dahisar corridor provides for the following:

a) The train operation plan provides for 8 **min** headway with 6 – Car train in Andheri- Dahisar during peak hours and **24 min** headway during lean hours in the year 2016.

b) The train operation plan provides for 6.75 **min** headway with 6 – Car train in Andheri- Dahisar during peak hours and **24 min** headway during lean hours in the year 2019.

c) The train operation plan provides for **5.5 min** headway with 6 – Car train in Andheri- Dahisar during peak hours and **16 min** headway during lean hours in the year 2021.

d) The train operation plan provides for **5.5 min** headway with 6 – Car train in Andheri- Dahisar during peak hours and **16 min** headway during lean hours in the year 2031.

e) No services are proposed between 00.00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

6.3.6 HOURLY TRAIN OPERATION PLAN

The hourly distribution of daily transport capacity is presented in **Table 5.4, 5.5, 5.6 & 5.7** for years 2016, 2019, 2021 & 2031 and enclosed as **Attachment II.** Number of train trips per direction per day is worked out as 103 in the year 2016, 109 in the year 2019,133 in the year 2021 and 133 in the year 2031.

6.3.7 VEHICLE KILOMETER

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Andheri- Dahisar is given in Table 5.9 enclosed as Attachment IV.

6.3.8 YEARWISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as **Attachment V** & has been tabulated below in Table 5.3:

Table 5.3: Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
Andheri-Dahisar	2016	8	10	6 car	60
	2019	6.75	13		78
	2021	5.5	15		90
	2031	5.5	15		90

Requirement of coaches is calculated based on following assumptions:-

Assumptions -

(i) Train Composition planned as under:
6 Car Train Composition : DMC+TC+MC+ MC+TC+DMC

Train Carrying Capacity of 6 Car
Train@6 person per square meter : 1756 passengers
Train@8 person per square meter : 2244 passengers

(ii) Coach requirement has been calculated based on headway during peak hours.

(iii) Traffic reserve is taken as one trains to cater to failure of train on line and to make up for operational time lost.

(iv) Repair and maintenance reserve has been estimated as 10 % of total requirement (Bare +Traffic Reserve).

(v) The calculated number of rakes in fraction is rounded off to next higher number.
(vi) Schedule speed is taken as 35 KMPH.
(vii) Total Turn Round time is taken as 6 min at terminal stations.

6.4 ROLLING STOCK (Technical data)

Numbers of cars	:6
Composition	: DMC+TC+MC+ MC+TC+DMC
Power System[Kv/Hz]	:25 KV AC
Acceleration[m/s^2]	:1.0
Deceleration[m/s^2]	:1.0
Emergency Braking [m/s^2]	:1.35
Maximum Design speed[kmph]	:90
Track Gauge[mm]	:1435
Width over body of rolling Stock[mm]	:3200

6.5 Cost Estimate

The estimated cost per car at March' 2015 Price level (exclusive of taxes and duties) may be assumed as Rs. 9.8 Crores per car. Total 13 rakes (78 cars) would be required in horizon year 2019 for Mumbai Metro (Andheri- Dahisar corridor). Accordingly budget provision of INR 764.4 Crores is to be kept in the estimate for Rolling Stock, with revenue operation targeted for year 2019.

6.6 Recommendation

TOP chapter has been prepared considering 6-car train with 67% motoring. Smaller rakes with 6 cars instead of 8 cars will enable us to achieve better headways for same PHPDT demand and 67% motoring will help in achieving better acceleration.

Trains with 6 car train consist (with 67% powering cars) operating @ 90 seconds headway can achieve PHPDT of approximately 72,000 with loading of 6 Passengers per sq m. The traffic projections do not suggest such requirements. However, for higher PHPDT requirements in future(upto approximately 1,08,000), the train consist of 9 cars can be adopted in future. In case such scenario is planned, platform lengths shall be planned for 9 car trains. Also, it recommended that 3.2 m wide stock, suitable for SG may be adopted.

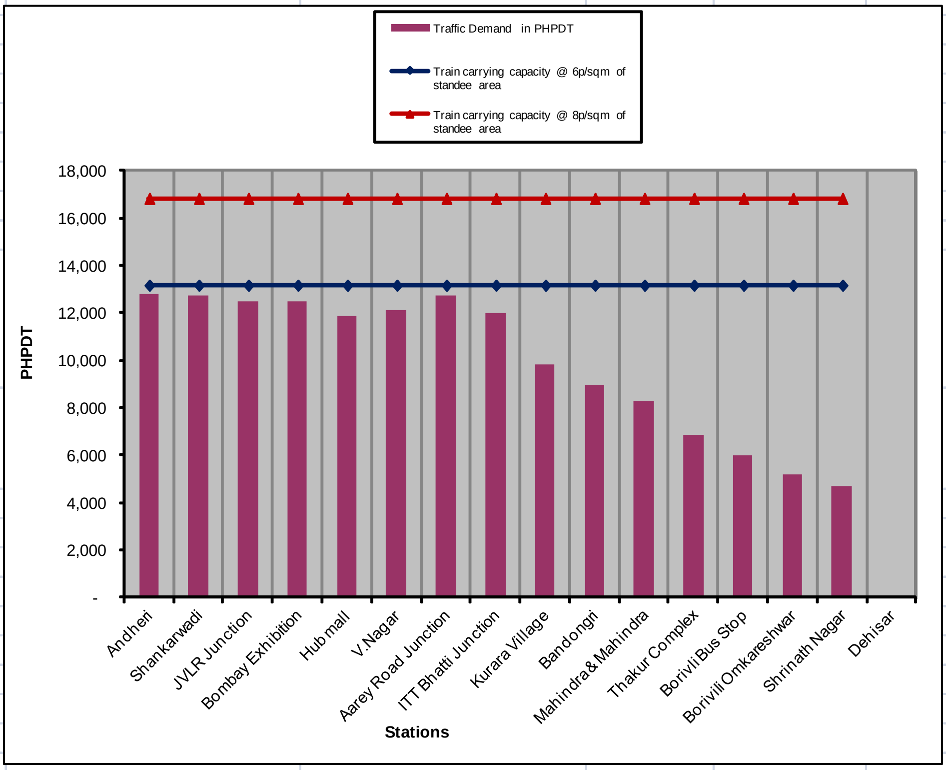
Attachment - I/A

PHPDT Demand and Capacity Chart

Mumbai Metro(Andheri- Dahisar corridor)

Year:	2016
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	8.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Andheri	Shankarwadi	12,800	13,170	16,830
2	Shankarwadi	JVLR Junction	12,726	13,170	16,830
3	JVLR Junction	Bombay Exhibition	12,474	13,170	16,830
4	Bombay Exhibition	Hub mall	12,474	13,170	16,830
5	Hub mall	V.Nagar	11,876	13,170	16,830
6	V.Nagar	Aarey Road Junction	12,088	13,170	16,830
7	Aarey Road Junction	ITT Bhatti Junction	12,751	13,170	16,830
8	ITT Bhatti Junction	Kurara Village	11,990	13,170	16,830
9	Kurara Village	Bandongri	9,832	13,170	16,830
10	Bandongri	Mahindra & Mahindra	8,943	13,170	16,830
11	Mahindra & Mahindra	Thakur Complex	8,257	13,170	16,830
12	Thakur Complex	Borivli Bus Stop	6,885	13,170	16,830
13	Borivli Bus Stop	Borivili Omkareshwar	6,008	13,170	16,830
14	Borivili Omkareshwar	Shrinath Nagar	5,164	13,170	16,830
15	Shrinath Nagar	Dahisar	4,718	13,170	16,830
16	Dehisar				



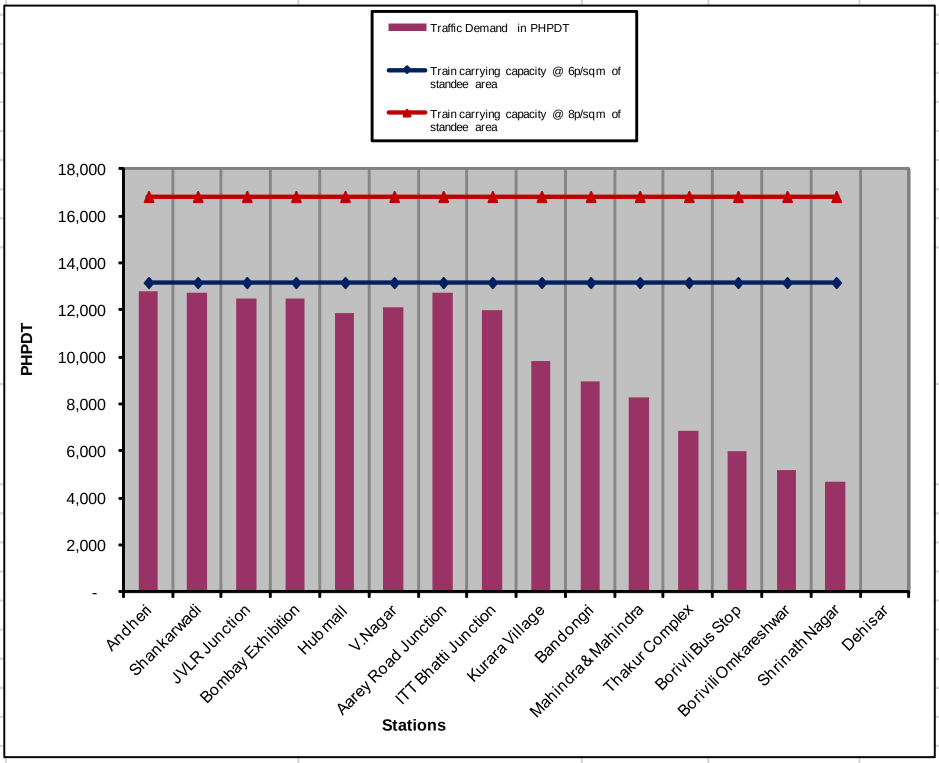
Attachment - I/B

PHPDT Demand and Capacity Chart

Mumbai Metro(Andheri- Dahisar corridor)

Year:	**2019**
No. of cars per train	**6**
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	**1756**
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	**2244**
Headway (min)	**6.75**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Andheri	Shankarwadi	10,252	15,609	19,947
2	Shankarwadi	JVLR Junction	10,097	15,609	19,947
3	JVLR Junction	Bombay Exhibition	15,281	15,609	19,947
4	Bombay Exhibition	Hub mall	15,449	15,609	19,947
5	Hub mall	V.Nagar	**15,602**	15,609	19,947
6	V.Nagar	Aarey Road Junction	15,557	15,609	19,947
7	Aarey Road Junction	ITT Bhatti Junction	15,352	15,609	19,947
8	ITT Bhatti Junction	Kurara Village	14,726	15,609	19,947
9	Kurara Village	Bandongri	13,229	15,609	19,947
10	Bandongri	Mahindra & Mahindra	12,640	15,609	19,947
11	Mahindra & Mahindra	Thakur Complex	11,064	15,609	19,947
12	Thakur Complex	Borivli Bus Stop	9,290	15,609	19,947
13	Borivli Bus Stop	Borivili Omkareshwar	8,368	15,609	19,947
14	Borivili Omkareshwar	Shrinath Nagar	6,528	15,609	19,947
15	Shrinath Nagar	Dehisar	5,660	15,609	19,947
16	Dehisar				



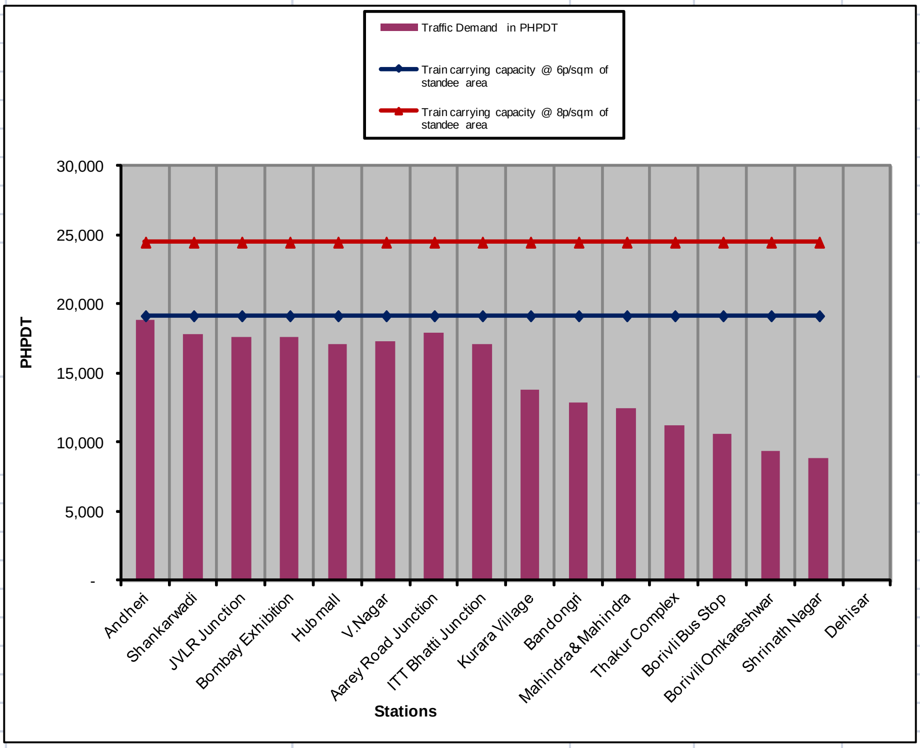
Attachment - I/C

PHPDT Demand and Capacity Chart

Mumbai Metro(Andheri- Dahisar corridor)

Year:	2021
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	5.50

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Andheri	Shankarwadi	**18,860**	19,156	24,480
2	Shankarwadi	JVLR Junction	17,845	19,156	24,480
3	JVLR Junction	Bombay Exhibition	17,587	19,156	24,480
4	Bombay Exhibition	Hub mall	17,587	19,156	24,480
5	Hub mall	V.Nagar	17,090	19,156	24,480
6	V.Nagar	Aarey Road Junction	17,309	19,156	24,480
7	Aarey Road Junction	ITT Bhatti Junction	17,891	19,156	24,480
8	ITT Bhatti Junction	Kurara Village	17,122	19,156	24,480
9	Kurara Village	Bandongri	13,791	19,156	24,480
10	Bandongri	Mahindra & Mahindra	12,843	19,156	24,480
11	Mahindra & Mahindra	Thakur Complex	12,434	19,156	24,480
12	Thakur Complex	Borivli Bus Stop	11,188	19,156	24,480
13	Borivli Bus Stop	Borivili Omkareshwar	10,624	19,156	24,480
14	Borivili Omkareshwar	Shrinath Nagar	9,421	19,156	24,480
15	Shrinath Nagar	Dehisar	8,903	19,156	24,480
16	Dehisar				



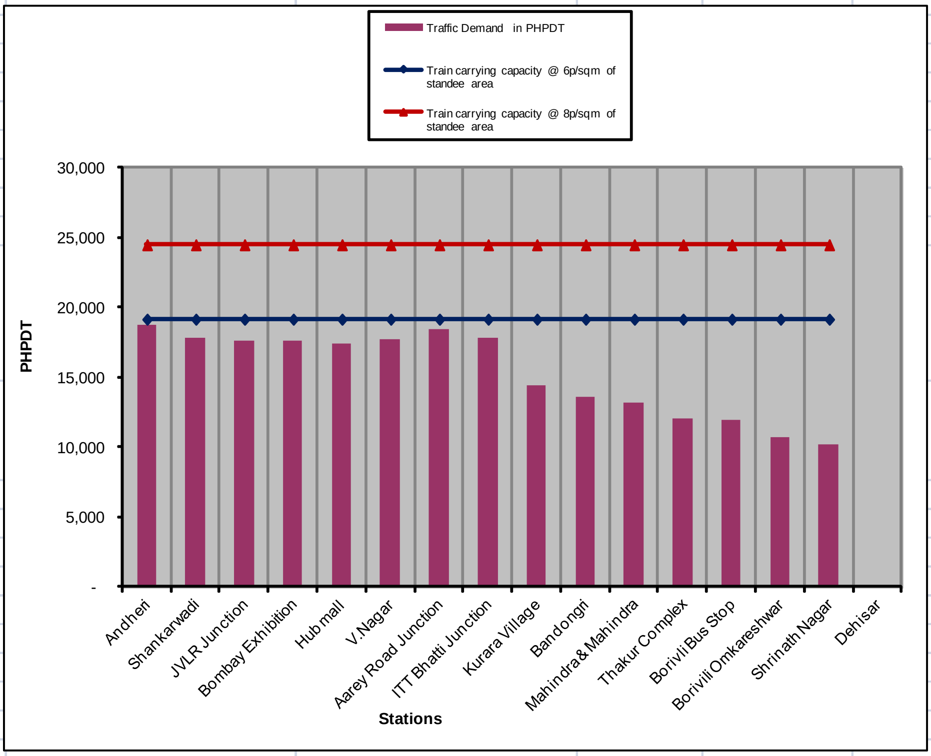
Attachment - I/D

PHPDT Demand and Capacity Chart

Mumbai Metro(Andheri- Dahisar corridor)

Year:	2031
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	5.50

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Andheri	Shankarwadi	**18,752**	19,156	24,480
2	Shankarwadi	JVLR Junction	17,794	19,156	24,480
3	JVLR Junction	Bombay Exhibition	17,636	19,156	24,480
4	Bombay Exhibition	Hub mall	17,636	19,156	24,480
5	Hub mall	V.Nagar	17,383	19,156	24,480
6	V.Nagar	Aarey Road Junction	17,678	19,156	24,480
7	Aarey Road Junction	ITT Bhatti Junction	18,472	19,156	24,480
8	ITT Bhatti Junction	Kurara Village	17,783	19,156	24,480
9	Kurara Village	Bandongri	14,460	19,156	24,480
10	Bandongri	Mahindra & Mahindra	13,607	19,156	24,480
11	Mahindra & Mahindra	Thakur Complex	13,196	19,156	24,480
12	Thakur Complex	Borivli Bus Stop	12,104	19,156	24,480
13	Borivli Bus Stop	Borivili Omkareshwar	11,942	19,156	24,480
14	Borivili Omkareshwar	Shrinath Nagar	10,680	19,156	24,480
15	Shrinath Nagar	Dehisar	10,168	19,156	24,480
16	Dehisar				



Attachment- II

TABLE 6.4
Hourly Train Operation Plan
(Mumbai Metro(Andheri- Dahisar corridor)

Year- 2016

8 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**8**	**8**	**8**
9 to 10	**8**	**8**	**8**
10 to 11	**8**	**8**	**7**
11 to12	10	6	6
12 to 13	11	5	6
13 to 14	12	5	5
14 to 15	11	6	6
15 to 16	11	5	5
16 to 17	10	6	6
17 to 18	**8**	**8**	**8**
18 to 19	**8**	**7**	**7**
19 to 20	**8**	**8**	**8**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**103**	**103**

TABLE 6.5
Hourly Train Operation Plan
(Mumbai Metro(Andheri- Dahisar corridor)
Year- 2019

6.75 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6.75**	**9**	**9**
9 to 10	**6.75**	**9**	**9**
10 to 11	**6.75**	**9**	**8**
11 to12	10	6	6
12 to 13	11	5	6
13 to 14	12	5	5
14 to 15	11	6	6
15 to 16	11	5	5
16 to 17	10	6	6
17 to 18	**6.75**	**9**	**9**
18 to 19	**6.75**	**8**	**8**
19 to 20	**6.75**	**9**	**9**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**109**	**109**

TABLE 6.6
Hourly Train Operation Plan
(Mumbai Metro(Andheri- Dahisar corridor)
Year- 2021

5.5 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	8
8 to 9	**5.5**	**11**	**10**
9 to 10	**5.5**	**11**	**10**
10 to 11	**5.5**	**11**	**10**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	14	5	5
14 to 15	14	5	5
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.5**	**10**	**11**
18 to 19	**5.5**	**10**	**11**
19 to 20	**5.5**	**10**	**11**
20 to 21	8	8	8
21 to 22	12	5	5
22 to 23	16	4	4
Total No. of train trips per direction per day		**133**	**133**

TABLE 6.7
Hourly Train Operation Plan
Mumbai Metro Andheri- Dahisar corridor

Year- 2031

5.5 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	8
8 to 9	**5.5**	**11**	**10**
9 to 10	**5.5**	**11**	**10**
10 to 11	**5.5**	**11**	**10**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	14	5	5
14 to 15	14	5	5
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.5**	**10**	**11**
18 to 19	**5.5**	**10**	**11**
19 to 20	**5.5**	**10**	**11**
20 to 21	8	8	8
21 to 22	12	5	5
22 to 23	16	4	4
Total No. of train trips per direction per day		**133**	**133**

Attachment III

TABLE 6.8

Mumbai Metro(Andheri- Dahisar corridor)

PHPDT for the year 2016

S.No	From Station	To Station	Peak hour Load	Directional Split to Andheri	Directional Split to Dehisar Toll
1	Andheri	Shankarwadi	**12,800**	50%	50%
2	Shankarwadi	JVLR Junction	12,726	50%	50%
3	JVLR Junction	Bombay Exhibition	12,474	50%	50%
4	Bombay Exhibition	Station x	12,474	50%	50%
5	Station x	Hub mall	11,876	50%	50%
6	Hub mall	Aarey Road Junction	12,088	50%	50%
7	Aarey Road Junction	ITT Bhatti Junction	12,751	50%	50%
8	ITT Bhatti Junction	Kurara Village	11,990	50%	50%
9	Kurara Village	Bandongri	9,832	50%	50%
10	Bandongri	Mahindra & Mahindra	8,943	50%	50%
11	Mahindra & Mahindra	Thakur Complex	8,257	50%	50%
12	Thakur Complex	Borivli Bus Stop	6,885	50%	50%
13	Borivli Bus Stop	Borivili Omkareshwar	6,008	50%	50%
14	Borivili Omkareshwar	Shrinath Nagar	5,164	50%	50%
15	Shrinath Nagar	Dehisar	4,718	50%	50%
16	Dehisar	Dehisar Toll	4,718	50%	50%

Attachment IV

TABLE 6.9

Vehicle Kilometer

Year	2016	2019	2021	2031
Section Length	16.80	16.80	16.80	16.80
No of cars per train	6	6	6	6
No of working Days in a year	340	340	340	340
Number of Trains per day each Way	103	109	133	133
Daily Train -KM	3461	3663	4469	4469
Annual Train - KM (10^5)	11.77	12.45	15.19	15.19
Annual Vehicle - KM (10^5)	70.60	74.73	91.17	91.17

Attachment-V

Year-2016

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(8-car configuration)	
1	Mumbai Metro(Andheri-Dehisar Corridor)	16.80	35	2016	8.00	28.80	6	0	6	63.60	8	1	1	10	**60**

Year-2019

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(8-car	
1	Mumbai Metro(Andheri-Dehisar Corridor)	16.80	35	2019	6.75	28.80	6	0	6	63.60	10	1	2	13	**78**

Year-2021

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(8-car configuration)	
1	Mumbai Metro(Andheri-Dehisar Corridor)	16.80	35	2021	5.50	28.80	6	0	6	63.60	12	1	2	15	**90**

Year-2031

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(8-car configuration)	
1	Mumbai Metro(Andheri-Dehisar Corridor)	16.80	35	2031	5.50	28.80	6	0	6	63.60	12	1	2	15	**90**

NOTE Repair & Maintenance Reserve as a percentage of total requirement (Bare + Traffic Reserve) 10%

Chapter - 7

MAINTENANCE DEPOT

7.1 Corridor: Andheri- Dahisar corridor comprises as below:

Corridor	Route length(Km)
Andheri- Dahisar corridor	16.475

7.2 Depot- cum- Workshop at Dahisar

7.2.1 It is proposed to establish one depot- cum- workshop with following functions:

(i) Major overhauls of all the trains.
(ii) All minor schedules and repairs.
(iii) Lifting for replacement of heavy equipment and testing thereafter.
(iv) Repair of heavy equipments.

7.2.2 The Depot planning is based on following assumptions:

(i) Enough space should be available for establishment of a Depot- Cum-workshop.
(ii) All inspection lines, workshop lines, stabling lines are designed to accommodate one train set of 6- Car each and space earmarked for future provision.
(iii) All Stabling lines are designed to accommodate one trains of 6- Car each.
(iv) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere to cater to the required stability facilities.

In broad terms, based on the planned Rolling Stock requirements, this chapter covers conceptual design on following aspects and will work as a guide for detailed design later:

- Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

7.3 MAINTENANCE PHILOSOPHY

- 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 check, “A” checks, “B” type checks, “IOH” and “POH”.
- Labour intensive procedures are kept to the minimum. 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 is given due attention.

7.4 ROLLING STOCK MAINTENANCE NEEDS

7.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 390 kms running per train per day, taking in consideration the passenger load of 2016,2019,2021 & 2031 respectively.

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
“A” Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub - systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
“B” Service Check	15,000 Km (approx. 45 days)	Detailed Inspection of ‘A’ type tasks plus items at multiples of 15,000 Km (‘B’ type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km, (3 and half Years approx.) whichever is earlier	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km, (7 Years approx.) whichever is earlier	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

7.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	Automatic washing plant & cleaning & washing shed

7.5 Year-wise planning of maintenance facility setup at depot cum workshop based on planned Rolling Stock requirement in TOP is tabulated below:

(i) Planned rakes as per TOP:

TABLE-7.3

Year	No. of Rakes	No. of coaches
2016	10	60
2019	13	78
2021	15	90
2031	15	90

ii) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum -Workshop.

Stabling, Inspection and Workshop lines

Year	No. of Rakes	SBLs	IBLs	WSLs
2016	10	8 lines x one train of 6-car	One bay of 2 lines each with one train of 6- cars. One line is required from year 2016 and catering up to year 2019 and 2nd line is required from the year 2021 and catering up to 2031.	One bay of 2 lines each with one train of 6- cars. Two lines are required from year 2016 and catering up to year 2031.
2019	13	11 lines x one train of 6-car		
2021	15	13 lines x one train of 6-car		
2031	15	13 lines x one train of 6-car		

7.6 Requirement of maintenance/Inspection lines for depot-cum-workshop:

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2016 - Maximum no. of rake holding is 10 TS x6 (= 60 Cars)		
'A' Checks (5000 km) approx. 15 days	(10X6) Cars = 60 Cars	1 Line x one train of 6- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(10X6) Cars = 60 Cars	1 Line x one train of 6- Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	
Requirement		1 Bay of 2 lines. One line is required from year 2016 and catering up to year 2019.
ii) Year 2019 - Maximum no. of rake holding is 13 TS x6 (= 78 Cars)		
'A' Checks (5000 km) approx. 15 days	(13X6) Cars = 78 Cars	1 Line x one train of 6- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(13X6) Cars = 78 Cars	1 Line x one train of 6- Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	

Requirement		1 Bay of 2 lines. One line is required from year 2016 and catering up to year 2019.
iii) Year 2021 - Maximum no. of rake holding is 15 TS x6 (= 90 Cars)		
'A' Checks (5000 km) approx. 15 days	(15X6) Cars = 90 Cars	1 Line x one train of 6- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(15X6) Cars = 90 Cars	1 Line x one train of 6- Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	
Requirement		1 Bay of 2 lines. 2nd line is required from year 2021 and catering up to year 2031.
iv) Year 2031 -Maximum no. of rake holding is (15 x6 = 90Cars)		
'A' Checks (5000 km) 15 days	(15 X 6) Cars = 90 Cars	No additional requirement
'B' Checks (15000 km) 45 days	(15 X 6) Cars = 90 Cars	
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	

7.7 Inspection requirements at depot :

Facilities for carrying out inspection activitities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks and "B" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off peak and night. Since "B" checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for "A" checks.

For “B” checks, separate line will be nominated where the rakes may be kept for long time.

7.8 Design of Depot- cum- Workshop Facilities

7.8.1 Stabling lines at depot:

As per advised dimensions of the Rolling Stock, the length of 6- Car train would be Approx. 138 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates lengths have been taken in consideration:

(i) Length of one 6- Car rake= 138 m

(ii) Pathway in the entry side=10m

(iii) Free length at outer ends (for cross pathway, Signal and Friction buffers)= 10m

(iv) Total length of Stabling lines = 10+138+10= 158 m approx .

Looking to the car width of 3200 mm on SG, 5.3 m “Track Centre” is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include 1 m wide pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection with provision of following facilities:

a) Each Stabling line to have water connection facility so that local cleaning, if required, is facilitated.

b) Platforms at suitable points at each end of stabling lines to enable train operators to board or de- board conveniently.

7.8.2 Inspection Bay at depot-cum-workshop:

The length of Inspection shed is computed as below:

(i) Length of one 6- Car rake=138 m

(ii) Pathway in the entry side = 11 m

(iii) Free length at outer ends (for cross pathway, Signal and Friction buffers)= 11m

(iv) Total length of Inspection lines = 11+138+11= 160m approx

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the lines= 7.5 m

(ii) Centre line of outer lines to column of Shed= 3 m

(iii) Width of a 2 line Inspection Bay= 3+ 7.5+ 3= 13.5 approx 14 meter

a) There shall be one inspection bay of 160 m X 14 m size each with provision of accommodating two inspection lines each having sunken floor and overhead roof inspection platforms at each of the line. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m.

b) Roof Inspection platforms of 1.2m width and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. The inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

7.8.3 Workshop Shed at Depot:

Requirement of workshop lines is planned as under:

<table>
<tr><th>Year</th><th>IOH & POH</th><th>Major Overhauling</th><th>Unscheduled repairs /lifting</th><th>Total</th><th>Remarks</th></tr>
<tr><td>2016</td><td colspan="2">1 line of 6-Car train and free space for storage of other equipment.</td><td>1 line x 1 train of 6 Car train length.</td><td rowspan="4">One bays of 2 lines each with one trains of 6-cars is to be required for the year 2016 and catering up to year 2031.</td><td rowspan="4">The size of one workshop bay shall be 160 X 21 m comprising of two lines capable of accommodating one train of 6- Car each with Bogie turn table facility, with free space for storage of wheel/ bogie/ equipments etc.</td></tr>
<tr><td>2019</td><td>-do-</td><td>-do-</td><td>-do-</td></tr>
<tr><td>2021</td><td>-do-</td><td>-do-</td><td>-do-</td></tr>
<tr><td>2031</td><td>-do-</td><td>-do-</td><td>-do-</td></tr>
</table>

(a) There shall be one bay comprising of two lines (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 160m x 21m. The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 6- Car unit simultaneously for quick change of bogie, thereby saving down time of Rolling Stock. The arrangement of jack system shall be such that lifting of any coach in train formation for replacement of bogie/equipments is also individually possible. Space on one line shall be available for stocking of Bogies and wheels. These lines are to be provided with pits at regular intervals for inspection of undercarriage and lines are to be interconnected by turn tables. Each workshop bay shall be equipped with two 15T and 5T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be space provided for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AWo (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 166 x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor
10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs
16. Couplers/Gangways
17. Coach Painting (Applicable only for Aluminum coaches, if any)

7.9 Car Delivery Area

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum- Workshop by rail.

However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

7.10 Operational Features

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

7.11 Infrastructure Facilities

I. Inspection and Workshop facilities:

As indicated in 7.8.2 & 7.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 7.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Annexure I.

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting ‘On’ duty or going ‘Off’ duty can obtain updates regarding ‘Special Notices’, ‘Safety Circulars’ and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 6- Car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

i) Close to the depot entry.

ii) Close to the stabling lines.

iii) Close to the Workshop/IBL.

b) Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated at Para 7.12.1. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given at Paras 7.12.1 & 7.12.2.

7.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.

b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is 'Live'.

c) Multi level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.

d) Pillars in the inspection bay & workshop should have provision for power sockets.

e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.

f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.

g) Control Centre, PPIO & store depot must be close to Workshop.

h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.

i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior of buildings for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

7.12 List of Buildings & List of Plants & Equipments at Depot-cum-workshop

7.12.1 List of Buildings at Depot-cum-workshop:

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	160m x 14m	Servicing of Cars for 15 days & 45 days inspection.
	Workshop Shed	160 x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	166m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	158m x 59m	Provisional for total area as per requirement of stabling of 15 rakes during year 2021 is to be made (with initial provision for 13 rakes only).
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.

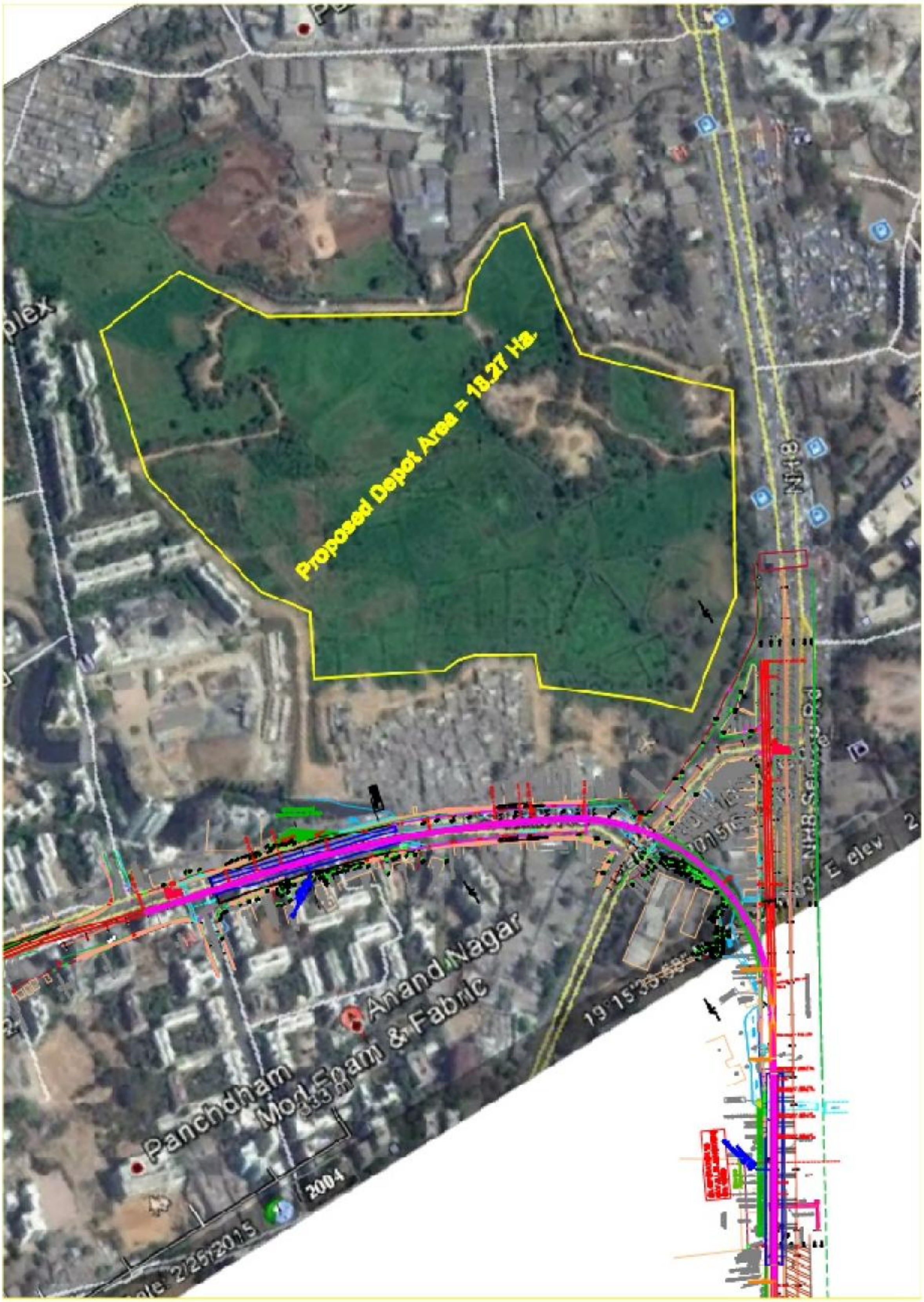
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	60m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	160m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
12.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
13.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
14.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
15.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
16.	Waste Collection Bin	10m x 10m	Garbage dumping

17.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
18.	Work shop Manager Office	30m x 20m	Office of Depot in charge
19.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
20.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
21.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
22.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

7.12.2 List of Plants & Equipments at Depot-cum-Workshop :

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Re-railing equipments	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.

16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	High capacity vacuum cleaner	2	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (including Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools	-	Set
28.	Measuring and testing equipment	-	Set
29.	Tool Kits	-	Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV for carrying of rerailing equipments including container	1	No.
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments	-	Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.
38.	Special jigs and fixtures and test benches for Rolling Stock	1	set
39.	Stackers (1T for DCOS)	2	No.
40.	Storage Racks (W/shop & DCOS stores)	1	Set
41.	Test benches	1	Set
42.	Battery operated platform truck	1	No.
43.	Vehicle mounted crane	1	No.
44.	Impulse Tester for TMs	1	No.
45.	Bearing puller	1	No.
46.	Truck	1	No.
47.	Wheel profile meters	1	No.
48.	High rise work lift platform(HRWP)	1	No.
49.	Video Diagnostic equipments for traction motor	1	No.


Proposed Depot Area = 18.27 Ha.
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Anand Nagar
Panchdham
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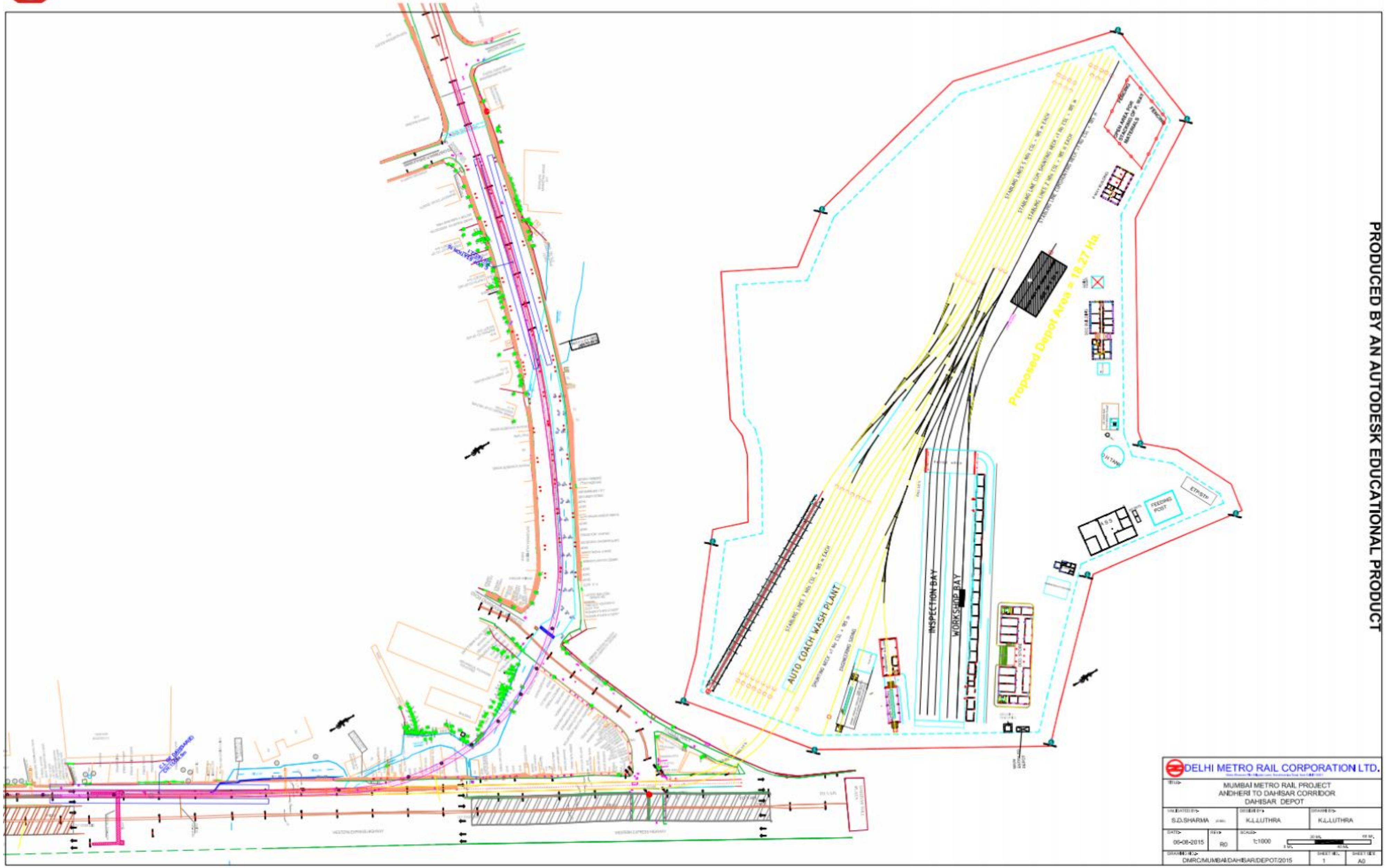
Proposed Depot Area = 18.27 Ha.
INSPECTION BAY
WORKSHOP BAY
AUTO COACH WASH PLANT
FEEDING POST
ETP/STP
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
DELHI METRO RAIL CORPORATION LTD.
MUMBAI METRO RAIL PROJECT
ANDHERI TO DAHISAR CORRIDOR
DAHISAR DEPOT
S.D.SHARMA
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Chapter - 8

POWER SUPPLY ARRANGEMENTS

Power supply is the lifeline of Metro System

8.1 Power Requirements

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, 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. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 80 KWh/1000 GTKM
(ii) Regeneration by rolling stock – 30%
(iii) Elevated/at –grade station load – initially 250 kW, which will increase to 500 kW in the year 2031
(iv) Depot auxiliary load - initially 2000 kW, which will increase to 2500 kW in the year 2031.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2016, 2019, 2021 and 2031 are summarized in table 8.1 below:

Table 8.1 Power Demand Estimation (MVA)

Corridor	Load	Year			
		2016	**2019**	**2021**	**2031**
Andheri to Dahisar 16 Stations (16.48 km)	Traction	7.74	9.30	10.83	11.06
	Auxiliary	7.41	9.70	10.69	12.97
	Total	**15.15**	**19.00**	**21.52**	**24.03**

The detailed calculations of power demand estimation are attached at annexure 8.1

8.2 Need for High Reliability of Power Supply

The proposed Mumbai metro system is being designed to handle about 19,641 passengers per direction during peak hours when trains are expected to run at 5.5 minutes intervals. 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 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.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220, 110 or 66 kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

8.3 Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in brief. The city has 220, 110 and 66 kV network to cater to various types of demand in vicinity of the proposed corridors.

Keeping in view the reliability requirements, two Receiving Sub-stations are proposed to be set up for the line. This is an economical solution without compromising reliability. It is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations of TATA Power Company Limited at 110 kV voltage through cable feeders:

Table 8.2 Sources of Power Supply

	station (GSS) (Input voltage)	of RSS of Metro Authority	ength cables from GSS to RSS
Andheri to Dahisar 16 Stations (16.48 km)	10 or 66 kV Grid Sub Station (GSS) Near Andheri	Andheri Station	confirmed by TATA Power
	rid Sub Station (GSS) Near Dahisar	Dahisar Depot	confirmed by TATA Power

Tata Power company have assured that reliable power supply from their 110 kV Borivli Sub-station will be provided for Dahisar Depot RSS (Annexure – 8.2) and for Supply of Andheri RSS, a letter No. DMRC/Elect/Mumbai/2015, dated 04.08.2015 has been sent to TATA Power Company for confirmation of source of power supply (Annexure – 8.3). In view of this, during the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 8.3.

Table 8.3 – Power Demand projections for various sources

Corridor	**Input Source**	Peak demand – **Normal (MVA)**		**Peak demand** – Emergency (MVA)**	
		Year (2016)	Year (2031)	Year (2016)	Year (2031)
Andheri to Dahisar 16 Stations (16.48 km)	**RSS Near Andheri Station**				
	Traction	3.04	4.42	7.74	11.06
	Auxiliary	2.47	4.94	7.71	12.97
	Sub-total (A)	**5.51**	**9.36**	**15.15**	**24.03**
	RSS Near Dahisar Depot				
	Traction	4.70	6.63	7.74	11.06
	Auxiliary	4.94	8.04	7.71	12.97
	Sub-total (B)	**9.64**	**14.67**	**15.15**	**24.03**
	Total (A+B)	**15.15**	**24.03**		

** Incase of failure of other source of power

The 110 kV power supply will be stepped down to 33 kV level at the RSS's of metro authority. The 33 kV power will be distributed along the alignment through 33 kV Ring main cable network for feeding traction and auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of One RSS of the line on fault or input supply failure, train services can be maintained from stand-by source of the same line. But if one more RSS fails, only curtailed services can be catered to. 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. However, no train services can be run with power supply received from DG Sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well, except for the train running.

Typical High Voltage Receiving Sub-station

The 110 kV cables will be laid through public pathways from TATA Power Sub-stations to RSS of Metro Authority. RSS Near Andheri Station shall be provided with 2 Nos. (one as standby) 220 or 110 or 66/ 25 kV, 15 MVA (ONAN) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 220 or 110 or 66/ 33 kV, 15 MVA (ONAN) three phase Transformers for feeding auxiliary loads and RSS Near Dahisar Depot shall also be provided with 2 Nos. (one as standby) 110/ 25 kV, 15 MVA (ONAN) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 110/ 33 kV, 15 MVA (ONAN) three phase Transformers for feeding auxiliary loads. The capacity of transformers may be reviewed considering the load requirement/distribution of both the corridors at the time of detailed design.

Conventional Outdoor type 110 kV Switchgear is proposed for all the RSS to be located in approx. 100 X 80 m (8000 sq. m) land plot as the availability of Land in this area may not be a constraint. If Gas Insulated Switchgear (GIS) type Switchgear will be planned in future due to less space and reduced maintenance the capital cost need to be enhanced. 110 kV GIS substation land requirement will be approx. 60 X 70 m (4200 sq. m). In that case the cost of sub-station works will increase by nearly Rs. 10 Crores per 110 kV RSS with respect to conventional substation.

8.4 Various options of Traction system:-

There are three options available for power supply system for MRTS:-

- 25 kV & 2X25 kV AC Overhead Catenary system
- 750 V DC third rail system
- 1500 V DC Overhead Catenary system

A sub- committee set up by "Ministry of Urban Development" on Traction system for metro railway has studies various aspects of merits and demerits of various traction system. The following are the highlights of Report:-

Merits and Demerits of various traction systems

a) **25 kV AC with OCS (Flexible/rigid):-Merits**

- **Reduced cost** – Unlike dc traction this system, does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in cost. Cost of 25 kV AC traction systems is about 30% less as compared to 750V DC 3rd rail traction system.
- **Energy regeneration & line losses-** Energy regeneration is more than 30% in 25 kV AC traction system as compared to 18% in 750V DC 3rd rail traction system. In 25 kV AC traction system line losses are 12% less as compared to 750V DC 3rd rail traction system
- **Cost of rolling stock-** The cost of rolling stock & maintenance cost of traction system are comparable.
- **Capacity** – The system can cater to traffic needs even in excess of 75000 PHPDT, which, however, is restricted on account of other constraints.
- **Easy of capacity enhancement** – Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation.
- **Higher efficiency of operation** – The efficiency of regeneration is substantially more than DC systems and line losses are very less of the order of 5%. 100% recovery of regenerated energy is possible in the case of 25 kV AC traction compared to a figure of 75% in the case of 1500 V DC systems and 60% in the case of 750 V DC systems.
- **Less Fire hazards**-AC system poses lesser fire hazards as current levels are much lower than DC system.

- **Stray current** - There are no problem of stray currents and hence nearby metallic structures are not affected by corrosion. However there are problems of EMC / EMI which can be controlled by using return conductor & screened cables in signaling applications & fiber optic cable in telecommunication system without using booster transformer as per recent developments. This also helps in avoiding use of booster transformer which causes 2% line loss and excessive voltage drops besides involving maintenance & reliability issues.
- Traction equipments in 25 kV AC system are standardized & mostly indigenously available.
- Though in underground section higher side tunnel diameter because an issue but this is not the case here.

b) **600-850 V DC third rail traction system:-Demerits**

- **High operating currents and High voltage drops necessitating reduction in spacing of sub-station-** This leads to larger voltage drops along the Third Rail distribution system, which necessitates closer spacing of sub- stations at an interval of almost every 2 Km, leading to higher costs of construction.
- **Low levels of regeneration-** 60% of re-generated energy in a 750 V DC system is possible to be retrieved.
- **Safety hazards with use of high voltage at ground level-** Due to existence of the "live" third rail at ground level, this system can be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.
- **Line losses-** Line losses are more due to higher current. Transmission line losses on 750 V DC traction system are around 21% as against 5% of 25 kV AC traction system.
- **Phenomenon of stray current-** In a third rail system, where the running rails are used as a return path, a part of the return current leaks into track structure. This current is called stray current. It is necessary to manage the stray current to ensure minimal corrosion effect and consequent damages to metallic components in the track structure as well as metallic reinforcement and metal pipes of building of metro and public areas adjacent to the Metro alignment.

c) 1500 V dc system with Overhead Catenary System:-Demerits

- Higher maintenance requirement and costs as compared to 750V DC third rail system.
- Theoretical traffic capacity with 1500 V traction system is less as compared to 25 kV AC system.
- Line losses are more due to higher current as compared to 25 kV AC. It may be in the range of 10 to 12% as against 5% of 25 kV AC system.
-

In view of above techno-economic considerations, 25 kV AC traction system is recommended.

8.5 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

25 kV AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors –Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated via duct 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 25 kV OHE and the elevated viaduct.

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 plan will be required to be developed during project implementation stage.

8.6 Auxiliary Supply Arrangements for Elevated Stations

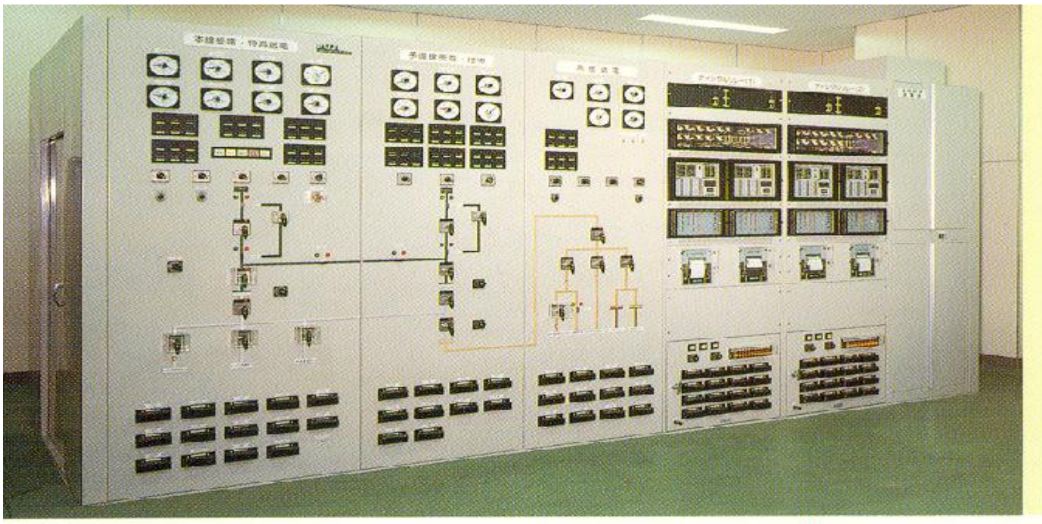
Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 500 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415 kV) of 630 kVA capacity are proposed to be installed at the stations (one transformer as standby).

8.7 Auxiliary Supply Arrangements for DEPOT

The Following major plant and machinery are to be provided in Depot:-

- RRV for carrying re railing equipments
- Road vehicles (pick up van/ truck)
- Flat wagon for carrying material.
- Diesel/Electric battery powered locomotive with traction battery charger.
- Under floor Pit wheel lathe, chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe.
- Travelling O/H crane workshop 15T/3T,1.5T capacity(IBL),ETU shed 5T crane
- Mobile Jib crane
-

A separate ASS is required at the depot. The Depot ASSs will also be provided with 2x2500 kVA auxiliary transformers.



Typical Indoor Auxiliary Sub-station

8.8 25 kV AC Flexible Overhead Equipment (OHE) system

25 kV AC flexible OHE system shall comprise 107 sqmm silver copper contact wire and 65 sq.mm Cd-copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be All Aluminum Conductor (AAC) of 93.3 sq.mm cross section. For tensioning of OHE, ATD shall be a mix of spring ATD (50%) and 5 pulley ATD (balance 50%) spring ATD shall not be having counterweight and shall be provided at critical location like road crossing etc. 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, and expected power demand during emergency, RSS Near Andheri Station shall be provided with 2 Nos. of (One to be in service and one as standby) 220 or 110 or 66 /25 kV, 15 MVA Traction Transformers for feeding traction load and 2 Nos. of (One to be in service and one as standby) 220 or 110 or 66/33 kV, 15 MVA three phase transformers for feeding auxiliary loads. RSS Near Dahisar Depot shall also be provided with 2 Nos. of (One to be in service and one as standby) 110/25 kV, 15 MVA Traction Transformers for feeding traction load and 2 Nos. of (One to be in service and one as standby) 110/33 kV, 15 MVA three phase transformers for feeding auxiliary loads. The incoming cable shall be 3-phase single core XLPE insulated with 630 mm^2 Aluminum conductors to meet the normal & emergency loading requirements and fault level of the 110 kV supply.

33 kV and 25 kV switchgear shall be rated for 1250 A being standard design. 33 kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of Single core 150 mm^2 FRLSH Aluminum conductor cable XLPE insulated 33 kV cable is proposed for ring main network.

Adequate no. of cables are required for transfer of traction power from Metro's RSS to 25 kV OHE. Single-phase XLPE insulated cables with 240 mm^2 copper conductor are proposed for traction power. Based on current requirements, 2 cables are required for each of the two circuits to feed power to 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 for better accuracy during design stage of project implementation.

8.10 MV/LV System

Following major E&M Equipments/system shall be required for elevated stations:-

- MV/LV panels
- DG set
- UPS & Battery system
- Lifts
- Escalators
- Fire suppression and detection system
- Lights & fans
- Air conditioning system
- BMS system
- Lightning protection system
- Earthing system

Panels shall be front operated front access cubical type indoor duty floor mounted totally enclosed dust and vermin proof with neoprene gaskets fabricated from CRCA sheet with powder coated finish suitable for 415 V 3 Phase 4 wire 50 Hz system.

8.11 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 a standby DG set of 180 kVA capacity at the elevated stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

8.12 Solar Photo Voltaic (PV) Power system

In DMRC solar PV power system are installed at various sites in RESCO (Renewable Energy Service Company) model. In Dwarka sector-21 station 500KWp solar PV power system has been installed in RESCO model.

Solar PV Power panel

"RESCO Model" means where the developers intend to provide solar power system on rooftop/sites owned by DMRC on mutually agreed terms and conditions from DMRC and enters into the PPA (Power purchase agreement) with DMRC for supply of Solar power for 25 years from the date of Commissioning of project.

In elevated stations about 50KWp to 100KWp capacity of Solar PV power system can be provided depending upon type of roof availability, shadow free roof area, orientation of stations. In DMRC receiving sub-station 50KWp capacity Solar PV system are generally provided. In DMRC Depot area, approx.1000KWp Solar PV can be provided. Solar PV system in station parking area can also be planned.

8.13 Sewage Treatment System using Integrated Constructed wetlands (ICW)

Following are the objectives for providing Sewage Treatment System using Integrated Constructed Wetlands (ICW):-

1) To establish an effective option for treatment of wastewater that is generated from campus.
2) Establish an onsite treatment solution which is effective and cost effective option without producing any by products.
3) To establish a sustainable and environmental friendly solution with minimal maintenance.
4) The treated water can be reused for various non-portable applications landscaping, flushing and cleaning.

The objective of Constructed Wetlands is to utilize the decomposable organic matter present in sewage, which can be disposed of into the environment without causing health hazards or nuisance. The degree of treatment to be adopted would meet the regulatory agencies (surface water discharge standards).

Constructed wetlands (CW) are complex and modular system provides an efficient and sustainable purification treatment method that is applicable to practically all pollutant sources and in all climate and environmental conditions. CW relies on Constructed Wetlands, and is based on the activity of plants together with microorganism communities in the root zone. Together they degrade, accumulate, extract, and volatilize contaminants of all kinds in water, soil and the air, resulting in clean and purified outflow.

In DMRC Faridabad RSS 1 KLD capacity Sewage Treatment System provided through integrated constructed wetland method.

8.14 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 fiber 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 33 kV AC switchgear, transformers, 25 kV 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.

8.15 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 benefit 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 25 kV AC OHE 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 (day or night, 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.

(viii) LED lights to be used in the station area and Depot area.

8.16 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 45.97 million units in initial years (2016), which will be about 67.80 Million Units in the 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 110 kV voltage level) plus nominal administrative Charges i.e. on a no profit no loss basis. The power tariff of Maharashtra Electricity Regulatory Commission for TATA power Company, FY 2015 – 16 demand charges Rs 200/ kVA per month and energy charges Rs 7.63/ kWh. Therefore it will be in the about **Rs 8.46 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. Similar approach has been adopted for Delhi Metro.

MUMBAI METRO									ANNEXURE - 8.1
ANDHERI TO DAHISAR									
POWER REQUIREMENT									**(25 kV AC TRACTION SYSTEM)**
S.No	**Particulars**	**Year 2016**		**Year 2019**		**Year 2021**		**Year 2031**	
A	**Traction Power Requirements**	1	2	3	4	5	6	7	8
1	No. of cars	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)
2	Passenger Weight	145.9	T	145.9	T	145.9	T	145.9	T
3	Train Tare Weight	251.68	T	251.68	T	251.68	T	251.68	T
4	Total Train Weight	397.5	T	397.5	T	397.5	T	397.5	T
5	Section Length	16.48	KM	16.48	KM	16.48	KM	16.48	KM
6	Headway	8.0	mts	6.5	mts	5.5	mts	5.5	mts
7	Specific Energy Consumption	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM
8	No. of Trains/hr in both directions	15	Nos.	18	Nos.	22	Nos.	22	Nos.
9	Peak Traction Power Requirement	7.86	MW	9.67	MW	11.43	MW	11.43	MW
10	Less Regeneration @ 30%	2.36	MW	2.90	MW	3.43	MW	3.43	MW
11	Depot Power Requirements	1.50	MW	1.65	MW	1.80	MW	2.00	MW
12	Total Traction Power Requirement	7.00	MW	8.42	MW	9.80	MW	10.00	MW
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**7.74**	**MVA**	**9.31**	**MVA**	**10.83**	**MVA**	**11.06**	**MVA**
B	**Aux. Power Requirements**								
1	Elevated/at-grade Station Power Consumption	0.25	MW	0.35	MW	0.40	MW	0.50	MW
2	Underground station Power Consumption	2.00	MW	2.25	MW	2.25	MW	2.50	MW
3	No. of Elevated/at-grade Stations	16	Nos.	16	Nos.	16	Nos.	16	Nos.
4	No. of Underground stations	0	No.	0	No.	0	No.	0	No.
5	Total Station Aux Power Requirement	4.0	MW	5.6	MW	6.4	MW	8	MW
6	Depot Aux Power Requirement	2.00	MW	2.25	MW	2.25	MW	2.50	MW
7	Total Aux Power Requirement	6.0	MW	7.9	MW	8.7	MW	10.5	MW
	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for aux loads	**7.41**	**MVA**	**9.70**	**MVA**	**10.69**	**MVA**	**12.97**	**MVA**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**15.15**	**MVA**	**19.00**	**MVA**	**21.52**	**MVA**	**24.03**	**MVA**
Note: The requirement of PD load is not consided in estimation of power calculation.									

MUMBAI METRO									ANNEXURE - 8.1 A
ANDHERI TO DAHISAR									
ENERGY CONSUMPTION									(25 kV AC TRACTION SYSTEM)
S.No.	**Year**	**Year 2016**		**Year 2019**		**Year 2021**		**Year 2031**	
A	**Traction Energy**	1	2	3	4	5	6	7	8
1	Section Length	16.48	KM	16.48	KM	16.48	KM	16.48	KM
2	No. of Trains per direction in a day*	103	Nos.	127	Nos.	133	Nos.	133	Nos.
3	Weight of Train & Passenger	397.5	T	397.5	T	397.5	T	397.5	T
4	SFC (NET) with 30% regen	56	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM
	Yearly Traction Energy consumption with 365 days working with 30% regen	**27.58**	**million units**	**34.00**	**million units**	**35.61**	**million units**	**35.61**	**million units**
B	**Station Aux. Energy**								
1	Elevated/at-grade Station	0.25	MW	0.35	MW	0.40	MW	0.50	MW
2	Underground Station	2.00	MW	2.25	MW	2.25	MW	2.50	MW
3	No. of Eevated/at-grade Stations	16	Nos.	16	Nos.	16	Nos.	16	Nos.
4	No. of Underground Stations	0	No.	0	No.	0	No.	0	No.
5	Total Station Aux. Power Requirement	4.0	MW	5.6	MW	6.4	MW	8.0	MW
6	Depot Aux power requirement	2.0	MW	2.25	MW	2.25	MW	2.5	MW
7	Total Aux. Power Requirement	6.0	MW	7.9	MW	8.7	MW	10.5	MW
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	**7.41**	**MVA**	**9.70**	**MVA**	**10.69**	**MVA**	**12.97**	**MVA**
9	Diversity Factor of Aux. loads	0.40		0.40		0.40		0.40	
	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**18.40**	**million units**	**24.07**	**million units**	**26.52**	**million units**	**32.19**	**million units**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**45.97**	**million units**	**58.07**	**million units**	**62.13**	**million units**	**67.80**	**million units**

Note: The requirement of PD load is not consided in energy calculation.

ANNEXURE – B-2

TATA

4th February, 2010
CDD / LR-N 4040 / 13674

SPAN Consultants Pvt. Ltd.
C-505 to 508, Kukreja Centre
Sector 11, CBD Belapur
Navi Mumbai 400 614

Kind Attn: Mr R S Gupta
Sr Associate Director

Dear Sir,

Sub: Mumbai Metro Rail Project Phase II & III – Requirement of power supply to two Metro Corridors

With reference to your letter No SCPL/ MUM/ C-843/ MMRDA / 40 dated 2nd February, 2010 we agree to supply the load from our Borivli and Malad 110kV Substation as per your requirements. The approx. cost of making available this power supply at Charkop and Dahisar Receiving Substations will be issued after conducting technical feasibility and preparation of cost estimate.

Tariff as approved by MERC from time to time will be applicable and copy of the tariff for FY10 is attached herewith for your perusal.

Thanking you and assuring you of our best attention at all times,

Yours faithfully,
THE TATA POWER COMPANY LTD.

4/2/2010
(H D THAKER)
CHIEF MANAGER

Encl: As above

TATA POWER
The Tata Power Company Limited
Consumer Development and Engineering Department Technopolis Knowledge Park Mahakali Caves Road Andheri East Mumbai 400 093
Tel 91 22 5668 8357 5668 8360 Fax 91 22 5668 8363
Registered Office Bombay House 24 Homi Mody Street Mumbai 400 001

Annexure – 8.3

CIN : U74899DL1995GOI068150

दूरभाष Tel. : 23417910/12
फैक्स Fax : 23417921

दिल्ली मेट्रो रेल कॉर्पोरेशन लि0
DELHI METRO RAIL CORPORATION LTD.
(भारत सरकार एवं दिल्ली सरकार का संयुक्त उपक्रम)
(A JOINT VENTURE OF GOVERNMENT OF INDIA AND GOVT. OF DELHI)

No. DMRC/Elect/Mumbai/2015 Date: 04.08.2015

To

Chief Manager,
Tata power Company Limited
Consumer Development and Engineering Department
Technopolis Knowledge Park
Mahakali Caves Road, Andheri East
Mumbai 400 001
Fax: 91 22 5668 8363

Sub: Power Supply Requirement for New Metro Corridor from Andheri to Dahisar (16.48 Km length).

Ref: Chief Manager, TATA Power Company Limited, letter No. CDD/LR-N 4040/13674, dated 4th February, 2010 (Copy enclosed).

Dear Sir,

In reference to above, Mumbai Metropolitan Region Development Authority (MMRDA) has requested to Delhi Metro Rail Corporation for preparing DPR for New Metro Corridor from Andheri to Dahisar with 16.48 Km length, 16 stations.

In view of the above, it is required to provide the power (66kV or above) from grid Sub – Station along the route where the metro authority will lay their own feeders up to Receiving Sub – Station (RSS), and step it down to 33 kV for auxiliary Load which will be distributed along the alignment through 33 kV Ring main cable network and step it down to 25 kV for traction purpose.

For this purpose, two bays for each Receiving Sub – Station (RSS) of 66 kV or above will be required for the corridor close to the alignment.

S. No.	Corridor	Receiving Sub-station	Power Demand in MVA (Tentatively)				Remarks
			2016	2019	2021	2031	
01	Andheri to Dahisar (16.48 Km	At Dahisar Depot	15.00	19.00	22.00	24.00	Vide above letter TATA has confirmed power supply from

Page 1 of 2

	length, 16 stations)						Borivali 110 KV substation
		Near Andheri station	15.00	19.00	22.00	24.00	

In view of above, it is requested that source locations close to alignment along the route may please be allocated at the earliest. Need be a meeting may kindly be arranged as per your convenience to finalize the issue this month.

Thanking you,

Yours faithfully

Encl: Index Plan

(A K Singh)
Executive Director/ Electrical – II
Fax No. 23417920

CHAPTER 9

ENVIRONMENTAL IMPACT ASSESSMENT

9.1. INTRODUCTION:

With the widening gap between the available amenities and Infrastructure and the humongous requirement of such facilities for the ever increasing population, Transport Infrastructure Development has become the biggest challenge for the Mumbai Metropolitan Development Authority (MMRDA).

Adoption of the land use policies proposed by MMRDA for the development of the region will arrest further deterioration of the urban environment and will facilitate a sustainable Development and growth.

With ever increasing migration (presently 350-400 per day) of poor rural families from various parts of India to Mumbai to satisfy their aspirations for a better life, it is not possible for the city to grow horizontally. Therefore vertical dense growth is the only viable alternative for the Development and Growth of this great Metropolis which is undisputedly the Financial Capital of India.

Transportation being the most vital element that effect normal life in Mumbai, any deficiency, in the infrastructure related to Transportation, seriously affects the productivity and economic growth of the city.

Car-besotted and flyover-obsessed Mumbai needs an alternate transport system which will be greener, safer, faster and non-polluting-in other words people friendly and environment friendly. As sufficient and timely investment was not made in the past on the development of an efficient alternate transport infrastructure, the presently available network of Suburban Railways and the Road Transport System has been stretched to the crisis levels. In order to effectively augment the present Transport Systems MMRDA has conceived the idea of Metro Railway Network.

9.1.1 Metro Railway System:

Metro Railway System is undoubtedly a technically and economically viable alternative transport system, provided it is designed and operated in a passenger friendly and eco-friendly manner providing the much desired comfort and safety for the passengers. Appreciating the major constraint posed by the prevailing land use pattern, MMRDA has conceived the idea of building the Metro Rail lines on elevated platforms above the existing trunk road ways to facilitate Mass Rapid Transportation of Passengers in MMRDA area which covers the Island city of Mumbai and its suburban towns

9.2 PROJECT DESCRIPTION:

9.2.1 General Advantages of Metro Railway System:

i Higher carrying capacity (50 seat+325 standing=375 per standard Coach) compared to road transport. (Equivalent to 7 lanes of bus traffic or 24 lanes of motor car traffic)

ii Higher speed (maximum speed of 80km/hr irrespective of normal time or peak time compared to bus and other road traffic which literally snarls during peak time.)

iii Smooth ride as it is not affected by other vehicles, pedestrians etc. (Travel in jam packed buses is very rough.)

iv Safer compared to road transport in Mumbai where road accident rate is very high.

v Occupies less land space as the Metro runs on elevated tracks which are supported on pillars; each pillar occupying a ground space of approximately 2M x 2M only. Elevated Metro Rail occupies only 2M width of the road space.

vi No gaseous, liquid or solid pollution as the Metro railway is run on clean energy viz. electricity which does not emit any pollutant during the operation.

vii Lower noise pollution compared to equivalent capacity of road transport. (By virtue of the state of the art technology applied for construction of the coaches and the track and by virtue of high elevation of the track (>7M) the noise nuisance caused by the Metro is far less compared to the road transport. (Noise levels of the modern Metro Rail Coaches and the track at the source is expected to be < 60 dBA.

viii Energy efficient (energy consumption per passenger km is only 20% of the energy consumed by the road based transport system).

ix Lower journey time (lower by 50-70% of the time taken by road traffic, depending on road conditions).

(A distance of approximately 16.0 km from Andheri (E) to Dahisar (E) with 16 halts at stations will be covered in just 30 minutes at an average speed of 32 km/hr.)

Thus Metro Railway, when compared to any Road Transport System in Mumbai, has high carrying capacity, higher speed, higher energy efficiency, better reliability, higher passenger comfort level and higher safety Index. It is also user friendly and eco-friendly.

9.2.2 Salient Features of Elevated Metro Railway:

The proposed metro rail will be running along the service road of the Western Express Highway on pillars that will be constructed on pile foundation there-by covering minimum of the road area. By and large, the land space available in the road is proposed to be used conveniently for the Metro also, thereby avoiding the most difficult task of acquisitioning of a large area of land for the metro separately. However some government land encroached / occupied by slum settlement will have to be procured for the construction of station and other passenger facilities and certain length of the ROW.

- It ensures minimum impact on the road transportation under the metro rail line.
- Running the Metro Rail line along the trunk roads enables the passengers to interchange from a feeder mode of road transport or Monorail to the Rapid Mass Transport Railway mode as per their requirement and convenience.
- Elevated Metro Railway System is one of the most viable transport systems, provided it is designed and operated in a user friendly and eco-friendly manner providing the much desired comfort and safety for passengers. MMRDA has chosen to build a network of Metro Railway lines on elevated platforms essentially above the ROW of existing Roads, in an Environmental friendly manner in order to facilitate Rapid Mass Transportation Infrastructure to solve the transportation problems of people of the BMRDA area which covers the Island city of Mumbai and its Suburban Towns.

9.2.3 Alignment of the Andheri (E)-Dahisar (E) Sector:

The Andheri (E)-Dahisar(E) Corridor (Corridor No 7 as per the MMRDA master plan for Mumbai Metro) starts from chainage 0.00, which is about 50m North of Metro Line No.1, Versova-Ghatkopar at the East side of Western Express Highway at Andheri (E). The corridor starts on East side of WEH and changes to Express Highway just after Andheri (E) proposed station and thereafter runs on West side up to Dahisar.

Western Express Highway and the Service road there off was well planned, well designed, well laid out and beautifully developed as a Green Field Road Infrastructure project by MMRDA. The Metro line is aligned to run essentially along the slip road/ service road for the entire length of the ground level road from

Andheri (E) to Dahisar (E). However for the length of the alignment from 8075m to 8350 and the Bandongiri slum area the service road is non-existent because of high depression of the terrain. In these segments of the alignment the metro line will have to be erected on viaducts constructed on the low level land on the West side of the Express Highway.

9.3 ENVIRONMENTAL QUALITY- BASELINE DATA:

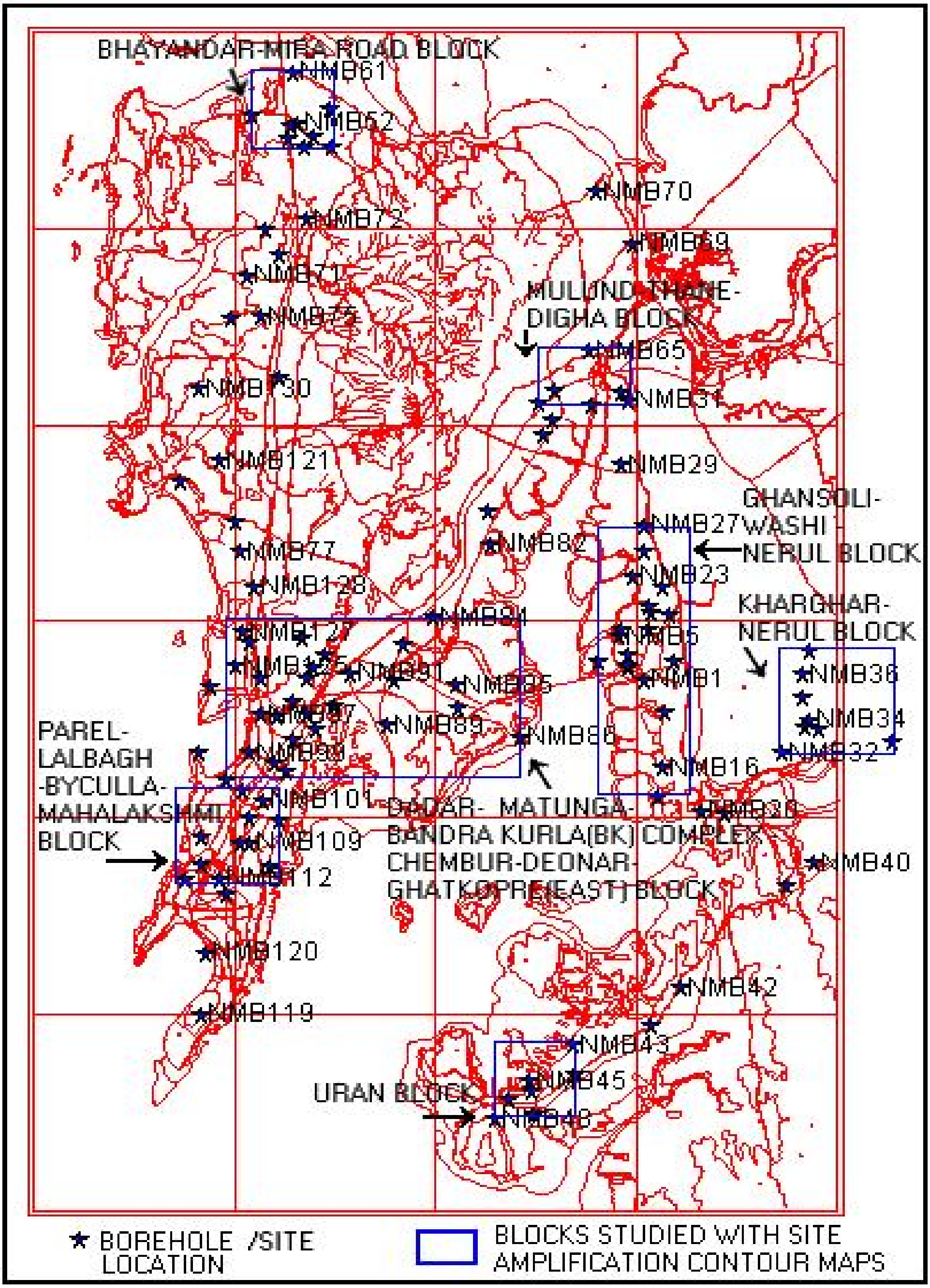
9.3.1 Meteorological Data for Western Suburban Mumbai:

Primary meteorological data collected by India Meteorological Department (IMD) from the Santacruz station is representative of western suburb where the Metro Railway-Phase-II is proposed to be constructed. In the summer month of March, 2009 the Avg. Maximum temperature was 34.3^{0}C; while the Avg. Min Temperature was 21.8^{o}C.In the winter month of December the Avg. Maximum temperature was 32.8^{o}C; while the Avg. Minimum temperature was 16.2^{o}C.Mumbai receives rains essentially for 3 months starting from June and the annual average rain fall is 2146.6 mm for the Island city and 2457 mm for the suburbs. A maximum rain fall of 950.5 mm was recorded at Santacruz in July month of 2009, which is 35 % of the total annual rainfall. Occasional cloud burst has resulted in abnormally high daily rainfall of about 300 mm, which in conjunction with high tide condition, has caused serious flooding conditions which Mumbai has experienced several times in the past. Mean humidity at 0830 hrs varies from 68% to 87 %.

9.3.2 Seismicity of the Region:

Geological Survey of India has carried out an important scientific study on Geotechnical mapping of the Mumbai region with special reference to fault lines and consequential Earth quake hazards. On the basis of the data published as a report entitled “Seismic Hazard and Risk Micro-zonation of Mumbai Area”, Mumbai is falling in the range of Seismic Zone- Category III & IV. Seismicity map for Mumbai region is given in Annexure 9.3.1.

Map – 3.1
Seismic Microzonation Map



9.3.3 Geotechnical (Subsoil) Investigation by Bore-Logging:

9.3.3.1 Soil Analysis:

29 Trial bores were drilled at selected location along the Andheri–Dahisar alignment by M/s OCE projects Pvt. Ltd to investigate the subsoil composition and to evaluate engineering properties of soil and to determine the load bearing capacity of the founding strata. Laboratory tests and standard penetration tests were conducted on rock and soil samples to evaluate engineering characteristics. Bore logs were prepared as per IS-5313. Grain size Analysis of soil samples was done as per IS-2720 (Part-IV). Undisturbed Soil Samples were tested for field density moisture content as per I.S.2720 (Part-II). Chemical Analysis of the soil was done as per IS/APHA methods for criteria parameters as per standard analytical procedures. Results are tabulated in Table 9.3.1.A & Table 9.3.1.B.

Table- 9.3.1.A Chemical Analysis of Soil

Sr. No.	BH NO.	Depth(m)	PH	Sulphates (ppm)	Chlorides (ppm)
1.	BH – 12	3.50	7.16	345	810
2.	BH – 13	4.50	7.29	390	765
3.	BH – 14	2.50	7.47	350	820
4.	BH – 15	2.50	7.38	315	845
5.	BH – 16	3.50	7.22	320	720
6.	BH – 17	3.50	7.49	365	765
7.	BH – 18	3.50	7.26	370	8115
8.	BH – 19	3.50	7.38	325	860
9.	BH – 20	3.50	7.31	340	835
10.	BH – 21	3.50	7.49	335	795
11.	BH – 22	3.50	7.33	360	805
12.	BH – 23	4.50	7.29	315	840
13.	BH – 24	3.50	7.77	325	745
14.	BH – 25	3.50	7.36	370	780
15.	BH – 26	3.50	7.29	345	695
16.	BH – 27	3.50	7.22	380	810
17.	BH – 28	3.50	7.41	340	735
18.	BH - 29	4.00	7.53	355	770

Table 9.3.1.B

Chemical Analysis of Soil

Sr. No.	**Test Parameters**	**Soil Samples**					***Units***	**Test Method**
		Chainage -16200 BH No.- 12	Chainage -11475 BH No.- 17	Chainage -7820 BH No.- 21	Chainage -4520 BH No.- 25)	Chainage -100 BH No.- 29)		
1.	**pH (10% Solution)**	6.7	6.9	6.9	6.8	6.7	--	APHA
2.	Total Kjeldhal Nitrogen	479	733	433	708	746	mg/Kg	APHA
3.	Phosphorous	98	57	62	39	62	mg/Kg	APHA
4.	Potassium	2837	3174	2836	3221	3242	mg/Kg	AAS
5.	Calcium	106	113	126	104	88	mg/Kg	APHA
6.	Magnesium	72	117	102	95	94	mg/Kg	APHA
7.	Sodium	108	156	137	142	124	mg/Kg	AAS
8.	Organic	2.9	4.8	2.96	1.55	2.6	%	APHA

Chainage is measured from Andheri end of the alignment in (m)

9.3.4 Water Quality:

Water samples collected from 4 locations along the alignment were subjected to chemical analysis and the results are tabulated in Table 9.3.2.A and Table 9.3.2.B. As the locations are close to the sea/creek, the water samples indicate high salinity and TDS which is normal. Salinity of the soil will be considered while designing and constructing the pile foundation for the pillars.

Table 9.3.2.A

Chemical Analysis of Water Samples

Sr. No.	**BH. NO.**	**pH**	**Sulphates(ppm)**	**Chlorides (ppm)**
1.	BH – 12	7.82	425	955
2.	BH – 13	7.46	460	1050
3.	BH – 14	7.79	405	1030
4.	BH – 15	7.64	395	1020
5.	BH – 16	7.73	485	945
6.	BH – 17	7.55	430	1065
7.	BH – 18	7.81	410	1025
8.	BH – 19	7.92	450	985

Sr. No.	BH. NO.	pH	Sulphates(ppm)	Chlorides (ppm)
9.	BH – 20	7.68	485	920
10.	BH – 21	7.59	460	965
11.	BH – 22	7.61	435	1015
12.	BH – 23	7.53	420	1005
13.	BH – 24	7.84	455	990
14.	BH – 25	7.91	480	950
15.	BH – 26	7.99	495	965
16.	BH – 27	7.83	415	915
17.	BH – 28	7.75	440	980
18.	BH - 29	7.88	455	1050

Table 9.3.6.B

Chemical Analysis of Water

Sr. No.	Test Parameters	Samples of Water					Units	Test Method
		Chainage 182000 BHNo.- 12	Chainage 11476 BHNo- 17	Chainage 7820 BHNo- 21	Chainage 4520 BHNo-25	Chainage 100 BHNo-29		
1.	**Calcium**	35	31	26	40	31	mg/l	APHA
2.	Magnesium	27	35	24	24	27	mg/l	APHA
3.	Sodium	160	300	130	215	105	mg/l	AAS
4.	Potassium	72.29	104.82	50.60	54.22	37.35	mg/l	AAS
5.	Total Kjeldhal Nitrogen	12	27	15	12	9	mg/l	APHA
6.	Phenol	Absent	Absent	Absent	Absent	Absent	mg/l	APHA
7.	Copper	BDL	BDL	BDL	BDL	BDL	mg/l	AAS
8.	Nickel	BDL	BDL	BDL	BDL	BDL	mg/l	AAS
9.	Lead	BDL	BDL	BDL	BDL	BDL	mg/l	AAS
10.	Zinc	BDL	BDL	BDL	BDL	BDL	mg/l	AAS
11.	Chromium	BDL	BDL	BDL	BDL	BDL	mg/l	AAS
12.	Cadmium	BDL	BDL	BDL	BDL	BDL	mg/l	AAS

Chainage measured from Andheri end of the alignment (m)

9.3.5 Air Quality:

9.3.5.1 Ambient Air Quality Monitoring along the Andheri-Dahisar Alignment:

Four locations, along the Andheri(E)-Dahisar(E) alignment, at approximately equal spacing were chosen by an MPCB recognized laboratory, as fixed stations for 24 hour mass sampling for of ambient air for analysis for criteria pollutants. The results are tabulated in Table 9.3.3.

Table 9.3.3

Ambient Air Quality Monitoring at Selected Locations along Andheri (E)-Dahisar (E) Alignment

Parameter	Results at Selected Locations				National AAQM Std.	Unit	Method
	Andheri –E BMC Office Ch-50m Parking area in front of Crystal Tower Building	Goregaon-E Kama Estate Ch-4500m Near Jay Enterprises	Kandivili-E Bandongri Area Ch-8800m Btween ISA Glass & CNG Gas Station	Borivili-E Magothane Tel. Ex.Rd Ch-11300m Near Magothane Exchange Bus Stop			
Total Suspended Particulate Matter(SPM)	320	285	270	210	500	µg/m3	IS-5182 (part- 4)
Respirable Particulate Matter (RSPM)	105	80	85	80	150	µg/m3	IS-5182 (part- 4)
SO_2 Conc.	20	12	16	14	120	µg/m3	IS-5182 (part- 2)
NOx Conc.	88	78	80	72	120	µg/m3	IS-5182 (part- 6)

9.3.5.2 Observations on Ambient Air Quality Monitoring Results:

Results obtained from AAQM done at 4 locations along the Andheri-Dahisar alignment indicate that the pollution levels for all the criteria pollutants like SO_2, NO_X, SPM_{10} and $SPM_{2.5}$ are within the permissible limits as per the National AAQ Standards. Air Pollution is caused mainly by the Road Transport. Even though the traffic density on the Western Express Highway is very high, the movement of traffic in the 8 lane- Express Highway is quite fast and smooth, thanks to the existence of many flyovers and under passes at all the important inter-junctions. With the construction of infrastructure facilities like Flyovers, Metro Railway lines, Sky walks, concreting of roads etc and the redevelopment of residential buildings, the western suburb, in general, is witnessing a big transformation for the better. However, the road traffic along the service road is slow as it is not well regulated. The high Ambient SPM level and RSPM level along the service road are likely to continue till the construction activity is completed and alternate Rapid Mass Transport Systems like the Metro Railway commence operation.

9.3.6 Dust Pollution:

Suspended Particulate Matter (SPM_{10} & $SPM_{2.5}$) levels were monitored for 24 hours at different locations along the Andheri-Dahisar alignment. The results are presented in Table 9.3.3.

9.3.6.1 Dust Pollution –Observations:

Average SPM level was found to be 271.0 µg/m3 as against the National Standard of 500 µg/m3 and Average RSPM level was found to be 133.75 µg/m3 as against the National Standard of 150 µg/m3. Dust pollution levels in all the locations are found to be within the permissible limits as per the National Standards. In the Mumbai Suburb, road traffic causes maximum dust pollution and noise pollution. Alternate Mass Transport Systems like Metro Railway and Monorail, which are motivated by clean energy, are undoubtedly the best solutions for the menace of Air Pollution in general and Dust Pollution in particular.

9.3.7 Noise Pollution:

9.3.7.1 Base line Noise Levels:

Round the clock Noise Level measurements were made on 2-3 April, 2010, using Sound Level Meter Model No.325 Solano 03070509, certified by NABL accredited lab, on 18-09-2009(Certificate No. CC/ECL/641/09-10). Every reading was taken as a 3 minute average. The noise levels measured at various locations are tabulate in Table 9.3.4.

Table No 9.3.4
Noise Level (dBA) at different locations along the Andheri-Dahisar Alignment (April 2010)

(Noise measurement was done along the service road on the west side of the Western Express Highway)

Location	6-8 hrs	8-10 hrs	10-12 hrs	12-14 hrs	14-16 hrs	16-18 hrs	18-20 hrs	20-22 hrs	22-24 hrs
Andheri	72	76	78	80	80	78	85	82	80
Jogeshwari	74	77	78	82	80	84	87	84	80
Jogeshwari (NSE Gr.)	72	73	77	75	78	78	85	86	78
Goregaon	75	70	72	80	81	83	85	80	80
Dindoshi	70	73	80	80	82	80	83	85	78
Malad	75	78	77	80	82	80	81	80	76
Kanthivli	76	78	75	76	78	80	82	82	80
Borivli	77	80	80	77	79	78	80	80	78
Dahisar	68	72	76	78	78	76	78	80	75

The Noise Level varied in the range of 70-87 dBA during the day time when the traffic density is high. Even during the night time the noise level remained above 57.5 dBA. At the peak time when traffic density was the highest, a maximum noise level of 87dBA was recorded at Jogeshwari.

It is important to note that the base line noise level at any time of the day along the Andheri(E)-Dahisar(E) service road of the Express Highway is normally higher than the permissible levels of 55 dB (A) (day) and 45 dB (A) (night) applicable for residential area as per the National Standards mainly due to the continuous movement of automobiles on the Express Highway. It is higher than the levels applicable to even commercial areas (65dBA).

9.3.8 Compliance with the Coastal Regulation Zone (CRZ) Rules:

The Andheri(E)-Dahisar(E) Metro Rail line passes through a fully developed urban area. At no point, the line touches the Coastal Regulation Zone. Minimum distance from the high tide line is more than 3 km. even at the nearest water front. Development of the Western Express Highway itself had complied with the CRZ rules. As the Metro Rail line passes essentially through the service road of the Express Highway, the conditions of compliance applied for the Highway are applicable to the Metro Rail line also.

Observations

Even though all the relevant elements have been considered during the collection of the Base line Environmental data, Air Quality, Dust nuisance and Noise Pollution and to a great extent Flora are the elements which are likely to be impacted by the project to various degrees of significance. A qualitative assessment of the impacts of the project on various elements of Environment during the construction stage and during the operation stage is presented in the Environment Management Plan.

9.4 REHABILITATION AND RESETTLEMENT OF PROJECT AFFECTED PEOPLE:

9.4.1 Rehabilitation:

The report on Socio Impact Assessment including Rehabilitation and Resettlement is being submitted separately.

9.5 ENVIRONMENT MANAGEMENT PLAN:

9.5.1 Environmental Impact Identification and Recommended Remediation Plan:

Environmental Impact Identification and Recommended Remediation Measures to be adopted to minimize the negative impacts during the Construction stage is summarized in three tables via Table 9.5.1(a). Similarly, Environmental Impact Identification and Recommended Remediation Measures to be adopted to minimize the negative impacts during the Operation stage also are summarized in Table 9.5.1(b).

Table 9.5.1 (a)

Environmental Impact Identification and Recommended Remediation Measures during Construction

Sr No	Environmental Element	Possible Impacts	Severity of Impact	Remediation Suggested	Residual Impact
1	Topography	Land is fully developed. Alignment along the Service Road of the Western Express Highway. Road space is partially used for the construction of	Insignificant	After construction the obstructions will be removed.	Each pillar to occupy 2mx2m land space

Sr No	Environmental Element	Possible Impacts	Severity of Impact	Remediation Suggested	Residual Impact
		pillars			
2	Climate	GHG emission from machinery, Heat dispersed effectively by sea breeze	Minor	Use PUC certified and Fitness Certified Fuel efficient new machines	Minor
3	Road Traffic Diversion	6m wide portion of the road will be isolated to facilitate piling, construction of foundation & Pillars.	Significant	Develop the sides of the Service Road to effect safe diversion of traffic. Restore the road to the original condition after construction. Ensure circular (unidirectional) movement of transport vehicles	Minor 2Mx2M space occupied by pillars at every 25 m.

Sr No	Environmental Element	Possible Impacts	Severity of Impact	Remediation Suggested	Residual Impact
4	Air Quality-A Dust Nuisance	Dust Pollution Levels SPM_{10} (210-320 $\mu g/m^3$) & $SPM_{2.5}$ (80-105$\mu g/m^3$) are within limits as per the National Quality Standards of 500 &150 respectively. During the Construction dust emission is likely to be high. It is a health hazard to the workers and the exposed public	Significant	Isolate the work area by constructing partitions of minimum 5 m height on the west side of the road. Provide dust barriers on the partition to prevent spread of dust. Provide Personnel Protective Equipment (PPE) to the workers. Excavated soil and Debris should be transported in properly covered trucks to the designated disposal site.	Minor
5	AIR quality-Criteria Pollutants such as SO_2, NO_x etc	AAQM results indicate the concentration of pollutants within	Significant 'No Project Option' will be	Only PUC certified, Fuel Efficient and Fitness certified new machines to be used for construction.	Significant but it is temporary. Considering

	as per CPCB	acceptable limits. Machinery operated with fossil fuel will emit criteria pollutants during the construction period. Air pollutants are health hazards which affect national economy	severe	Avoid, Fabrication of Steel structures, production of RCC structural components like, Girders, columns, platforms, staircases, lifts etc at the site. Fabricating them off-site and assembling them at the site will minimize Air Pollution, Dust Pollution and Noise Pollution.	the Importance of the project, this Temporary Impact is acceptable
6	Noise Pollution	Noise level varied from 68-87 dBA at all the locations along the Express Highway where the road traffic is very high most of the time. It exceeds the levels specified by CPCB, for residential area. During construction the noise level emitted by the machines will exceed permissible limits.	A major Health Hazard to the workers. Moderate health hazard to general public	Provide suitable noise barriers in the sensitive areas. Provide PPE like Ear plugs & Mufflers to the workers and enforce the use of it. Provide sound proof cabins for the machine operators. Periodic Health Monitoring including Audiometry of workers Use new low Noise Electrical Machines. Minimize/ Avoid the use of reverse alarms for heavy mobile machines. Avoid/ minimize the use of Vibro-hammers. All machines to be fitted with approved mufflers.	Significant Temporary. Considering the Importance of the project, Temporary Impact is acceptable

7	Flora	223 trees (native, not exotic) are to be transplanted & 30 trees are to be trimmed. Greenery Index of the region defined as the ratio of the number of people to the number of trees is 5.25 which is very low (good) for a city like Mumbai. The number of trees transplanted is only 0.04% of the total number (5, 68,499) of trees in the region as per tree census.	Highly Adverse	Try to transplant as many of the 223 trees as possible. Compensatory forestation of 2230 trees in 1 hectare of secured plot and nursing / protection of the plants for 5 years.	Moderate
8	Fauna	No Impact. No life sanctuary /zoo in the region	Nil	Not Applicable	Nil
9	Archeological/ Historical Monument	Nil	Nil	Not Applicable	Nil
10	Place of Worship	Few small temples exist. No Impact	Nil	Save 3 major places of worship by excluding them in the design of Station facilities and Alignment	Insignificant

Table 9.5.1(b)
Environmental Impact Identification and Recommended Remediation Measures during Operation

Sr No	Environmental Element	Possible Impacts	Severity of Impact	Remediation Suggested	Residual Impact
1	Topography	Land is fully developed. Alignment along the Service Road of Western Express highway, on Elevated Viaduct	Insignificant	Provide crash wall protection. Beautify the Crash walls and Noise Barriers.	Nil
2	Climate	No GHG emission. Heat from Air Conditioning gets dispersed by sea breeze	Insignificant	No Action	Insignificantly Adverse
3	Road Traffic Diversion	Flyovers at all road junctions. Pillars act as minor obstruction at intervals of 25m.	Minor Adverse impact	Provide safety barriers	Insignificantly Adverse
4	Air Quality-& Dust Nuisance	Dust Pollution Levels SPM $_{10}$(210-320 µg/m^3) & SPM $_{2.5}$ (64-84µg/m^3) are within limits as per the National Quality Standards of 500 &150 respectively. During the Operation no significant dust emission is expected as the Trains run on electric energy on elevated platform.	Insignificantly Adverse	No Action	Insignificantly Adverse

Sr No	Environmental Element	Possible Impacts	Severity of Impact	Remediation Suggested	Residual Impact
5	AIR quality-Criteria Pollutants such as SO_2, NO_x etc as per CPCB	AAQM results indicate the concentration of pollutants within acceptable limits. Metro Railway is normally operated on the main supply of electricity. Diesel Generator is providing for emergency operations only at stations. Frequency of use of standby source of energy very low. Air pollutants from the generator exhaust are health hazards.	Insignificant-ly Adverse	Generators with Green Label, BEE rating for Energy efficient and Eco friendly to be installed at safe distance from residential, sensitive and commercial locations.	Insignificant & temporary negative impact. Considering the Importance of the project, this Temporary Impact is acceptable
6	Noise Pollution	Base Line Noise level varied from 68 dBA to 87 dBA at different locations. During Operation of the Metro Rail the noise level emitted by the machines and the tracks will exceed the permissible limits of 55 dBA (day) and 45 dBA (night). In few residential locations, the target population is located at a horizontal distance <50m	Moderate health hazard to general public	Provide suitable noise barriers in the sensitive areas. Use Low Noise Electrical Machines.	Slightly Adverse. Considering the Importance of the project, slightly negative Impact is acceptable

Sr No	Environmental Element	Possible Impacts	Severity of Impact	Remediation Suggested	Residual Impact
7	Flora	Greenery Index of the region defined as the ratio of the number of people to the number of trees is 5.25 which is very low (good) for a city like Mumbai.	Moderately Adverse residual impact because of transplantation of trees	Continue to maintain the forestation effort.	Slightly Adverse
8	Fauna	No Impact. No life sanctuary /zoo in the region	Nil	Not Applicable	Nil
9	Archeological/ Historical Monument	Nil	Nil	Not Applicable	Nil
10	Place of Worship	A Few small places of worship exist. No Impact	Insignificantly Adverse	Temples Isolated	Insignificantly Adverse

9.5.2 Observations:

A study of the impact of the project on different elements of the Environment indicates that many remediation measures are required to be taken during the construction stage of the project for the control of Air Pollution, Dust Nuisance and Noise Pollution and for the protection of the transplanted tree and compensatory forestation for a small loss of Greenery along the Andheri-Dahisar alignment.

A similar study for the operation stage has indicated the only environmental elements which are adversely impacted by the operation of the Metro Railway are the Noise Pollution and de-rooting of trees. The effect of the Metro Railway Operation on all other environmental elements is only insignificantly or slightly adverse.

'No Project Option' will be extremely adverse as far as Air Pollution, Noise Pollution and Dust Pollution are concerned. Increase in the capacity of road transport that will have to be added to match the capacity of the Metro Rail will cause so much more of pollution, health hazard to the general public and

Environmental damage and that it would not be tolerable and hence would not be acceptable for the inhabitants of the Metropolis.

9.5.3 Waste Management:

Improper or incomplete management of waste and hygiene has serious implications on the quality of environment and on the quality of life of the citizens. Therefore due attention is required to be given to waste management during the construction and operation of the Metro.

9.5.3.1 Waste Management during Construction:

The Soil excavated during the construction of the foundation of the pillars is the main source of solid waste spillage and dust nuisance. Loading, Transportation and unloading of the waste should be done without any exposure, spillage and dust emission.

9.5.3.2 Waste Management during Operation:

Electric coaches will not generate any gaseous/ liquid/solid effluent during operation. Assuming a solid waste generation rate of 3 gm/passenger/day (source-RITE) each station is likely to generate 72 Kg/day of refuse. The characteristics of such waste are non-hazardous requiring no special pretreatment. Waste collection bins should be provided in every station and waste should be disposed off regularly into the Collection Bin provided by BMC in the near vicinity.

9.5.3.3 Liquid Waste:

Water effluent generated during floor washing should be collected and disposed off in to storm water drain through an oil separator.

As toilet or wash rooms are provided inside the stations, waste water generated during the operation will have to be discharged through pipe line into sewage collection line provided by BMC along the service road.

During repair, regular maintenance, painting, washing, cleaning etc solid, liquid and gaseous effluents are likely to be generated.

All the Environmental Protection laws and rules of MPCB and Maharashtra Government Factories Act/Rules, Labor Welfare Rules etc. applicable to any Engineering Industry will be applicable for the workshops and the design, construction and operation of these sections of the project should strictly comply with these rules.

9.5.4 Compliance with the Coastal Regulation Zone (CRZ) Rules:

The Andheri(E)-Dahisar(E) Metro Rail line passes through a fully developed urban area. At no point, the line touches the Coastal Regulation Zone. As the Metro Rail line passes essentially through the service road of the Express Highway, the conditions of compliance applied for the Highway are applicable to the Metro Rail line also.

9.6 IMPACT IDENTIFICATION AND PREDICTION:

This chapter deals with Impact of the project on various elements of the Environment and Prediction of severity of the impact.

9.6.1 Impact on the Topography:

The terrain of the study area is essentially plain as it is already developed by MMRDA as the Western Express Highway. The project will not have any impact on the Topography of the region

9.6.2 Impact on Climate:

No fossil fuel is used for the operation of the Metro Railway, therefore the project will not cause any Green House Gas Emission and Carbon Foot Print in the region. Emission of heat from the engine and the Air conditioning system is not high enough to cause any significant rise in ambient temperature.

9.6.3 Impact on Air Quality:

As no combustion of any fuel is done normally (except during any failure of supply of power from the grid when Diesel generator will be started to mitigate emergency), no gaseous pollutant is likely to be emitted due to the operation of electrically operated Metro Railway.

'No Project Option' will be extremely adverse as far as Air Pollution, Noise Pollution and Dust Pollution are concerned. Capacity of the road transport that will have to be added to match the capacity of the Metro Rail will cause a manifold increase in Air Pollution, which would not be acceptable for the inhabitants of the Metropolis.

As the Metro Railway is elevated above the ground it is not likely to cause Dust Pollution. **No Project Option** in this case also is adverse as an equivalent capacity of road transport will generate very high loads of Respirable and Non-respirable Suspended Particulate Matter (RSPM & SPM) which can cause acute health hazards to the people. Air Pollution has serious negative impact on health care expenditure, productivity and overall economy of the country.

Even during the construction stage most of the prefabricated structural components except the support pillars, which are cast in situ, are transported to the site from the manufacturing site located away from the metro line and they are assembled locally. However machinery used for pile foundation and the cranes used for lifting and erecting the components will be operated with fossil fuels and emission of some combustion products emitted by these machine is likely to cause some temporary Air Pollution. A minor increase in SPM, NO_x and $CO_2$is expected around the area of the construction which gets shifted progressively as the construction progresses. Compared to the load of pollution caused by the road transport and other human activities in the region, this temporary source of pollution is not significant. As such this pollution is restricted to the construction time only and not during the regular operation and hence it may be accepted in the larger interest of Infrastructure Development.

9.6.4 Impact on Water Environment:

Insignificant quantity of domestic waste water generated by the passenger facilities will be connected to the main sewage collection system of BMC.

Small quantity of waste water (non toxic, but polluted by Suspended Solids) generated during the civil construction, will be discharged to the storm water drain safely.

Waste Water generated in the Depot, where cleaning, servicing, repair, painting etc will be done is likely to be contaminated with Oil, Grease, Paint, Suspended Solids etc. This water will have to be either treated at the site as per the Maharashtra Pollution Control Board (MPCB) norms or transported to MPCB approved Hazardous Waste Management Facilities following all the procedures given in the Environment Protection Rules of Government of India. Proper records should be maintained for generation, treatment, quality assurance and disposal of waste water.

9.6.5 Impact on the Land Environment:

During the operation of the Metro Railway hardly any solid waste of hazardous nature is generated. Domestic waste materials like paper, plastic bottles, discarded tickets etc collected from the waste bins and floor sweepings will have to be disposed off into the Green Waste Collection Bins provided by BMC at various locations.

During the construction stage the solid waste generated by land excavation, wasted construction materials etc is not hazardous and hence it is transported away from the site of construction to the designated sites for dumping debris hygienically in covered trucks/dumpers. No Air Emission that can contaminate land is likely to be generated during the construction and operation of Metro Railway.

As no toxic or hazardous liquid waste is generated during the construction or operation of the Metro Railway any waste water disposed off to the storm water drain is not likely to contaminate the land.

9.6.6 Impact on the Noise Environment:

Noise level in the area is already higher than the Noise Levels Permitted by CPCB norms, due mainly to road transport and other human activities. During the running of the Metro also noise is expected to be emitted at regular intervals. It can be minimized by providing technological solutions.

The proposed high speed Metro Railway should be designed and constructed using modern state-of the- art – technology to effect minimum Air and Noise Pollution.

In case of the **No Project Option**, an equivalent capacity of road transport that would carry the same number of passengers as the metro railway would generate very high level of noise nuisance. Noise emission from the Metro Railway designed and constructed as per the State of the Art technology during the normal operation is only 60 dBA which is insignificant considering the base line Noise Level in the range of 60-90 dBA. However, the application of noise barriers at the critical/ sensitive locations will reduce the Noise Level at the target locations.

9.6.6.1 Impact on Sensitive Establishments:

Few Sensitive Establishments like Hospitals, Educational Institutions and Residential buildings are located on the West side of the Service Road.

A list of Sensitive Target Buildings on the basis of activities is given below in Table 9.6.1. Estimation of Area to be provided with Noise Barriers and the cost of providing Noise Barriers is given also in Table 9.6.2.

Table 9.6.1

List of Sensitive Targets

Sr. No	Name	Location	Chainage from Andheri(E) (m)	Approx. Distance from Central line & Corrective action
1	Dhiraj Vihar & Dhiraj Apartments	North of STN-2	1540-1665	10m. Provide noise barrier
2	Anand Hospital &Dr. Rane Hospital	Jogeshwari Near Ismail Yusuf College Bus Stop	2025-2075	12m. Provide noise barrier
3	Primary Marathi School	Jogeshwari	2595-2625	10m. Provide noise barrier
4	Hospital under construction	Jogeshwari	2650-2700	10m. Provide noise barrier
5	Shah Arcade Apartments G+7	Malad	7300-7400m	5m.Provide noise barrier
6	Sai Ashish Hospital+ Residences	Kanthivili North of Thakur Complex Rd	10210-10260	15m. Provide noise barrier
7	Residences Sri Sai Dham, Sri Shakthi Dham, Sri Shani Dham	Kanthivali	10885-10940	<5m. Provide noise barrier
8	Gayatri & vasant Marvel buildings G+8	Magothane Near STN-11	11200-11330	10m. Provide noise barrier
9	Residences above Toyoto Showroom	STN-14	14450-14500	Very close to Platform. Provide Noise Barrier

Table No 9.6.2

Estimation of Area & Cost for Providing Noise Barrier

Sr. No	Sensitive location To be protected with noise barrier	Chainage M	Length M	Area Lx(H=3) m^2	Total Cost Ax @ Rs10,000/m^2 Rs
1	Dhiraj Vihar & Dhiraj Apartments	1540-1665	**125**	**375**	
2	Anand Hospital &Dr. Rane Hospital	2025-2075	**50**	**150**	
3	Primary Marathi School	2595-2625	**130**	**390**	
4	Hospital under construction	2650-2700	**50**	**150**	
5	Shah Arcade Apartments G+7	7300-7400	**100**	**300**	
5	Sai Ashish Hospital+ Residences	10210-10260	**50**	**150**	
6	Residences Sri Sai	10885-10940	**55**	**165**	

Sr. No	Sensitive location To be protected with noise barrier	Chainage M	Length M	Area Lx(H=3) m^2	Total Cost Ax @ Rs10,000/m^2 Rs
	Dham,Sri Shskti Dham,Sri Sani Dham				
7	Gayatri & vasant Marvel buildings G+8	11200-11330	**130**	**390**	
8	Residences above Toyoto Showroom	14450-14500	**50**	**150**	
	Total		**740**	**2,220**	**2,20,00,000 220 lacs**

9.6.7 Impact on Flora:

The area under consideration falls under the green zone which is characterized by a high degree of tree cover. Low human-tree ratio (5.25) indicates a very high population density of trees. Displacing/ transplanting of 223 trees which forms a negligible fraction (0.04%) of the total number of trees existing in the area is not likely to affect the green cover of the area significantly. However, it is mandatory to transplant the existing trees in a scientific manner in any open area that would be suggested by BMC. Compensatory plantation of 2230 extra trees will more than compensate for the loss of greenery due to transplantation of trees to clear the corridor for the construction of the Metro line.

9.6.7.1 **Action Plan for Mitigation of Impact on Flora:**

Action Plan for mitigation of Impact on Flora is given in Table 9.6.3 given below.

Table 9.6.3

Action Plan for Protection of Trees

Sr No	Action	Number of trees	Follow-up action	Mitigation
1	Transplantation/ cutting of Trees from the sides of the road	223	Watering, Protection for 5 years	Compensatory plantation of 2230 new trees of the same type or any type suggested by BMC/ MPCB
	Total No. of trees to be Transplanted	**223**		
2	Trimming (cutting the branches of trees existing on the West side of the Service road	30	Watering, Protection for 5 years	
3	**Total**	**253**		

9.6.8 Impact on Fauna:

The Andheri- Dahisar Alignment does not pass through any wild life sanctuary or zoo. There is hardly any wild life other than the commonly found birds in the vicinity of the alignment and the project is not likely to have any impact on the life of these birds. Therefore the project is not expected to endanger any Fauna.

9.6.9 Impact on Public Health and Hygiene:

Even though the elevated alignment of the Metro Railway runs along the service road, land adjacent to the service road on the west side of the service road is required to be acquisitioned to facilitate the construction of pillars and portals for the stations, the support columns for facilities such as the stations, entry, exit etc. Hundreds of families live in these highly congested slums under extremely unhygienic and inhuman conditions with limited or no access to clean drinking water and public toilets, compelling them to use the service roads and footpaths as open public toilet. Congestion and lack of public health facilities make the baseline public health and hygiene element of the Environment pertaining to the area Extremely Adverse as these places are most vulnerable to epidemics such as Malaria, Dengue, Swine Flu, Gastro Enteritis, Diarrhea etc.

Implementation of the Metro project will necessitate at least partial evacuation of these illegal encroachments. It will result in the up-gradation of the Index of the environmental element of Public Health and Hygiene of the region from Extremely Adverse to Moderately Beneficial.

Therefore, the project will have a Positive Environmental Impact.

9.6.10 Impact on Socio Economic Environment:

There are some encroachment of the government land on the west side of the service road which necessitates economic evaluation, compensation and relocation of the encroachers. Shifting the poor people living in subhuman conditions in the slums a resettling them modern flats with all facilities such as clean drinking water, electricity, proper toilet facility etc in hygienic location will change the life style of those people and make them less susceptible to disease and suffering. Up-gradation of the economic environment of these people will result in improvement in the economy of the city and the nation.

Implementation of the project is likely to improve the prospects of economic activity of the region and appreciation of land value and property value all along the Metro Railway line. The project will predominantly have positive impact on the socio-economic environment.

9.6.10.1 Cost of Rehabilitation and Resettlement for Project Affected People:

Extent of R&R has been assessed and the total funds to the tune of Rs.58 crores has been provided in the cost.

9.6.11 Impact on Cultural and Religious Institutions:

Considering sensitivity attached to the places of worship like mosques and temples many station facilities like platform have been designed to accommodate such institutions in the present location by appropriate planning.

9.6.12 Slum Redevelopment Plan of MMRDA:

A few of the large clusters of hutments in the government land along the alignment are being taken over by developers for redevelopment under Slum Redevelopment Scheme. Kama Estates Area, in which Hub Mall station is proposed to be constructed, is reported to be in the process of acquisition by a developer. The layout of the redevelopment project can be designed to accommodate the station in the proposed location. Similarly the area earmarked for Kurur Village station is also reported to be under Slum Redevelopment Scheme. Most of the encroachment has been vacated and the balance is being vacated by the developer.

9.7 EVALUATION OF TOTAL ENVIRONMENTAL IMPACT BY METRIX METHOD:

9.7.1 Introduction:

Impact of the project on different elements of the environment has been discussed separately in the foregoing sections of this chapter. Total score of the environment impact of this important Infrastructure Project can be obtained by aggregating all the individual impacts. Even though such an aggregation involves a certain degree of subjectivity, a rationalized procedure based on logic, experience and expertise can minimize the subjectivity. A simple and reliable procedure of **'Modified Matrix'** used by National Environmental Engineering Research Institute (NEERI) is applied for assessing the aggregate impact.

9.7.2 Modified Matrix Procedure:

Matrix Procedure involves establishing 'cause -effect relationship' and assigning Parameter Impact Value (PIV) against each identified parameter. After assigning the PIVs, the values are distributed among all cause effect relations established between the project activities by means of indices called 'Relative Parameter Importance Indices (RPII). RPII is proportional to the importance of the particular cause and effect relationship.

9.7.3 Environment Impact Index (EII):

Environment Impact Index (EII) is a quantitative index in a scale of 0 to 1 of the qualitative indication of the extent of environmental impact due to any associated cause. Table 9.7.1 gives EII for both Beneficial Environmental Impacts & Adverse Environmental Impacts. While the beneficial impact takes a positive sign, the adverse impact takes a negative sign.

Table 9.7.1
EII for Environmental Impacts

Impact Magnitude	EII – Beneficial Impact	EII – Adverse Impacts
No Change	0.0	0.0
Insignificant	0.1	(-) 0.1
Slight	0.2	(-) 0.2
Moderate	0.3	(-) 0.3
Significant	0.6	(-) 0.6
High	1.0	(-) 1.0

9.7.4 Cause and Effect Relationship:

The whole project is broadly divided into many activities and the impact of these activities on various elements of environment such as ground water, air quality etc are indicated qualitatively in **Table No 9.7.2** (Refer Annexure-7.1)

9.7.5 Parameter Importance Value (PIV):

Importance of various Impact Components such as ground water, air etc are estimated on the basis of the ranking assigned to the component and the weighting given to these components. Total PIV being 1000 the part of the PIV attributed to each Impact component is calculated. The values of PIV derived for each component is given in **Table 9.7.3** (Refer Annexure-7.1)

9.7.6 Relative Parameter Importance Indices (RPII):

After assigning the PIVs, the values are distributed among all cause-effect relations established between the project activities by means of indices called 'Relative Parameter Importance Indices' (RPII). RPII is proportional to the importance of the particular cause and effect relationship. For every component or element of environment like air quality, RPII is assigned for each and every stage like foundation, operation etc of the project.

Estimated Relative Parameter Importance Index and Environmental Impact Index for every component of the Environment are tabulated in: Table 9.7.4 (Refer Annexure-7.1)

9.7.7 Evaluation of Overall Environmental Impact Score:

Having calculated RPII & EII for every activity for a particular Environmental component, Weighted EII (WEII) is calculated. Multiplication of the sum of all the WEII thus calculated for that particular component with the PIV of that component (WEII*PIV) will result in the total impact of all the activities on the particular component of environment. This exercise is repeated to get the value of (WEII*PIV) for every component of environment. Sum total of all the (WEII*PIV) values for all the components of environment will give the **Overall Environmental Impact Score** of the Project.

Evaluation of the Overall Environmental Impact Score of the Project is illustrated in Table 9.7.5 entitled 'Impact Matrix without Mitigation Plan' (Refer Annexure-7.1).

The Overall Environmental Impact Score (without Mitigation Plan)
= (-) 290.6.

A negative Impact of (-) 290.8 is moderately adverse for an Infrastructure project of this type and therefore normally accepted even without remediation measures, from Environmental Impact point of view.
However, it is possible and desirable to further reduce the Adverse impact or even to convert it to a positive score by adopting certain mitigation plan and by the inclusion of 'No Project Option' in the Impact Matrix for the evaluation of Overall Environmental Impact Score.

9.7.8 Evaluation of Environmental Impact Score with Environmental Management Plan (EMP):

Improvement in Environmental Quality by virtue of the implementation of the EMP is reviewed by revisiting the Modified Matrix method. EII values have been worked out again considering the projected Environmental Impact Magnitude with EMP which involves several mitigation measures.

Revised Environment score of (-) 6.8 given in Table 9.7.6 (Refer- Annexure-9.7.1) indicates that the Adverse Impact is almost totally balanced by the Beneficial Impact.

9.7.9 Final Recommendation:

The proposed infrastructure project is absolutely necessary to meet the transportation requirement of the people of Mumbai.

Environmental impact assessment has indicated only minor adverse impact while the beneficial effects are very significant. **'No project alternative' will have extremely high negative impact on the environment. The implementation of the project, therefore, is strongly recommended.**

Table No 9.7.2

List of Project Activities and Impacts

Sr. No	Project Activity	Impact								
		GW Source	Air Quality	Water Quality	Noise Level	Health	Public Amenities	Public Health & Hygiene	Soil Quality	Flora & Fauna
1	Pile Foundation For pillars	√	√	√	√	√	√	√	√	√
2	Transportation of components	–	√	–	√	√	√	√	–	–
3	Construction of Pillars	√	√	√	√	√	√	√	√	–
4	Construction of Girders, Rails, Platform ,FOB etc	√	√	√	√	√	√	√	√	–
5	Operation	–	–	√	√	√	√	√	–	–

Table N0 9.7.3

Determination of Parameter Importance Value (PIV)

Sr. No	Impact Component	Ranking					Total	Weighting	PIV
		1	2	3	4	5			
1	Ground Water Resources	√					**1**	**0.06**	**60**
2	Air Environment			√			**3**	**0.08**	**80**
3	Water Environment	√					**1**	**0.06**	**60**
4	Noise Environment				√		**4**	**0.15**	**150**
5	Public Amenities		√				**2**	**0.08**	**80**
6	Health during Construction		√				**2**	**0.10**	**100**
7	Public Health & Hygiene after construction				√		**4**	**0.12**	**120**
8	Land/Soil Environment		√				**1**	**0.08**	**80**
9	Flora & Fauna				√		**4**	**0.15**	**150**
10	Socio-Economic Environment				√		**4**	**0.12**	**120**
	Total						**26**	**1.00**	**1000**

Table No 9.7.4

Estimation of Relative Parameter Importance Index and Environmental Impact Index without EMP

Sr.No	Environmental Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII
1	Water Resource	Pile Foundation	0.3	Demand for water	Insignificantly adverse	-0.1
		Construction of Pillars	0.25	Demand for water	Insignificantly adverse	-0.1
		Construction of Girders & Platform &foot over bridge etc	0.25	Demand for water	Insignificantly adverse	-0.1
		Operation	0.2	Demand for water	Insignificantly adverse	-0.1
		Total	**1.0**			
2	Air Quality	Pile Foundation	0.2	Dust Nuisance	Insignificantly Adverse	-0.1
		Transportation of prefab components	0.2	Vehicular Exhaust	Slightly adverse	-0.2
		Construction of Pillars	0.25	Dust Nuisance	Insignificantly Adverse	-0.1
		Construction of Girders & Platform &foot over bridge etc	0.25	Dust Nuisance	Insignificantly Adverse	-0.1
		Operation	0.1	Dust Nuisance	Insignificantly Adverse	-0.1
		Total	**1.0**			
		Pile Foundation	0.3	Surface water pollution	Insignificantly Adverse	-0.1
3	Water Quality	Construction of Pillars	0.3	Surface water pollution	Insignificantly Adverse	-0.1
		Construction of Girders & Platform &foot over bridge etc	0.3	Surface water pollution	Insignificantly Adverse	-0.1
		Operation	0.1	Surface water pollution	Insignificantly Adverse	-0.1
		Total	**1.0**			

Sr.No	Environmental Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII
4	Noise Nuisance	Pile Foundation	0.3	Noise from Machinery	Moderately adverse	-0.3
		Transportation of prefab components	0.1	Noise from vehicles	Slightly adverse	-0.2
		Construction of Pillars	0.2	Noise from Machinery	Moderately adverse	-0.3
		Construction of Girders & Platform &foot over bridge etc	0.3	Noise from Machinery	Moderately adverse	-0.3
		Operation	0.1	Noise from Train	Moderately adverse	-0.3
		Total	**1.0**			
5	Health	Pile Foundation	0.3	Noise/Dust Nuisance	Slightly Adverse	-0.1
		Transportation of prefab components	0.05	Toxic emission from exhaust/ Noise	Slightly Adverse	-0.1
		Construction of Pillars	0.3	Noise/Dust Nuisance	Slightly Adverse	-0.1
		Construction of Girders & Platform & FOB etc	0.3	Noise/Dust Nuisance	Slightly Adverse	-0.1
		Operation	0.05	Noise Nuisance	Slightly Adverse	-0.1
		Total	**1.0**			
6	Public Amenities	Pile Foundation	0.3	Traffic slow down	Moderately Adverse	-0.3
		Transportation of prefab components	0.1	Traffic slow down	Moderately Adverse	-0.3
		Construction of Pillars	0.25	Traffic slow down	Moderately Adverse	-0.3
		Construction of Girders & Platform &foot over bridge etc	0.25	Traffic slow down	Moderately Adverse	-0.3
		Operation	0.1	Electric energy consumed	Slightly Adverse	-0.1
		Total	**1.0**			

Sr.No	Environmental Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII
7	Health	Pile Foundation	0.2	Dust Noise Impact	Slightly Adverse	-0.1
		Transportation of prefab components	0.2	Dust Noise Impact	Slightly Adverse	-0.1
		Construction of Pillars	0.2	Dust Noise Impact	Slightly Adverse	-0.1
		Construction of Girders & Platform &foot over bridge etc	0.2	Dust Noise Impact	**Slightly Adverse**	-0.1
		Operation	0.2	Noise Impact	Slightly Adverse	-0.1
		Total	**1.0**			
8	Public Health & Hygiene after Project	Land Acquisition Resettlement in healthy environment	0.6	Evacuation of slum leads to better Hygiene. Prevents epidemic (Malaria, Dengue, Swine flu, water borne deceases	Highly beneficial	+0.8
		Construction	0.2	Encroachment from neighborhood	Slightly adverse	-0.2
		Operation	0.02	Encroachment from neighborhood	Slightly adverse	-0.2
		Total	1.0			

Sr.No	Environmental Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII
9	Land Use/ Soil Quality	Pile Foundation	0.6	Dumping of Excavated Soil Change in Land use	Moderately adverse	-0.3
		Construction of Pillars Girders & Platform &foot over bridge etc	0.3	Dumping of Debris Change in Land use	Slightly adverse	-0.2
		Operation	0.1	Disposal of Solid Waste/ Disposal of liquid waste	Insignificantly adverse	-0.1
		Total	**1.0**			
10	Flora & Fauna	Pile Foundation/ Construction	0.60	Cutting/ De-rooting of trees	Highly Adverse	-0.6
			0.20	Transplantation	Moderately Beneficial	+0.20
			0.020	Forestation	Highly beneficial	+0.20
		Total	**1.0**			

Table No. 9.7.5

Impact Matrix With-out Mitigation

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
1	Water Resource	Concrete Pile Foundation	0.30	Demand for water	Insignificantly adverse	-0.1	-0.03			
		Concreting of Pillars, Girders etc	0.25	Demand for water	Insignificantly adverse	-0.1	-0.025			
		Support Services	0.25	Demand for water	Insignificantly adverse	-0.1	-0.025			
		Operation	0.20	Demand for water	Insignificantly adverse	-0.1	-0.02			
		Total	1.00					-0.10	60	-6.00
2	Air Quality	Pile Foundation	0.20	Dust Machine Exhaust	Insignificantly adverse	-0.1	-0.020			
		Transportation Of Parts	0.20	Vehicle Exhaust	Insignificantly adverse	-0.2	-0.040			
		Construction of Pillars	0.25	Dust Machine Exhaust	Insignificantly adverse	-0.1	-0.025			
		Girders, Platform, Rail FOB etc	0.25	Dust Machine Exhaust	Insignificantly adverse	-0.1	-0.025			
		Operation	0.10		No Impact	0.0				
		Total	1.00					-0.11	80	-8.80

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
3	Water Quality	Pile Foundation	0.30	Wastewater to Storm water drain	Insignificantly adverse	-0.1	-0.03			
		Construction of Pillars	0.30	Wastewater to Storm water drain	Insignificantly adverse	-0.1	-0.03			
		Girders, Platform, Rail FOB etc	0.30	Wastewater to Storm water drain	Insignificantly adverse	-0.1	-0.03			
		Operation	0.10	Wastewater to Storm water drain	Insignificantly adverse	-0.1	-0.01			
			1.0					-0.1	60.0	-6.0
4	Noise	Pile Foundation	0.30	Machine Noise	Significantly Adverse	-0.5	-0.15			
		Transportation Of parts, materials	0.10	Vehicle Noise	Moderately Adverse	-0.3	-0.03			
		Construction of Pillars	0.20	Machine Noise	Significantly Adverse	-0.5	-0.10			
		Girders, Platform, Rail FOB etc	0.30	Machine Noise	Significantly Adverse	-0.5	-0.15			
		Operation	0.10	Train Noise	Moderately Adverse	-0.3	-0.03			
			1.0					-0.46	150	-69.0

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
5	Health during construction	Pile Foundation	0.25	Noise, Dust, exhaust gas	Slightly adverse	-0.1	-0.025			
		Transportation of parts, materials	0.15	Noise, Dust, exhaust gas	Slightly adverse	-0.1	-0.015			
		Construction of Pillars	0.25	Noise, Dust, exhaust gas	Slightly adverse	-0.1	-0.025			
		Girders, Plat-form, Rail FOB etc	0.25	Noise, Dust, exhaust gas	Slightly adverse	-0.1	-0.025			
		Operation	0.10	Noise,	Slightly adverse	-0.1	-0.010			
			1.0					-0.10	100	-10.0
6	Public Amenities	Pile Foundation	0.2	Traffic constraint	Moderately adverse	-0.3	-0.06			
		Transportation of parts, materials	0.2	Traffic constraint	Moderately adverse	-0.3	-0.06			
		Construction of Pillars	0.2	Traffic constraint	Moderately adverse	-0.3	-0.06			
		Girders, Platform, Rail, FOB	0.2	Traffic constraint	Moderately adverse	-0.3	-0.06			
		Operation	0.1	Electricity consumed	Insignificantly Adverse	-0.1	+0.01			
			1.0					-0.25	80	-20.0

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
7	Effect on Public Health & Hygiene after project implementation	Land Acquisition	0.60	Elimination of Slum. Improvement in Hygiene	Significantly Beneficial	+0.6	+0.36			
		Construction	0.20	Encroachment by Neighboring slum	Slightly Adverse	-0.1	-0.02			
		Operation	0.20	Encroachment by Neighboring slum	Insignificantly adverse	-0.1	-0.02			
			1.0					+0.32	120	+38.4
8	Land/Soil Quality	Pile Foundation	0.5	Dumping of excavated Soil	Significantly adverse	-0.3	-0.30			
		Construction of Pillars	0.2	Dumping of Debris	Moderately adverse	-0.3	-0.06			
		Construction of Girders, Plat-form, Rail FOB etc	0.2	Dumping of Debris	Moderately adverse	-0.3	-0.06			
		Operation	0.1	Solid waste disposal	Insignificantly adverse	-0.1	-0.01			
			1.0					-0.43	60	-25.80

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
9	Flora & Fauna	Right of way	1.0	Removal/cutting of trees	Extremely Adverse	-1.0	-1.0	-1.0	120	-120.00
10	Socio economic Environment	Land acquisition	0.80	Displacement of poor people	Significantly Adverse	-.0.6	-0.48			
		Construction	0.10	Nuisance to neighborhood	Moderately Adverse	-0.3	-0.03			
		Operation	0.10	Noise nuisance	Slightly negative	-0.2	-0.02	-0.53	120	-63.60
		Total	1.00							
		Total Impact Score								**-290.80**

EII: Environment Impact Index

RPII: Relative Parameter Importance Index

PIV: Parameter Importance Value

For Impact Analysis ‘No Project Alternative’ not considered.

Table No. 9.7.6
Environmental Impact Matrix with Mitigation

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude W/O EMP	EMP Suggested	Impact Magnitude with EMP*	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
1	Water Resource	Concrete Pile Foundation	0.3	Demand for water	Insignificantly adverse	Conserve Water	Insignificantly adverse	-0.1	-0.03			
		Concreting of Pillars, Girders etc	0.25	Demand for water	Insignificantly adverse	Conserve Water	Insignificantly adverse	-0.1	-0.025			
		Support Services	0.25	Demand for water	Insignificantly adverse	Conserve Water	Insignificantly adverse	-0.1	-0.025			
		Operation	0.2	Demand for water	Insignificantly adverse		Insignificantly adverse	-0.1	-0.02			
			1.0							-0.10	60	-6.00
2	Air Quality	Pile Foundation	0.20	Dust Machine Exhaust	Insignificantly adverse	Isolation curtains with water screens	Insignificantly adverse	-0.1	-0.025			
		Transportation Of Parts	0.20	Vehicle Exhaust	Insignificantly adverse	Avoid peak time	Insignificantly adverse	-0.1	-0.025			
		Construction of Pillars	0.25	Dust Machine Exhaust	Insignificantly adverse	Isolation curtains with water screens	Insignificantly adverse	-0.1	-0.025			
		Girders, Platform, Rail FOB etc	0.25	Dust Machine Exhaust	Insignificantly adverse	Isolation curtains with water screens	Insignificantly adverse	-0.1	-0.025			
		Operation	0.1		No Impact							
			1.0							-0.1	80	-8.0

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude W/O EMP	EMP Suggested	Impact Magnitude with EMP*	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
3	Water Quality	Pile Foundation	0.30	Wastewater to Storm water drain	Insignificantly adverse	Direct waste water	Insignificantly adverse	-0.1	-0.025			
		Construction of Pillars	0.30	Wastewater to Storm water drain	Insignificantly adverse	Properly	Insignificantly adverse	-0.1	-0.025			
		Girders, Platform, Rail FOB etc	0.30	Wastewater to Storm water drain	Insignificantly adverse	To storm	Insignificantly adverse	-0.1	-0.025			
		Operation	0.10	Waste water to Storm water drain	Insignificantly adverse	Water drain	Insignificantly adverse	-0.1	-0.025			
			1.0							-0.1	60.0	-6.0
4	Noise	Pile Foundation	0.30	Machine Noise	Highly Adverse	Isolate work area with sound barrier	Moderately Adverse	-0.4	-0.08			
		Transportation Of parts, Materials	0.10	Vehicle Noise	Highly Adverse		Moderately Adverse	-0.4	-0.08			
		Construction of Pillars	0.20	Machine Noise	Significantly Adverse	Isolate work area with sound barrier	Moderately Adverse	-0.4	-0.08			
		Girders, Platform, Rail FOB	0.30	Machine Noise	Significantly Adverse	Isolate work area with sound barrier	Moderately Adverse	-0.3	-0.06			
		Operation	0.10	Train Noise	Significantly Adverse	Engineering solutions for noise control	Insignificantly Adverse	-0.1	-0.02			
			1.0							-0.32	150	-48.0

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude W/O EMP	EMP Suggested	Impact Magnitude with EMP*	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
5	Health Impact during Construction	Pile Foundation	0.25	Noise, Dust, exhaust gas	Moderately adverse	Engg. soln for noise/dust control	Moderately adverse	-0.3	-0.075			
		Transportation of parts, materials	0.15	Noise, Dust, exhaust gas	Slightly adverse	Low noise vehicles	Insignificantly adverse	-0.1	-0.015			
		Construction of Pillars	0.25	Noise, Dust, exhaust gas	Slightly adverse	Engg. soln noise/dust control	Insignificantly adverse	-0.1	-0.025			
		Girders, Plat-form, Rail FOB etc	0.25	Noise, Dust, exhaust gas	Slightly adverse	Engg. soln noise/dust control	Insignificantly adverse	-0.1	-0.025			
		Operation	0.10	Noise,	Slightly adverse	Engg. Soln noise/dust control	Insignificantly adverse	-0.1	-0.010			
			1.0							-0.10	100	-10.0
6	Public Amenities	Pile Foundation	0.2	Traffic constraint	Moderately adverse	Regulate traffic	Moderately adverse	-0.3	-0.06			
		Transportation of parts, materials	0.2	Traffic constraint	Moderately adverse	Regulate traffic	Moderately adverse	-0.3	-0.06			
		Construction of Pillars	0.2	Traffic constraint	Moderately adverse	Regulate traffic	Moderately adverse	-0.3	-0.06			
		Girders, Platform, Rail, FOB	0.2	Traffic constraint	Moderately adverse	Regulate traffic	Moderately adverse	-0.3	-0.06			
		Operation	0.3	Efficient, Comfortable transport	Highly significant benefit		Highly significant benefit	1.0	+0.30			
			1.0							+ 0.06	80	+4.8

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude W/O EMP	EMP Suggested	Impact Magnitude with EMP*	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
7	Public Health & Hygiene after project implementation	Land Acquisition	0.60	Elimination of Slum. Improvement in Hygiene in public place	Highly Beneficial	Nil	Highly Beneficial	+0.6	+0.36			
		During Construction	0.20	Encroachment by Neighboring slum	Slightly Adverse	Barricade/ Fencing	Insignificantly adverse	-0.01	-0.02			
		During Operation	0.20	Encroachment by Neighboring slum	Insignificantly adverse	Compound wall	Slightly beneficial	+0.01	+0.02			
			1.0							+0.36	120	+43.00
8	Land/Soil Quality	Pile Foundation	0.5	Dumping of excavated Soil	Significantly adverse	Use Soil to reclaim designated site	Slightly adverse	-0.2	-0.10			
		Construction of Pillars	0.2	Dumping of Debris	Moderately adverse	Use Soil to reclaim designated site	Slightly adverse	-0.2	-0.04			
		Girders, Plat form, Rail FOB etc	0.2	Dumping of Debris	Moderately adverse	Use Soil to reclaim designated site	Slightly adverse	-0.2	-0.04			
		Operation	0.1	Solid waste disposal	Insignificantly adverse	Dispose Neatly in Waste bins	Slightly adverse	-0.2	-0.02			
			1.0							-0.20	60	-12.0

Sr. No	Environment Component	Project Activity	RPII	Cause of Impact	Impact Magnitude W/O EMP	EMP Suggested	Impact Magnitude with EMP*	EII	Weighted EII	Sum of WEII	PIV	Product of WEII*PIV
9	Flora & Fauna	Clearing Right of way	0.4	Removal of trees	Significantly Adverse	Do not cut the trees De root scientifically	Significantly Adverse	-0.6	-0.24			
		Mitigation Transplant at designated locations	0.3			Transplantation of trees	Moderately Beneficial	+0.3	+0.09			
		Compensatory Forestation	0,3			Planting 1000% more trees	Significantly Beneficial	+0.4	+0.12			
			1.0							-0.03	120	-3.60
10	Socio Economic Environment	Land acquisition	0.8	Displacement of poor people	Highly Adverse	Provide flats as alternate accommodation +Compensation	Highly beneficial	+0.8	+0.64			
		Construction	0.1	Nuisance to neighborhood	Moderately Adverse	Provide Isolation/noise barrier	Slightly Adverse	-0.2	-0.20			
		Operation	0.1	Noise nuisance	Moderately Adverse	Provide Noise Barrier in all sensitive locations	Slightly Adverse	-0.20	-0.20			
			0.1							+0.24	120	+28.80
		Total Impact		**Score after EMP**								**-6.80**

Marginal improvement does not make measurable change in Impact

By the application of the suggested Mitigation Measures, the Score of EIA by the Modified Matrix Method can be reduced from (-) 290.8 to (-) 6.80 which is negligible and is acceptable for an Infrastructure project like Metro Railway.

9.8 COST OF REMEDIATION:

9.8.1 Environment Management and Emergency Control Centre:

The Environment Management Systems and Emergency Control Systems can be housed in the same premises.

The Environment Management division should have qualified and well trained personnel.

They will work on supervision and coordination of monitoring activities, record keeping, reporting, communication, implementation and periodic review of mitigation measures. An Environment advisor (consultant) will review the progress and monitor the effectiveness of the system.

Cost of the establishment is estimated approximately at **Rs.30 lacs.**

Salaries and other employment benefits of the staff and workers will be included in the operational cost of Mumbai Metro.

9.8.2 Estimated Cost of Rehabilitation and Resettlement of Project Affected People (PAPs):

Fund to the tune of Rs.58 crores have been provided.

9.8.3 Estimated Cost of Providing Noise Barriers used during Operation:

Sr.No	Particulars	Quantity, m^2	Rate, Rs/m^2	Cost Rs (lacs)
1	Noise Barriers	2220	10,000	220.00

(Considering the socio-economic conditions and the street culture that prevail in Mumbai, the selection of materials of construction and method of construction should make the noise barriers theft proof and vandal proof)

9.8.4 Water Supply and Sanitation (Within the Scope of the Contractor):

Make sure that:

- The contractor develops a temporary all weather residential camp for the workers in a safe and hygienic manner.
- Arrangement is made for the supply of safe drinking water as per WHO standard.
- Sufficient number (4) Portable Chemical Toilet with hygienic waste disposal facilities is provided

9.8.5 Cost of Solid Waste Management:

Sr No	Particulars	Quantity	Unit Rate Rs	Cost Rs (lacs)
1	Cost of collection bins 16 nos per station for 15 stations	240	2,000	4.80

9.8.6 Cost of Environmental Monitoring:

Sr No	Particulars	Quantity	Unit Rate, Rs	Cost Rs (lacs)
1	Water Quality Monitoring at 3 locations, 4 time /yr for 7 yrs	84 samples	5000	4.20
2	Ambient Air Quality Monitoring at 3 locations, once monthly for 7 yrs	252	10,000	25.20
3	Noise Level Monitoring at 3 locations once monthly for 7 yrs	252	1,000	2.52
4	**Total Cost of Environmental Monitory**			**31.92**

All the above costs have been provided in R&R and Cost Head No.1 and Environment Protection in Cost Head No.9.

9.9 EMERGENCY PREPAREDNESS:

9.9.1 Emergency Facilities to be provided for Safety:

- Emergency Control Centre.
- Communication system between the passengers and the driver and Emergency Control Room.
- Adequate Fire Alarms and Fire Fighting Facilities in each coach and station to control any accidental fire.
- First Aid facility inside the train and at the station.
- CCTV and Public Address System at appropriate locations.
- Interlock system to ensure safe closure of all the coaches before the engine starts.
- Emergency Alarm System inside the coaches.

9.9.2 Emergency Management Plan:

- Considering the elevated track supported on pillars and its vulnerability to terrorist attack, it is essential to have adequate security and an Emergency Response Plan periodically tested for preparedness of all the agencies involved in the disaster management. The plan must be tested periodically through table top exercises and mock drills.

- It is essential to subject the design to Hazard Operability (HAZOP) Studies and incorporate all the necessary systems in the design to prevent any disaster and to mitigate the impact of any emergency.
- Use of Fire resistant materials for the construction of the rake and provision of built in Fire detectors and Fire Fighting Systems, Emergency Exits (Fire Escape routes, emergency kits for passengers, first aid etc. are some of the safety systems to be incorporated in the design. Regulatory control on restaurants, eateries etc will prevent the possibility of Fire & Explosion.
- Metro Railway should participate in Responsible Care, an initiative of Chemical Industry to improve preparedness related to Safety, Health, environment and Security.

9.9.3 Emergency Response System Committee:

- Government should form a Local Emergency Response Committee consisting representatives from:
- Fire &Emergency Department
- Police
- Health Department
- Transport Department
- Educational Institutions
- Industrial Associations
- NGOs, Public.

This committee shall provide a forum to the local community to discuss health, safety, security, noise nuisance and other environmental and emergency issues.

9.9.4 Emergency Response Management Communication Center (ERMCC):

On the lines of Federal Rail Road Administration, USA, and Emergency Response Management Communication Center (ERMCC), may be conceived for the quick response to any call coming from toll free emergency numbers. Emergency notification signs indicating a unique number of Department of Transportation (DOT) may be installed at all stations, crossings etc. The DOT number will be helpful for ERMCC to identify the exact location of the train to enable emergency corrective actions and to rush relief.

CHAPTER 10

MULTI MODEL TRAFFIC INTEGRATION AT METRO STATIONS

10.1 INTRODUCTION

The Metro Rail System in Mumbai Andheri (E) – Dahisar (E) corridor will cover a length of approximately 16.475 kms. It will be augmented through enhanced flexibility of criss-cross interchanges to other modes and reduce the travel time of commuters. While Metro is a high capacity mode of transport, the need for integration with other secondary/intermediate transport mode is getting highlighted more than ever to ensure a seamless journey. This concept is to provide first mile and last mile connectivity to the commuters with their places of stay. With top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Rail Systems. (Ref: MoUD (Urban Transport Wing) Advisory Circular No. K-14011/1/2007-UT-IV dated 30.08.2013).

The share of various modes of secondary/intermediary mode of travel is complex and debatable issue which is dependent on a large number of variables like available road width, penetration in the residential areas, Road condition, distance from the Metro Stations, availability of parking and lay out and availability of circulating areas at the Metro Rail Stations, Business centre or Market & existing traffic densities. These factors relate with each other and evolve with development of new model mix of transport, infrastructure and changes with the passage of time. Even though for a given urban transport scenario, optimal mode share may be determined from computer based models but actual **optimal mode share** is never achievable on the road due to dynamic nature of demand and supply of transport modes.

10.2 PRESENT CONDITION OF TRANSPORT ON CITY ROADS

At present the various modes coming to Metro Stations comprise of State Transport buses, Mini buses, Auto-rickshaws, Private cars, Two Wheelers and Bi-cycles. These can be classified in three groups of transport modes namely Public, IPT and Private.

In public transport group there are Mini Buses (20 Seaters), and large buses of State Transport (50 Seaters) and Charted Buses hired by Schools and private offices.

Generally the public transport in Mumbai comprises of the buses which are operated by the Transport Corporation.

Auto-rickshaws are also an important part of public transports at Mumbai. After bus, it is these auto rickshaws which are the most important modes of public transport in Mumbai even though they are little expensive. Auto rickshaws are Intermediate Public Transport (IPT) Modes. Another public transport at Mumbai which can be ranked third among all is the cabs or taxis that run on the streets of Mumbai.

In the personalised transport modes, there are Cars, Two Wheelers and Bicycles of all possible sizes.

A chaotic situation is observed when all the above mentioned transport vehicles are seen jostling to each other for space for moving forward. More pathetic conditions are seen at the Road Intersections.

The solution lies in the showcasing a workable arrangement of co-existence through identification of good points of each mode and then utilise the same to get the attention and embedding it in public psyche.

Because of high traffic and less capacity as well as length of the roads, average distance between two consecutive vehicles becomes very less. Such situation does not permit speed higher than 15-20 km/hr. This indicates that unless there is some solution to reduce this unmanageable mix of the vehicle fleet, real transport integration may not be possible. While the Road length on main & arterial Roads may not be seen significant increase and relieve the congestive/chaotic/slow moving road traffic, a divergent policy of linking commuters directly through E-Rickshaw or Mini Buses using the service/inner road length to supplement the main road traffic will impact the congestion and provide relief to the Metro commuters in reaching out to Metro Stations.

10.3 IMPACT OF BUS/CLUSTERS IN MODE SHARE

Primary reasons for using personal vehicle (for buying vehicle) is **to save travel time** during journey. On the other hand, Government has tried to increase number of public buses on the road in many different ways.

Government has tried hard to popularise public buses by subsidising the fare but could not bring higher (and middle) income group to use public bus simply because it is slow. Therefore objective of achieving optimal mode share remained elusive than reality.

10.4 BALANCING ACT OF METRO

After introduction of Metro Rail System in the city, Traffic and Transportation scenario will significantly change. People will no longer be afraid to travel a much longer distance. With Metro in place, longer distances can be travelled in shortest time.

10.5 WAY FORWARD

In view of above deliberations in back ground, along with planning for Metro System in any city, there is a need for providing a transportation system which is seamlessly integrated across all modes and provides first mile as well as last mile connectivity. It is also necessary that various public transportation modes including Inter-mediate Public Transport (IPT) and feeder buses etc. work together in order to facilitate increase in ridership to the Metro/Metro system and provide ease of using Metro system by the public at large.

Therefore, there is a need for doing more scientific study exclusively for this. To achieve this goal, Metro Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. Detailed Study is required to be done in this influenced zone of a Metro station for following aspects mainly:

i) Availability and review of existing public and IPT facilities, in terms of motorized and non-motorised mode with main consideration of the streets/roads adjoining to the stations and also to examine adequacy of availability of pedestrians/cycle paths in the influenced zone.

ii) Analysis and identification of gaps between supply and demand in terms of feeder facilities and other requirements for better first and last mile connectivity.

iii) Proposal for introduction/enhancement of feeder buses and cycle/pedestrians tracks, bike sharing arrangement for each Metro station to be finalised.

iv) Proposal for better integration of Metro station with other mode of transport, such as relocation of existing bus stop, introduction of new bus stop, bus base etc.

v) Cost of the requirements namely road widening including roads for pedestrian/cycle paths, feeder buses based on the outcome of the study.

The detailed study and requirement for providing first mile as well as last mile connectivity to the Metro users will be carried out separately and the same should be in place before the commercial operation of the Metro services for the benefit of the users as well as for better ridership and the financial viability of the project.

Since, it is envisaged that detailed study for provision of feeder buses, public bike sharing and pedestrianisation in the influence zone of Metro stations will be done and put in place by the time commercial operation of the Metro services, a lump-sum cost of Rs. 2.31 crores per station has been considered sufficient and included in the project cost of proposed Metro System. If at any stage more feeder services etc. will be required, same can be augmented by concerned city transportation authorities.

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CHAPTER 11

FRIENDLY FEATURES FOR DIFFERENTLY ABLED

11.1 INTRODUCTION

The objective of making this chapter is to create a user-friendly mass transport system in India which can ensure accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems (e.g. a leg in plaster) and the elderly persons.

The design standards for universal access to Public Transport Infrastructure including related facilities and services, information, etc. would benefit people using public transport.

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons", 1998 and 2013 edition (under revision by MoUD), and international best practices / standards

Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around Metro stations.

11.2 CONTENT

1. Rail Transport
2. Light Metro Station
    - Way finding
    - Signage
    - Automated Kiosks
    - Public Dealing Counters
    - Audio-visual Displays
    - Public Telephones
    - Rest Areas/Seating
    - Tactile Paving - Guiding & Warning

- Doors
- Steps & Stairs
- Handrails
- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

3. Street Design
   - Footpath (Sidewalk)
   - Kerb Ramp
   - Road Intersection
   - Median/Pedestrian Refuge
   - Traffic Signals
   - Subway and Foot Over Bridge

4. Alighting and Boarding Area
   - Approach
   - Car Park
   - Drop-off and Pick-up Areas
   - Taxi/Auto Rickshaw Stand
   - Bus Stand/Stop

11.3 RAIL TRANSPORT

1. General
   - Whether over-ground or underground, rail travels is a highly effective mode of transport.
   - Every train should contain fully accessible carriages.
   - Staff should be trained in methods of assistance and be at hand on request.
   - Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways
   - Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
   - All new railway stations should be designed to be fully accessible.
   - For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
   - For persons with visual impairments audio system announcing the station names and door location should be available.

2. Accessible Railway Cars

The railway cars should have the following features:

- Railway car doors should be at least 900 mm wide;
- The gap between the car doors and the platform should preferably be less than 12 mm;
- Identification signage should be provided on the doors of wheelchair accessible coach
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

3. Wheel Chair Space

- Space for a wheel chair should be available at the side of the door:-
- The space should be indicated inside and outside the car by using the international symbol of access; and
- Wheel stoppers and ring-strap or other appropriate safety grip should be provided for wheelchair users.

4. Seats

- An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles

- Aisles should be at least 900 mm wide.

11.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

11.5 METRO STATIONS

1. LEVEL APPROACH

- Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should have a ramp.
- Walkway surfaces should be non-slip.
- Approach walkway should have tactile pavements for persons with visual impairments.

2. STATION ENTRANCES AND EXITS

- These should have a minimum width of 1800mm and is level or ramped.

3. RESERVATION AND INFORMATION COUNTERS

- Should have clear floor space of at least 900 mm x 1200 mm in front of the counters;
- There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
- At least one of the counters should have an induction loop unit to aid people with hearing impairments; and
- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

4. TOILET FACILITIES

- There should be at least one unisex accessible toilet
- Ticket Gates

At least one of the ticket gates should:

- Be minimum 900 mm wide to allow a wheelchair user through; and
- Have a continuous line of guiding paver for people with visual impairments.

5. PLATFORMS

The Platforms should:

- Have a row of warning paver installed 600mm before the track edge (photo 6);
- Have non-slip and level flooring;
- Have seating areas for people with ambulatory disabilities;
- Be well illuminated lux level 35 to 40;
- There should be no gap or difference in level between the train entry door and the platform.
- All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

- Way finding references should be available at decision points.
- Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.

- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travellers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille)

8. SIGN DESIGN SPECIFICATIONS

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.
- Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
- The colour of the text should be in a colour that contrasts with the sign board.
- The sign board should also contrast with the wall on which it is mounted.
- The surface of the sign should not be reflective.
- Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
- Illuminated signs should not use red text on a dark background.
- Signs should be supplemented by Braille where possible.

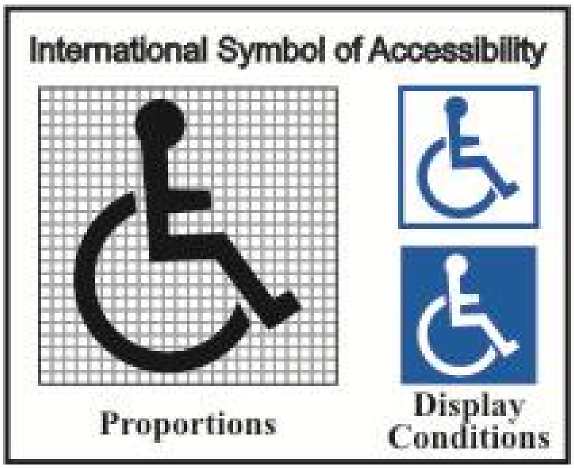


Fig. 11.1 - Way finding signage Fig. 11.2 - International Symbol of Accessibility

9. AUTOMATED KIOSKS

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. PUBLIC DEALING COUNTERS

- Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.
- Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
- It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.
- Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
- Staff manning the counters should know sign language.
- Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
- Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
- Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
- There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
- One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep.

11. AUDIO-VISUAL DISPLAYS

- Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
- Enable captioning at all times on all televisions and other audio-visual displays that are capable of displaying captions and that are located in any portion of the terminal.
- The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING

- Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
- Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
- Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.
- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. TACTILE PAVING- GUIDING & WARNING

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. PLACES TO INSTALL WARNING PAVER

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

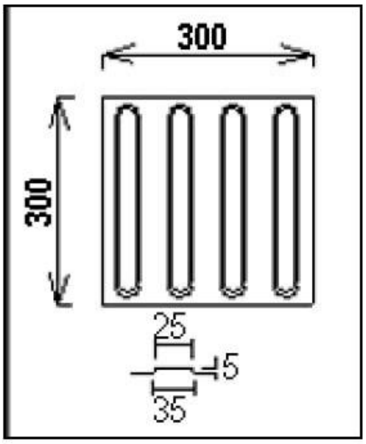


Fig. 11.3 - Guiding paver

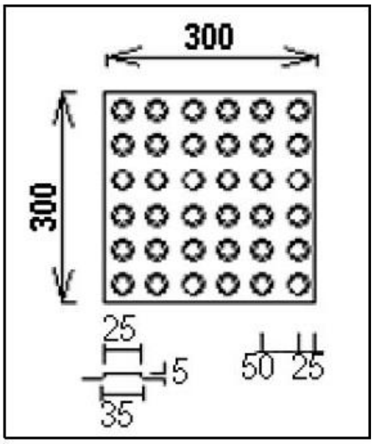


Fig. 11.4 - Warning paver

15. DOORS

Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.

- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).
  - Also be fitted with vision panels at least between 900mm and 1500mm from floor level.
  - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
  - Lever handles and push type mechanisms are recommended. When a sliding door is fully open, handles should be usable from both sides.

- Where revolving doors or turnstiles are used, an alternative wheelchair-
- Accessible entrance must also be provided.
- A distance of 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, colour (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor (figure 28).
- Operable devices such as handles, pulls, latches and locks should:
  - Be operable by one hand
  - Not require fine finger control, tight grasping, pinching or twisting to operate
- Glazed doors and fixed glazed areas should be made visible by use of a clear, colour and tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

16. STEPS & STAIRS

- Steps should be uniform with the tread not less than 300mm and the risers 150mm.
- The risers should not be open.
- The steps should have an unobstructed width of 1200mm minimum.
- All steps should be fitted with a permanent colour and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both tread and riser.
- Have continuous handrails on both sides including the wall (if any) at two levels
- Warning paver to be placed 300mm at the beginning and at the end of all stairs.
- Nosing to be avoided.
- The staircase should be adequately and uniformly illuminated during day and night (when in use). The level of illumination should preferably fall between 100-150 lux.
- The rise of a flight between landings must be no more than 1200mm.
- There should be no more than 12 risers in one flight run.
- The stair covering and nosing should be slip-resistant, non-reflective, firmly-fixed and easy to maintain.
- Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

17. HANDRAILS

- Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
- The handrail should contrast in colour (preferably yellow/orange) with surrounding surfaces.
- At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
- The handrail should be positioned at two levels- 760mm and 900mm above the pitch-line of a flight of stairs.
- Handrail at foot of the flight of stairs should extend 300mm beyond the stairs in the line of travel and returning to the wall or floor or rounded off, with a positive end that does not project into the route of travel.

18. RAMPS

- Ramps gradient should ideally be 1 in 20 and no greater than 1 in 12.
- Width of the ramp should not be less than 1200mm and preferred width is 1800mm.
- The steeper the gradient, the shorter the length of ramp between landings.
- On long ramps, a horizontal resting space should be provided every 6 meters.
- Surface materials should be slip-resistant, non-reflective, firmly-fixed and easily maintained
- The edge of the ramp should have an edge protection with a minimum height of 100mm.
- Landings every 750mm of vertical rise.
- A tapping or lower rail should be positioned so that its bottom edge is no higher than 200mm above ground level.
- Handrails on the ramps should be on both sides at two levels: upper at 900mm and lower at 760mm; both end to be rounded and grouted; extend 300 mm beyond top and bottom of ramp .
- A row of tactile warning paver should be placed 300mm beginning and end of each run.
- Landings should be provided at regular intervals as indicated in the table (Table 11.1).

Table 11.1 - Specifications for Ramps

Level difference	Minimum Gradient.of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	√	
≥ 300 mm ≤ 750 mm	1:12	1500 mm	√	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	√	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	√	Landings every 9 meters of ramp run.

19. LIFTS/ELEVATORS

A carefully designed lift makes a huge contribution to the accessibility of a multi-storied terminal building for persons with disabilities.

- Lift locations should be clearly signposted from the main pedestrian route and recognizable through design and location.
- The colour and tone of the lift doors should contrast with the surrounding wall finish to assist in their location. Lift doors with metallic finishes such as steel grey and silver should be avoided as they are difficult to identify by persons with low vision.
- The lift lobby shall be of an inside measurement of 1800mm X 2000mm or more. A clear landing area in front of the lift doors of minimum dimensions 1500mm x 1500mm should be provided.
- By making the landing area distinguishable by floor surface and contrast, it will aid location and recognition of core areas. This could comprise a change in floor finish from thin carpet to vinyl/PVC, or cement/mosaic floor to carpet.
- Changes in floor finish must be flushed. There should be no level

  difference between lift door and the floor surface at each level; the gap if unavoidable should not be more than 12mm.
- The floor level/location should be indicated on the wall adjacent to or just above the call buttons, and opposite the lift doors where possible.

20. Lift Dimensions

- Provisions of at least one lift shall be made for people using wheelchairs with the following car dimensions:
  - Clear internal depth -1500 mm minimum
  - Clear internal width - 1500 mm minimum
  - Entrance door width - 900 mm minimum

21. LIFT CONTROLS

- The lift call button should be wall-mounted adjacent to the lift and should contrast with wall finish, either by using a contrasting panel, or a contrasting border around the button panel.
- The call buttons should be located within the range 800-1000mm above floor finish.
- Buttons should not be touch sensitive, but should require a light positive pressure and should ideally be large enough to be operable by the palm of the hand if required.
- The control buttons inside the lift should be positioned on the side wall rather than front wall to allow access from the back and front of the lift car, by mobility aid users like wheelchair users.
- The control buttons should contrast with their surroundings and illuminate when pressed and should incorporate highly visible tactile embossed (NOT engraved) characters and in Braille.
- Time of closing of an automatic door should be more than 5 seconds and the closing speed should not exceed 25 meters per second. There should be a provision of censor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

22. CAR DESIGN

- Internal walls should have a non-reflective, matt finish in a colour and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.
- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, in order to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

11.6 INFORMATION SYSTEMS

- Lifts should have both visual and audible floor level indicators
- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 50 decibel.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

11.7 GENERAL ACCESSIBLE TOILETS

1. SIGNAGES
   - All signage of general toilets should be in bold and contrasting colors.
   - For persons with low vision and vision impairments: male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
   - Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.
   - Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.
2. ACCESSIBLE TOILETS
   - Should have the international symbol of accessibility displayed outside for wheelchair access.
   - The toilet door should be an outward opening door or two way opening or a sliding type and should provide a clear opening width of at least 900mm.
   - It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.
3. WC COMPARTMENT DIMENSIONS
   - The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
   - Layout of the fixtures in the toilet should be such that a clearing maneuvering space of 1500mm x 1500mm in front of the WC and washbasin.
4. WATER CLOSET (WC) FITTINGS
   - Top of the WC seat should be 450-480mm above finished floor level, preferably be of wall hung or corbel type as it provides additional space at the toe level.

- An unobstructed space 900mm wide should be provided to one side of the WC for transfer, together with a clear space 1200mm deep in front of the WC.
- WC should be centred 500mm away from the side wall, with the front edge of the pan 750mm away from the back wall. Have a back support. The WC with a back support should not incorporate a lid, since this can hinder transfer.
- L-shape grab bar at the adjacent wall and on the transfer side (open side) swing up grab bar shall be provided.
- The cistern should have a lever flush mechanism, located on the transfer side and not on the wall side and not more than 1000mm from the floor.

5. GRAB BARS

- Grab bars should be manufactured from a material which contrasts with the wall finish (or use dark tiles behind light colored rails), be warm to touch and provide good grip.
- It is essential that all grab rails are adequately fixed, since considerable pressure will be placed on the rail during maneuvering. Grab bars should sustain weight of 200kgs minimum.
- A hinged type moveable grab bar should be installed adjacent to the WC on the transfer side. This rail can incorporate a toilet tissue holder. A distance of 320mm from the centre line of the WC between heights of 200-250mm from the top of the WC seat. It should extend 100-150mm beyond the front of the WC.
- A fixed wall-mounted L- shape grab bar (600mm long horizontal and 700mm long vertical) on the wall side should be provided. It should be placed at a height of 200-250mm above the WC seat level.

6. WASHBASINS

- Hand washbasins should be fitted on cantilevered brackets fixed to the wall.
- The basin should be fixed no higher than 750mm above the finished floor level.
- Be of dimensions 520mm and 410mm, mounted such that the top edge is between 800- 900mm from the floor; have a knee space of at least 760mm wide by 200mm deep by 650-680mm high.
- The position of the basin should not restrict access to the WC i.e. it should be located 900mm away from the WC.
- A lever operated mixer tap fitted on the side of the basin closest to the WC is useful as it allows hot and cold water to be used from a seated position on the WC.
- The hand drying facilities should be located close to the hand washbasin

  between 1000-1200mm.
- Lever type handles for taps are recommended.

- Mirror's bottom edge to be 1000mm from the floor and may be inclined at an angle.

7. FIXTURES AND FITTINGS

- Contrast between fittings and fixtures and wall or floor finishes will assist in their location. For example, using contrasting fittings, or dark tiles behind white hand washbasins and urinals, contrasting soap dispensers and toilet roll holders.
- Contrast between critical surfaces, e.g. floors, walls and ceilings helps to define the dimensions of the room.
- Towel rails, rings and handrails should be securely fixed to the walls and positioned at 800-1000mm from the floor.
- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights-1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.
- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish

8. SIGNAGE OF ACCESSIBLE TOILETS

- All unisex accessible toilets to have access symbol in contrast colours. A distinct audio sound (beeper/clapper) may be installed above the entrance door for identification of the toilets.

Fig. 11.5 - Signage for accessible washroom

9. ACCESSIBLE URINAL

- At least one of the urinals should have grab bars to support ambulant persons with disabilities (for example, people using mobility aids like crutches).
- A stall-type urinal is recommended.
- Urinals shall be stall-type or wall-hung, with an elongated rim at a maximum of 430mm above the finish floor. This is usable by children, short stature persons and wheelchair users.
- Urinal shields (that do not extend beyond the front edge of the urinal rim) should be provided with 735mm clearance between them.
- Grab bars to be installed on each side, and in the front, of the urinal.
- The front bar is to provide chest support; the sidebars are for the user to hold on to while standing.

11.8 DRINKING WATER UNITS

- Drinking water fountains or water coolers shall have up front spouts and control.
- Drinking water fountains or water coolers shall be hand-operated or hand and foot-operated.
- Conventional floor mounted water coolers may be convenient to individuals in wheelchairs if a small fountain is mounted on the side of the cooler 800mm above the floor.
- Fully recessed drinking water fountains are not recommended.
- Leg and knee space to be provided with basin to avoid spilling of water. This allows both front and parallel access to taps for persons using mobility aids like wheel chair, crutches etc.

11.9 VISUAL CONTRASTS

- Visual contrasts means adequate contrast created by difference of at least 30 LRV (Light Reflectance Value) of the two surfaces/ objects and it helps everyone especially persons with vision impairments.
- Visual contrast should be provided between:
  - Critical Surfaces (walls, ceiling and floor),
  - Signage and background sign frame/ wall,
  - Step edges and risers/ treads on steps,
  - Handrails and background walls,
  - Doors and surrounding walls,
  - Switches/ sockets and background wall,
  - Toilet fixtures and critical surfaces in toilet.

- Barriers and hazards should be highlighted by incorporating colours and luminance contrast.

11.10 EMERGENCY EGRESS/EVACUATION

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.

- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a 'hotkey' on the phone keypad. This 'hotkey' should be distinct from the rest of the keypad.

11.11 ALERTING SYSTEMS

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.
- Consider having audible alarms with 'voice instructions' that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.
- Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).

  Non-auditory alarms include:
  - Flashing beacons
  - Vibrating pillows and vibrating beds.
  - Pagers or mobile phones that give out a vibrating alarm along with a flashing light (these may be issued to persons with vision or hearing impairments at the time of check-in or boarding the vehicle.)

11.12 WRITTEN EVACUATION PROCEDURE

A written evacuation procedure that details the egress plan for people with disability should be installed behind the entrance door in the accessible rest rooms. The evacuation procedure should be detailed in large print letters that contrast strongly against the background. Where possible, it should also incorporate raised letters and Braille. The evacuation route should be displayed on a high contrast tactile map for benefit of persons with vision impairments.

11.13 EMERGENCY EVACUATION ROUTE

- Designate routes that are at least 1200mm wide, to ensure that a person using a wheelchair and a non-disabled person are able to pass each other along the route. The route should be free of any steps or sudden changes in level and should be kept free from obstacles such as furniture, coolers, AC units and flower pots.

- Use Exit signage along the route. Orientation and direction signs should be installed frequently along the evacuation route and these should preferably be internally illuminated. The exit door signage should also be internally illuminated.
- A 'way guidance lighting system' consisting of low mounted LED strips to outline the exit route (with frequent illuminated direction indicators along the route) should be installed along the entire length of the evacuation route. Way guidance systems allow persons with vision impairments to walk significantly faster than traditional overhead emergency lighting. Moreover, emergency exit lights in green color and directional signals mounted near the floor have been found to be useful for all people in cases where a lot of smoke is present.

11.14 WAY GUIDENCE SYSTEM

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.
- Install clear illuminated sign above exit and also directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

11.15 Fire Resistant Doors

- Fire resistant doors and doors used along the emergency evacuation route are generally heavy and the force required to open these is much higher than 25 Newton, making it difficult for people with disability to negotiate these doors independently. There are, however, magnetic and other types of door holders available that can be connected to fire alarms so that they will hold the doors open normally but will release the doors when the fire alarm is activated.

11.16 STREET DESIGN

(a) Footpath (Sidewalk)

Footpaths should be regarded as a transportation system which is connected and continuous, just like roadways and railways. They should not be sporadically placed where ever convenient, but instead should be provided consistently between all major attractions, trip generators, and other locations where people walk.

Footpath should

- Be along the entire length of the road;
- Have height of a standard public step riser i.e. 150 mm maximum;
- Be at least 1800 mm wide;
- Have non-slip surface;
- Have tactile guiding paver for persons with visual impairments;
- Preferably have well defined edges of paths and routes by use of different colours and textures;
- Have no obstacles or projections along the pathway. If this is unavoidable, there should be clear headroom of at least 2200 mm from the floor level;
- The minimum 1.8m (width) x 2.2m (Height) Walking Zone should be clear of all obstructions – both horizontally and vertically.

Footpath should have:

- Have kerb ramps where ever a person is expected to walk into or off the pathway; and
- Have tactile warning paver installed next to all entry and exit points from the footpath.

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.
- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

(c) Road Intersections

- Pedestrian crossings should be equipped with traffic control signal.
- Traffic islands to reduce the length of the crossing are recommended for the safety of all road users.
- Warning pavers should be provided to indicate the position of pedestrian crossings for the benefit of people with visual impairments.
- Table tops (raised road level to the sidewalk height) are helpful in reducing the speed of traffic approaching the intersection

(d) Median/Pedestrian Refuge

Raised islands in crossings should:

- Cut through and level with the street; or
- Have kerb ramps on both the sides and have a level area of not less than 1500 mm long in the middle; and
- A colored tactile marking strip at least 600 mm wide should mark the beginning and end of a median/ pedestrian refuge to guide pedestrian with visual impairments to its location.

11.17 TRAFFIC SIGNALS

- Pedestrian traffic lights should be provided with clearly audible signals for the benefit of pedestrians with visual impairments;
- Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination;
- The installation of two adjacent acoustic devices such as beepers is not recommended in order to avoid disorientation;
- The time interval allowed for crossing should be programmed according to the slowest crossing persons; and
- Acoustical signals encourage safer crossing behavior among children as well.

11.18 SUBWAY AND FOOT OVER BRIDGE

Subways and foot over bridges should be accessible for people with disabilities. This may be achieved by:

- Provision of signage at strategic location;
- Provision of slope ramps or lifts at both the ends to enable wheelchair accessibility ;
- Ensuring that the walkway is at least 1500 mm wide;
- Provision of tactile guiding and warning paver along the length of the walkway;
- Keeping the walkway; free from any obstructions and projections; and
- Providing for seats for people with ambulatory disabilities at regular intervals along the walkway and at landings.

11.19 ALIGHTING AND BOARDING AREAS

- All areas and services provided in the Mass Rapid Transit System (Metro/subway), bus terminuses, etc. that are open to the public should be accessible.

11.19.1 APPROACH

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.

- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions or areas requiring maintenance should be white cane detectable1.
- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

11.19.2 CAR PARK

(A) SIGNAGE

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be

at a minimum height of 2100 mm .

(B) SYMBOL

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the centre of the lot; and
- The colour of the symbol should be white on a blue background.

(C) CAR PARK ENTRANCE

The car park entrance should have a height clearance of at least 2400 mm.

LOCATION

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.

- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) ACCESSIBLE CAR PARKING LOT

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm;
- Have a firm, level surface without aeration slabs;
- Wherever possible, be sheltered;
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings;
- Two accessible parking lots shall be provided for every 25 no of car spaces.

(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

CHAPTER 12

SECURITY MEASURES FOR A METRO RAIL SYSTEM

12.1 INTRODUCTION

Metro Rail System is emerging as the most favoured mode of urban transportation system. The inherent characteristics of Metro Rail System make it an ideal target for terrorists and miscreants. Metro Rail System is typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic importance, being the life line of city high news value, fear & panic and human casualties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

12.2 NECESSSITY OF SECURITY

It is well known that public transportation is increasingly important for urban areas to prosper in the face of challenges such as reducing congestion and pollution. Therefore, security places an important role in helping public transport system to become the mode of choice. Therefore, excellence in security is a prerequisite for Metro Rail System for increasing its market share. Metro Rail System administration must ensure that security model must keep pace rapid expansion of the Metro Rail System and changing security scenario.

12.3 THREE PILLARS OF SECURITY

Security means protection of physical. Human and intellectual assets either from criminal interference, removal of destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. There are three important pillars of security as mentioned under:

((i) The human factor;
(ii) Procedures; and
(iii) Technology

Staff engaging with the passengers creates a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective staff has to be qualified, trained, well equipped and motivated. They should be trained, drilled and tested. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed communicated and drilled in advance.

There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems are to differ i.e., making planning or execution of on attack too difficult, detect the planned evidence before it occurs deny the access after in plan of attack has been made and to mitigate i.e. lessen the impact severity as the attack by appropriate digits.

12.4 PHASES OF SECURITY

There are three phases of security as under:

(i) Prevention

These are the measures which can prevent a security incidence from taking place. These can be identified by conducting a risk assessment and gathering intelligence. Prevention begins with the daily operational security -problems.

Uncared for dirty, damaged property is a breeding ground for more serious crime.

(ii) Preparedness

Plans must be prepared to respond to incidents, mitigate the impact. Train staff accordingly and carry out exercises. The results of the risk assessment give a basis for such plans.

(iii) Recovery

Transport system must have laid down procedures/instructions for the quick recovery of normal service after an incident. Recovery is important for the financial health of the operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should also include an evaluation process for the lessons learnt.

12.5 RESPONSIBILITIES AND PARTNERSHIPS

Security is a sovereign function and hence is the responsibility of the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the Government of Maharashtra to ensure secured travelling to the public including Metro Rail System.

12.6 PROPOSED PROVISIONS FOR SECURITY SYSTEM

1. CCTV coverage of all Metro Rail System stations. With a provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations. Cost of this is included in Telecom estimate.

2. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required. Cost of one baggage scanner is Rs. 15.0 Lacs approximately, on 2013 prices.

3. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations. Cost of one Multi-zone DFMD is Rs 2.15 Lacs approximately.
4. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station. Cost of one HHMD is Rs 6000/- approximately at 2012 prices.
5. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of DMRC. Cost 1.25 crores including vehicle.
6. Bomb Blanket at least one per station and Depots. Cost is Rs. 50,000/- per bomb blanket.
7. Wireless Sets (Static and Hand Held) as per requirement of security agency.
8. Dragon light at least one per station and vital installation.
9. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
10. Dog Squads (Sniffer Dog), at least one dog for 4 Metro Rail System stations which is at par with current arrangement of Delhi Metro. Cost of one trained sniffer dog is Rs 1.25 Lacs approximately. Dog Kennels along with provision for dog handlers and MI room will also be provided by Metro Rail System train depot administration including land at suitable places line wise.

11. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of Metro Rail System train depot administration Metro Rail System station.

12. Bullet proof jackets and helmets for QRTs and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 Metro Rail System

stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.

13. Furniture to security agency for each security room, and checking point at every entry point at stations. Scale is one office table with three chairs for security room and office of GO and one steel top table with two chairs for checking point.

14. Ladies frisking booth - 1 per security check point (AFC Arrey)
    Wooden Ramp - 1 per DFMD for security check points.

15. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof Morcha, as per requirement.

16. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.

20. The provision procurement of all the above hardware is included in the cost of Stations.

CHAPTER 13

DISASTER MANAGEMENT MEASURE

13.1 INTRODUCTION

“Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation.” Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area”. As per World Health Organization (WHO):

“Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area.”

A disaster is a tragic event, be it natural or manmade, which brings sudden and immense agony to humanity and disrupts normal life. It causes large scale human suffering due to loss of life, loss of livelihood, damages to property and persons and also brings untold hardships. It may also cause destruction to infrastructure, buildings, communication channels essential services, etc.

13.2 NEED FOR DISASTER MANAGEMENT MEASURES

The effect of any disaster spread over in operational area of Metro Rail System is likely to be substantial as Mumbai Metro will be dealing with thousands of passengers daily. Disaster brings about sudden and immense misery to humanity and disrupts normal human life in its established social and economic patterns. It has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro Rail System. Therefore there is an urgent need to provide for an efficient disaster management plan.

13.3 OBJECTIVES:

The main objectives of this Disaster Management Measures are as follows:

- Save life and alleviate suffering.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instill a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation.
- Lay down the actions required to be taken by staff in the event of a disaster in VMRT in order to ensure handling of crisis situation in coordinated manner.
- To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

13.4 LIST OF SERIOUS INCIDENTS REQUIRING USE OF PROVISIONS OF THE DISASTER MANAGEMENT MEASURES

Medium Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

- **Man Made Disaster**
  1. Terrorist attack
  2. Bomb threat/ Bomb blast
  3. Hostage
  4. Release of Chemical or biological gas in trains, stations or tunnels
  5. Fire in Metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
  6. Train accident and train collision/derailment of a passenger carrying train.
  7. Sabotage
  8. Stampede
- **Natural Disaster**
  1. Earthquakes
  2. Floods

13.5 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

A. The National Disaster Management Authority (NDMA)
Establishment of National Disaster Management Authority:-

(1) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (The Disaster Management Act, 2005), an authority to be known as the National Disaster Management Authority.

(2) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:-

(a) The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;
(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disaster Management Authority:

Establishment of State Disaster Management Authority:-

(1) Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(2) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:-

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;
(b) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;
(c) The Chairperson of the State Executive Committee, ex officio.

(3) The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the State Authority.

(4) The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, ex officio: Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority: Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary
(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.
(3) State Level Committee under the chairmanship of Chief Secretary.
(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(iii) The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan and of any amendment thereto, to the District Authority.

13.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

To prevent emergency situations and to handle effectively in case 'one arises' there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

(A) FIRE DETECTION AND SUPPRESSION SYSTEM
(B) SMOKE MANAGEMENT
(C) ENVIRONMENTAL CONTROL SYSTEM (ECS)
(D) TRACK-WAY EXHAUST SYSTEM (TES)
(E) STATION POWER SUPPLY SYSTEM
(F) DG Sets & UPS
(G) LIGHTING SYSTEM
(H) STATION AREA LIGHTS
(I) SEEPAGE SYSTEM
(J) WATER SUPPLY AND DRAINAGE SYSTEM
(K) SEWAGE SYSTEM
(L) ANY OTHER SYSTEM DEEMED NECESSARY

The above list is suggestive not exhaustive actual provisioning has to be done based on site conditions and other external and internal factors.

13.7 PREPAREDNESS FOR DISASTER MANAGEMENT

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their wellbeing seeking their cooperation.

Since learning can only be perfected by 'doing' the following Mock Drills is considered essential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train
f. Hot line telephone communication with state disaster management authority.

13.8 Communication with State Disaster Management Cell.

Operation Control Centre will have a hotline connection with the State Disaster Management cell so as to avoid any time loss in communication of the information.

Chapter - 14

COST ESTIMATES

14.1 INTRODUCTION

Project Cost estimates for the Andheri (E) – Dahisar (E) Metro Corridor has been prepared covering civil, electrical, signalling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction at July 2015 price level.

While preparing cost estimates, various items have generally been grouped under three major heads on the basis of:-

(i) Route km. Length of alignment

(ii) No. of units of that item and

(iii) Item being an independent entity.

All items related with alignment, permanent way, OHE, signalling and telecommunication, have been estimated on rate per route km/km basis. The cost of elevated stations includes civil work for station structures, architectural finishes, platform roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc, have been worked out separately. These rates do not include cost of permanent way, O.H.E., power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, etc, costs have been summed up separately. 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.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-II, Phase-III. A suitable escalation factor has been applied to bring these costs to July 2015 price level. In addition the rates of Civil works have been escalated by 10% to compensate the higher costs in Mumbai compared to Delhi. Taxes & Duties such as Customs Duty, Excise Duty, Sales Tax, Works Tax, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the Andheri(E) – Dahisar(E) Metro Corridor of Mumbai at July 2015 price level works out to **Rs. 4158 Crores** excluding applicable Taxes & Duties of **Rs. 774 crores** as tabulated hereunder.

Table 14.1 – Corridor-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Andheri (E)– Dahisar(E) Metro Corridor (16.475 Km, 16 stations)	4158	774	4932

Details and methodology of arriving at these costs are discussed in paras hereinafter.

14.2 CIVIL ENGINEERING WORKS

14.2.1 Land

Land requirements have been kept to the barest minimum and worked out on area basis. Acquisition of private land has been minimised as far as possible. Elevated alignment is proposed within the Right of way of Western Express Highway and hence no land acquisition for alignment is considered. The land acquisition is required to be done mainly for exit and entries and also for putting station towers for Dahisar Station which has been proposed as low height station.

. Cost of Govt. land is based on the rate presently being charged by the concerned authorities. Private land for MRTS project shall be acquired by MMRDA/ Maharashtra State Government and compensation shall be paid as per Land Acquisition Act 1894. The average rate of private land has been worked out to be Rs.100 Crore per hectare on the basis of latest information available. Similarly average rate for govt. land has been taken 20 Crore per hectare to work out the cost of land.

Provision for Rehabilitation and Resettlement is made separately.

In addition to the lands required permanently, some areas of land (mainly Govt.) are proposed to be taken over temporarily for construction depots. Ground rent charges @ 6% per year for a period of 4 years have been provided for in project cost estimates.

Details of the lands with their costs have been shown in corridor cost estimate.

14.2.2 Formation and Alignment

Elevated section: A good portion of alignment is proposed with elevated viaduct and the rates adopted are based on the completion cost for these works of Phase-II and ongoing Phase-III works, duly updated to July 2015 price level and enhanced by 10% for the higher cost at Mumbai as compared to Delhi.

14.2.3 Stations

Elevated Stations: Rates adopted for elevated stations cover works of station structures, platforms, architectural finishes, covering, etc. Provisions for Electrical and Mechanical works have been made separately. Also provisions for Lifts and Escalators, Viaduct, P-way, O.H.E., Signalling & Telecommunication works, Automatic fare collection installations, etc, have been summed up in the cost estimates.

Mainly three types of stations are proposed for elevated alignment & rates are proposed accordingly.

Type A: Wayside station
Type B: Wayside with Signalling
Type C: Terminal Station

Rates for stations have also been arrived based on Delhi Phase-II and Phase-III accepted rates added by 10% more for higher cost at Mumbai compared to Delhi

14.2.4 Permanent way

For elevated alignment ballastless track and for depot, ballasted track is proposed. Rates adopted are based on similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.3 DEPOT

Maintenance Depot have been planned At Dehisar

14.4 UTILITY DIVERSIONS, ENVIRONMENTAL PROTECTION, MISCELLANEOUS OTHER WORKS

Provisions have been made to cover the cost of utility diversions, miscellaneous road works involved, road diversions, road signages etc. and environmental protection works on route km basis, based on the experience gained from the works done in Phase- II and III of Delhi Metro.

14.5 REHABILITATION AND RESETTLEMENT

Provisions have been made on fair assessment basis, to cover cost of relocation of Jhuggies, shops, residential Houses on private land etc.

Provisions for barracks and security equipment for CISF and Staff Quarters for O&M Wing have been made in the cost estimates on the basis of average cost involved per km length in the recent past.

14.6 TRACTION AND POWER SUPPLY

Provisions have been made to cover the cost of O.H.E., Auxiliary sub stations, receiving substations, service connection charges, SCADA and miscellaneous items, on route km basis separately for underground alignment, elevated and at-grade section as the requirements are different and costs are more for underground section.

Provisions towards cost of lifts, escalators for underground, elevated and at-grade stations have been made in the cost estimates. Rates provided are based on cost of similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level. Provision for mid section shaft is made separately.

14.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based on the completion cost of similar works for Delhi Metro under Phase-II and ongoing Phase-III works. These rates include escalation during manufacturing and supply of equipment and their installation at site.

14.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on accepted rates for similar work of Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.9 ROLLING STOCK

Adopted rates are based on awarded rates of similar works of Phase-II and ongoing Phase-III works duly updated to July 2015 price level considering likely indigenization.

14.10 SECURITY

A lump sum provision for providing security infrastructure in the station premises has been made on running kilometre basis. Adopted rates are as taken in phase III DPR suitably escalated to current price level.

14.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 2.31 Crore per station has been made to have seamless integration of metro stations with other modes of transport. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

14.12 GENERAL CHARGES AND CONTINGENCES

Provision @ 7% has been made towards general charges on all items, except cost of land, which also includes the charges towards Detailed Design Charges (DDC), etc. Provision for contingencies @ 3 % has been made on all items including general charges.

14.13 CAPITAL COST ESTIMATES

14.13.1 Andheri (E) to Dehisar (E) Corridor

The overall Capital Cost for this corridor estimated at July 2015 price level, based on the above considerations works out to **Rs. 4158 Crores** without Taxes & Duties. Taxes & Duties such as Customs Duty (CD), Excise Duty (ED), Sales Tax (ST), Works Tax (WT), VAT, etc, have been worked out as **Rs. 774 Crores.**

Table 14.1

Andheri (E) to Dehisar (E) Corridor

Capital Cost Estimate **July 2015 level**

Total length = 16.475 km Elevated (including elevated ramp) =16.475 km					
Total Station (All Elevated) =16					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	15.78	315.57
b	Private	ha	100.00	1.24	123.73
1.2	Temporary Land for Construction Depot	Ha.	5.00	8.00	40.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.52	16.48	58.04
	Subtotal (1)				**537.34**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	16.48	608.39
2.2	Depot entry connection	R. Km.	36.92	1.00	36.92
	Subtotal (2)				**645.31**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	13.00	378.13
b	Type (A) way side- EM works etc	Each	8.06	13.00	104.80
c	Type (B) Way side with signalling-civil works	Each	28.48	1.00	28.48
d	Type (B) Way side with signalling-EM works etc	Each	8.06	1.00	8.06
a	Type (C), Terminal station -civil works	Each	32.45	2.00	64.90
b	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	2.00	16.12
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	32	78.4
3.3	Metro bhawan, OCC bldg. Staff quarters				
a	civil works	LS			50.00
b	EM works etc	LS			25.00
	Subtotal (3)				**753.89**
4.0	**Maintenance Depot at Dehisar**	LS			
4.1	Depot				
a	Civil works	LS			90.00
b	EM works etc	LS			60.00

	Subtotal (4)				**150.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	**8.58**	17.48	149.94
5.2	Ballasted track for Depot	R. Km.	**4.72**	5.00	23.60
	Subtotal (5)				**173.53**
6.0	**Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R.Km.	10.50	16.48	173.04
	Subtotal (6)				**173.04**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	16.48	263.58
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	5.50	16.00	88.00
	Subtotal (7)				**351.58**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.5 cr/km)** + EM works (**3.5 cr/km**)	R. Km.	8.00	16.48	131.84
	Subtotal (9)				**131.84**
10.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	78.00	764.40
	Subtotal (10)				**764.40**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.30	16.48	4.92
b	EM works etc	R.Km.	0.06	13.27	0.82
	Subtotal (11)				**5.74**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.32	16.48	21.82
b	EM works etc	R.Km.	0.28	16.48	4.68
	Sub Total (12)				**26.49**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	16.00	36.96
	Sub Total (13)				**36.96**
14.0	**Total of all items except Land**				**3270.82**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**228.96**
16.0	**Total of all items including G. Charges except land**				**3499.77**
17.0	**Contingencies @ 3 %**				**104.99**
18.0	**Gross Total**				**3604.77**
	Cost without land			=	**3605**
	Cost with land including contingencies on land			=	**4158**

Table 14.2 Details of Taxes and Duties

Andheri (E)to Dehisar (E) Corridor

Customs duty =	23.4155	%
Excise duty =	12.50	%
VAT =	**12.5**	**%**
Octroi	**4**	**%**

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT(Cr.)		
1	**Alignment & Formation**						
	Underground	0.00	0.00	0.00	0.00		**0.00**
	Elevated, at grade & entry to Depot	645.31		56.46	63.52	14.04	**119.99**
2	**Station Buildings**						
	Elevated station - civil works	549.90		48.12	54.13	11.96	**102.25**
	Elevated station-EM works	128.99	6.04	10.96	12.33	4.09	**29.34**
	OCC bldg-civil works	50.00		4.38	4.92	1.09	**9.30**
	OCC bldg-EM works	25.00	1.17	2.13	2.39	0.79	**5.69**
3	**Depot**						
	Civil works	90.00	6.32	5.51	6.20	2.04	**18.04**
	EM works	60.00	2.81	5.10	5.74	1.90	**13.65**
4	**P-Way**	173.53	32.51	3.69	4.15	5.87	**40.34**
5	**Traction & power supply**						
	Traction and power supply	173.04	16.21	11.03	12.41	5.61	**39.65**
6	**S and T Works**						
	S & T	263.58	49.38	6.59	7.41	8.95	**63.38**
	AFC	88.00	15.45	2.75	3.09	2.97	**21.30**
	PSD	0.00	0.00	0.00	0.00	0.00	**0.00**
7	**R & R hutments**	58.04			3.63	1.16	**3.63**
8	**Misc.**						
	Civil works	153.34		13.42	15.09	3.34	**28.51**
	EM works	47.69		5.07	5.70	1.48	**10.77**
9	**Rolling stock**	764.40	157.51	7.45	8.38	29.74	**173.35**
	Total	**3270.82**	**287.40**	**182.65**	**209.11**	**95.02**	**774.18**
	Total taxes & Duties						**774**

Chapter 15

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

15.1 INTRODUCTION

The Mumbai Metro Rail Project (from Andheri to Dehisar) is proposed to be constructed with an estimated cost of Rs 4628.00 Crore with central taxes and land cost. The route length of the proposed metro rail system and estimated cost at July-2015 price level without central taxes, with central taxes and with all taxes are placed in table 15.1 as under:

Table 15.1 Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)	Estimated cost with all taxes, Octroi & land cost (Rs/Crore)
1	Andheri to Dehisar	16.475	4158.00	4628.00	4932.00

The estimated cost at July-2015 price level includes an amount of Rs.5.74 Crore as one-time charges of security personal towards cost of weapons, barricades, and hand held and door detector machine. However, the recurring cost towards salary and allowances of security personal have not been taken in to account in the FIRR calculation since providing required security at metro stations shall be the responsibility of state police.

15.2 COSTS

15.2.1 Investment Cost

15.2.1.1 For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes has been calculated by taking escalation factor @7.5% per annum. The taxes and duties consist of Custom Duty (CD), Excise Duty (ED), State Value Added Tax (VAT) and Octroi levied by the Brihanmumbai Municipal Corporation (BMC). Mumbai Metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective CD works out to 23.4155% (Basic CD (5%), Countervail Duty (CVD) + Additional Custom Duty (ACD)) on the imported portions, ED @ 12.50% and VAT @ 12.50% on indigenously manufactured items and Octroi @ 4% on supply items, which have been considered for working out the estimated taxes and duties. Service Tax on "Works Contract Services" on new construction pertaining to Metro and Mono Rail Projects is exempted from the Service Tax on date and therefore the same has been considered as Nil in the estimated cost. It has been assumed that Maharashtra State Government will exempt the local taxes or reimburse the same (Sate VAT, Octroi etc) and provide the land worth Rs. Rs. 606 crore on completion cost basis free of cost or shall provide Interest Free Subordinate Debt.

It is assumed that the construction work will start on 01.10.2015 and is expected to be completed on 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2019 for the corridor. The total completion costs duly escalated and shown in the table 15.2 have been taken as the initial investment. The cash flow of investments separately is placed in Table –15.2 as below.

Table 15.2 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost including land cost and central taxes
2015-16	225.00	229.00
2016-17	592.00	648.00
2017-18	1163.00	1369.00
2018-19	1019.00	1289.00
2019-20	815.00	1108.00
2020-21	408.00	596.00
2021-22	406.00	638.00
Total	**4628.00**	**5877.00**

15.2.1.2 Although the construction is expected to get over by 31st March 2019, the cash flow spill over up to March 2022 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

15.2.1.3 The cost of Land of Rs. 606 crore included in the above completion cost will be provided free of cost by the Maharashtra Government or it shall provide Interest Free Subordinate Debt for the same.

15.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 15.3 as under: -

Table 15.3 Additional Investment towards Rolling Stock

(Rs/Crore)

Financial Year	No. of Cars	Amount
2021-22	12	203.00
2043-44	30	1347.00
TOTAL	**42**	**1550.00**

15.2.3 Operation & Maintenance (O&M) 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 consumables
(iii) Energy costs

The requirement of staff has been assumed @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The prevailing rate of electricity in Mumbai is Rs. 8.46 per unit which has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 7.50% per annum. The O&M costs have been tabulated in Table 15.4.1as below.:

Table 15.4 Operation and Maintenance Costs

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2019	-	2020	36.37	24.71	65.62	126.70
2020	-	2021	39.64	26.57	70.54	136.75
2021	-	2022	43.21	28.56	81.13	152.90
2022	-	2023	47.10	30.70	87.22	165.02

YEAR			Staff	Maintenance Expenses	Energy	Total
2023	-	2024	51.34	33.00	93.76	178.10
2024	-	2025	55.96	35.48	100.79	192.23
2025	-	2026	61.00	38.14	108.35	207.49
2026	-	2027	66.49	41.00	116.48	223.96
2027	-	2028	72.47	44.07	125.21	241.76
2028	-	2029	78.99	47.38	134.60	260.97
2029	-	2030	86.10	50.93	144.70	281.73
2030	-	2031	93.85	54.75	155.55	304.15
2031	-	2032	102.30	58.86	182.48	343.63
2032	-	2033	111.50	63.27	196.16	370.94
2033	-	2034	121.54	68.02	210.88	400.43
2034	-	2035	132.48	73.12	226.69	432.29
2035	-	2036	144.40	78.61	243.69	466.70
2036	-	2037	157.40	84.50	261.97	503.87
2037	-	2038	171.56	90.84	281.62	544.02
2038	-	2039	187.00	97.65	302.74	587.39
2039	-	2040	203.83	104.98	325.44	634.25
2040	-	2041	222.18	112.85	349.85	684.88
2041	-	2042	242.17	121.31	441.83	805.32
2042	-	2043	263.97	130.41	474.97	869.35
2043	-	2044	287.73	140.19	510.59	938.51
2044	-	2045	313.62	150.71	548.88	1013.21
2045	-	2046	341.85	162.01	590.05	1093.91

15.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

15.2.5 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, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years.

15.3 REVENUES

The Revenue of Mumbai Metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

15.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on trip distribution at different distance zones.

15.3.2 Traffic

15.3.2.1 a). The projected ridership figures years are as indicated in table 15.5 as below: -

Table 15.5 Projected Ridership

Financial Year	Trips per day (lakhs)
2019-20	4.73
2021-22	5.29
2031-32	6.67
2041-42	7.36

b). The growth rate for traffic is assumed @5.75% Per Annum upto 2021-22, and @ 2.35% per annum upto 2031-32, @ 1% per annum upto 2041-42 thereafter 0% per annum.

15.3.2.2 Trip Distribution

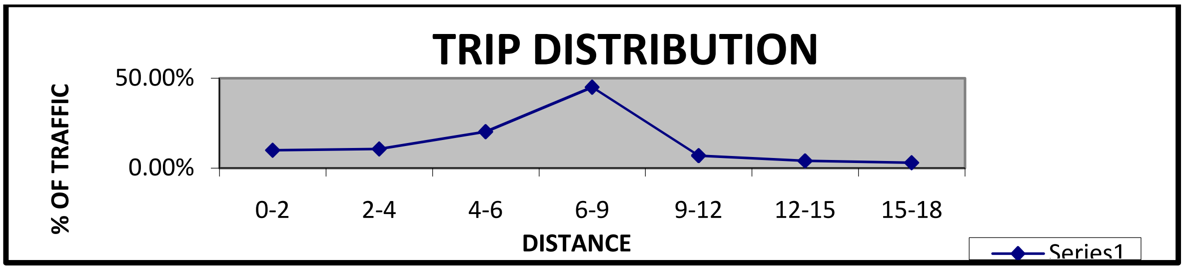
The trip distribution has been worked out by considering average lead of 6.58 KM which is shown in Table 15.6 below: -

Table 15.6 Trip Distribution

Distance in km	Percent distribution
0-2	10.00%
2-4	10.70%
4-6	20.30%
6-9	45.00%
9-12	7.00%
12-15	4.00%
15-18	3.00%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-15.1.

Figure 15.1 –Trip Distribution



Fare Structure

The fare structure for the FY 2019-20 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 15.7 below:

Table 15.7 Fare Structure in 2019-20

Sr. No.	Distance	Proposed Fare in 2019-20
1	0-2	11
2	2-4	13
3	4-6	16
4	6-9	20
5	9-12	22
6	12-15	24
7	15-18	26

The above fare structure has been taken as furnished by MMRDA due to the same having approval of GOM. DMRC proposed that the under mentioned fare structure in the multiple of Rs. 10 be adopted in 2019-20 at the time of commissioning of this Line.

Table 15.8 Fare Structure in 2019-20

Year 2019-20	
SLAB	**FARE (Rs)**
0-3 Kms	10.00
3-12 Kms	20.00
12 Kms and More	30.00

The proposed Fare Structure will have convenience in making use of ticket vending machine and also in issuing the ticket manually without having much effect on total value.

15.3.2.3 Other Sources of Revenues

Other revenues from Property Development and advertisement have been assumed @ 10% of the fare box revenues during first five years of operations and thereafter @ 20% of the fare box revenues. Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises.

15.4 FINANCIAL INTERNAL RATE OF RETURN (FIRR)

15.4.1 The Financial Internal Rate of Return (FIRR) with central taxes & duties and land cost for 30 years business model including construction period is produced in Table 15.9

Table 15.9 –FIRR with Central Taxes (Without Property Development)

Figs in cr. (Rs.)

Year	Outflow					Inflow			Cash Flow
	Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2015 - 201	229				229			0	-229
2016 - 201	648				648			0	-648
2017 - 201	1369				1369			0	-1369
2018 - 201	1289				1289			0	-1289
2019 - 202	1108		127		1235	290	29	319	-916
2020 - 202	596	0	137		733	306	31	337	-396
2021 - 202	638	203	153		994	372	37	409	-585
2022 - 202	0	0	165		165	380	38	418	253
2023 - 202	0	0	178		178	444	44	488	310
2024 - 202	0	0	192		192	455	91	546	354
2025 - 202	0	0	207		207	537	107	644	437
2026 - 202	0	0	224		224	549	110	659	435
2027 - 202	0	0	242		242	650	130	780	538
2028 - 202	0	0	261		261	666	133	799	538
2029 - 203	0	0	282		282	780	156	936	654
2030 - 203	0	0	304		304	798	160	958	654
2031 - 203	0	0	344		344	942	188	1130	786
2032 - 203	0	0	371		371	951	190	1141	770
2033 - 203	0	0	400		400	1109	222	1331	931
2034 - 203	0	0	432		432	1121	224	1345	913
2035 - 203	0	0	467		467	1299	260	1559	1092
2036 - 203	0	0	504		504	1312	262	1574	1070
2037 - 203	0	0	544		544	1520	304	1824	1280
2038 - 203	0	0	587		587	1535	307	1842	1255
2039 - 204	0	0	634		634	1794	359	2153	1519
2040 - 204	0	0	685	625	1310	1812	362	2174	864
2041 - 204	0	1347	805	656	2808	2094	419	2513	-295
2042 - 204	0	0	869	0	869	2094	419	2513	1644
2043 - 204	0	0	939	0	939	2417	483	2900	1961
2044 - 204	0	0	1013	0	1013	2417	483	2900	1887
Total	**5877**	**1550**	**11066**	**1281**	**19774**	**28644**	**5548**	**3419**	**8.20%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 15.10 below : -

Table 15.10 –FIRR (With PD)
Sensitivity Analysis

Capital Cost with Central Taxes but without land cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
7.47%	6.83%	9.03%	9.98%
REVENUE			
20% decrease in Fare Box revenue	**10% decrease in Fare Box revenue**	**10% increase in Fare Box revenue**	**20% increase in Fare Box revenue**
5.27%	6.85%	9.41%	10.50%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
7.78%		**8.61%**	

These sensitivities have been carried out independently for each factor.

15.5 FINANCING OPTIONS

Objectives of Funding: - The objective of funding metro rail systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
  - Low infrastructure maintenance costs
  - Longer life span
  - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai, Bengaluru and Mumbai Line-3 projects are funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

15.5.1 Alternative Models Of Financing

The financing option shall depend upon selection of the dedicated agency created to implement the project. The prominent models are: -

(i) Special Purpose Vehicle under the State Government Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC)

(ii) Built, Operate & Transfer (BOT), and

SPV Model: - The State Government has already constituted a fully owned company in the name of Mumbai Metro Rail Corporation (MMRC), a SPV company and is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The issue of extending JICA loan for the project was discussed informally with JICA India Office. It was told that an informal understanding between GOI & GOJ has taken place. According to which JICA will extend only modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan will be 40 years with 10 years moratorium period. JICA shall extend fund to the extent of 85% of the cost of project excluding cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. However, pending formal notification from the MOF, GOI, the existing terms applicable for JICA loan have been assumed except the quantum of project cost eligible for funding which has been taken as per the new terms. The funding pattern under this model (SPV) is placed in table 15.11 as under: -

Table 15.11 Funding pattern under SPV model (with central taxes and land)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	747.00	14.17%
Equity By GOM	747.00	14.17%
SD for CT by GOM	307.00	5.82%
SD for CT by GOI	307.00	5.82%
1.40% Step Loan from JICA / 12% Market Borrowings	3163.00	60.02%
Total	**5271.00**	**100.00%**
SD for Land by GOM	**606.00**	
Total	**5877.00**	
Interest During Construction	**20.00**	
Grand Total	**5897.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.443.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

BOT Model: - In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Maharashtra will be limited to cost of land only. Such a project become eligible for Viability Gap Funding (VGF) upto 20% from the Central Government provided the state government also contribute same or more amount towards the project. The metro being a social sector project not much private parties are available to bid for such a project. Besides quite expectedly the private operator may demand assured rate of return in the range of 16% to 18% or a comfort of guaranteed ridership. Here the BOT option has been worked out taking 16% pre-tax return to the BOT operator

The funding pattern assumed under this model excluding the cost of land is placed in table 15.12 tabulated as under: -

**Table 15.12 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost)**

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1054.00	20.00%
VGF by GOM	1396.00	26.48%
Equity by Concessionaire	940.00	17.83%
Concessionaire's debt @12% PA	1881.00	35.69%
Total	**5271.00**	**100.00%**
Land Free by GOM	606.00	
Total	**5877.00**	
IDC	29.00	
Total	**5906.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.443.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

15.6. RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 8.20%. The pre-tax Equity FIRR to the BOT operator worked out to 16% with total VGF of Rs.3056.00 crore. Accordingly, the corridors are recommended for implementation on DMRC/BMRCL/CMRL.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 15.13 excluding state taxes.

Table 15.13

Rs. In crore

Particulars	SPV Model	BOT Model
GOI	1054.00	1054.00
GOM	1660.00	2002.00
Total	**2714.00**	**3056.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.443.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Considering the difference, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern given in Table 15.11.

The detailed cash flow statements under various alternatives are enclosed as per the Table 15.12, 15.13, 15.14.

The funding pattern assumed under SPV model & BOT model is depicted in the pie chart i.e., Figure 15.2.1 & 15.2.2 as under: -

Figure 15.2.1
Funding pattern under SPV Model

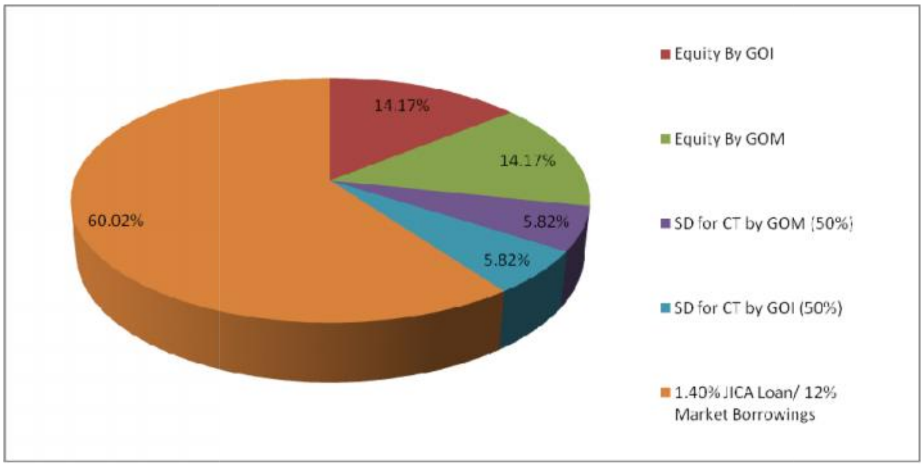
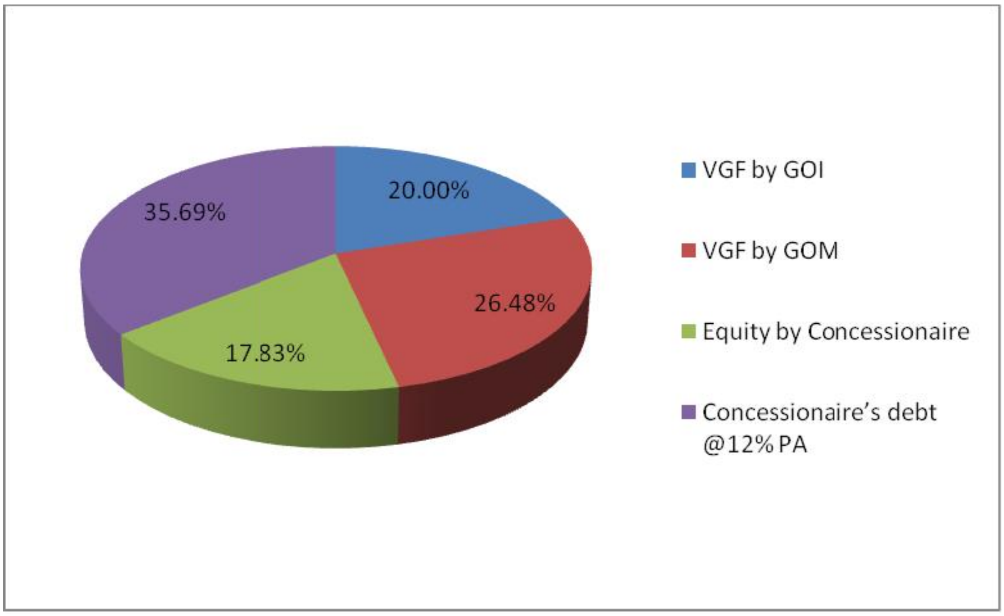


Figure 15.2.2
Funding pattern under BOT Model



	Mumbai Metro (Andheri to Dehisar Corridor													1215	JICA ELIGIBIITY		1948	3163	61.59%			**Table 15.12**
	CAPITAL COST-FIXED			4628											MB		12%	0.00%	0.00%			
	CAPITAL COST - CURRENT			5877											JICA Loan		1.40%	100.00%	1.40%			
	DOMESTIC FUNDING - BASE CASE														Front end Fee (one time)		0.20%		1.40%			
	Year	**Completion Cost**	**Additional Capital**	**Running Expenses**	**Depreciation**	**Replacement Cost**	**Total Cost**	**Fare box Revenue**	**PD & Advertisement**	**Total Revenue**	**Net Cash Flow for IRR**	**Equity from GOI & GOM**	**Availability of cash**	**Cumulative cash**	**Cum. Loan**	**Loan**	**Repayment of Loan**	**IDC**	**Cumulative loan incl. IDC**	**Interest**	**Profit before Tax**	**Cash Balance**	**Cumulative Cash**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	229					229			0	-229	337	108	108	0	0	0	6	6				
2	2016 - 2017	648					648			0	-648	729	81	189	0	0	0	0	6				
3	2017 - 2018	1369					1369			0	-1369	746	-623	-434	434	434	0	3	443				
4	2018 - 2019	1289					1289			0	-1289	528	-761	-1195	1195	761	0	11	1215				
5	2019 - 2020	1108		127	177		1235	290	29	319	-916	374	-734	-1929	1929	734	0		1949	22	-7	170	170
6	2020 - 2021	596	0	137	177		733	306	31	337	-396	0	-596	-2525	2525	596	0		2545	31	-8	169	338
7	2021 - 2022	638	203	153	183		994	372	37	409	-585		-638	-3163	3163	638	0		3183	40	33	13	351
8	2022 - 2023	0	0	165	183		165	380	38	418	253		0	0	0	0	0		3183	45	25	208	560
9	2023 - 2024	0	0	178	183		178	444	44	488	310		0	0	0	0	0		3183	45	82	265	825
10	2024 - 2025	0	0	192	183		192	455	91	546	354		0	0	0	0	0		3183	45	126	309	1135
11	2025 - 2026	0	0	207	183		207	537	107	644	437		0	0	0	0	219		2964	45	209	174	1308
12	2026 - 2027	0	0	224	183		224	549	110	659	435		0	0	0	0	219		2745	41	211	175	1483
13	2027 - 2028	0	0	242	183		242	650	130	780	538		0	0	0	0	219		2526	38	317	281	1763
14	2028 - 2029	0	0	261	183		261	666	133	799	538		0	0	0	0	219		2307	35	320	284	2047
15	2029 - 2030	0	0	282	183		282	780	156	936	654		0	0	0	0	219		2089	32	439	403	2450
16	2030 - 2031	0	0	304	183		304	798	160	958	654		0	0	0	0	219		1870	29	442	406	2856
17	2031 - 2032	0	0	344	183		344	942	188	1130	786		0	0	0	0	219		1651	26	577	541	3397
18	2032 - 2033	0	0	371	183		371	951	190	1141	770		0	0	0	0	219		1432	23	564	528	3925
19	2033 - 2034	0	0	400	183		400	1109	222	1331	931		0	0	0	0	219		1213	20	728	692	4617
20	2034 - 2035	0	0	432	183		432	1121	224	1345	913		0	0	0	0	219		994	17	713	677	5294
21	2035 - 2036	0	0	467	183		467	1299	260	1559	1092		0	0	0	0	97		897	14	895	981	6275
22	2036 - 2037	0	0	504	183		504	1312	262	1574	1070		0	0	0	0	97		799	13	874	960	7235
23	2037 - 2038	0	0	544	183		544	1520	304	1824	1280		0	0	0	0	97		702	11	1086	1171	8406
24	2038 - 2039	0	0	587	183		587	1535	307	1842	1255		0	0	0	0	97		604	10	1062	1148	9554
25	2039 - 2040	0	0	634	183		634	1794	359	2153	1519		0	0	0	0	97		507	8	1328	1413	10967
26	2040 - 2041	0	0	685	202	625	1310	1812	362	2174	864		0	0	0	0	97		410	7	1280	760	11726
27	2041 - 2042	0	1347	805	262	656	2808	2094	419	2513	-295		0	0	0	0	97		312	6	1440	-398	11328
28	2042 - 2043	0	0	869	262	0	869	2094	419	2513	1644		0	0	0	0	97		215	4	1378	1542	12871
29	2043 - 2044	0	0	939	262	0	939	2417	483	2900	1961		0	0	0	0	97		117	3	1696	1861	14731
30	2044 - 2045	0	0	1013	262	0	1013	2417	483	2900	1887		0	0	0	0	97		20	2	1623	1788	16519
		5877	**1550**	**11066**	**5081**	**1281**	**19774**	**28644**	**5548**	**34192**	**8.20%**	**2714**				**3163**	**3163**	**20**		**613**	**17432**	**16519**	
											14418												

Mumbai Metro (Andheri to Dehisar Corridor

Table 15.13

CAPITAL COST-FIXED 4628

CAPITAL COST - CURRENT 5877

MARKET BORROWING 12.00%

DOMESTIC FUNDING - BASE CASE

	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	229					229			0	-229	337	108	108	0	0	0	0	0				
2	2016 - 2017	648					648			0	-648	729	81	189	0	0	0	0	0				
3	2017 - 2018	1369					1369			0	-1369	746	-623	-434	434	434	0	26	460				
4	2018 - 2019	1289					1289			0	-1289	528	-761	-1195	1195	761	0	98	1319				
5	2019 - 2020	1108		127	180		1235	290	29	319	-916	374	-734	-1929	1929	734	0		2053	202	-190	-10	-10
6	2020 - 2021	596	0	137	180		733	306	31	337	-396	0	-596	-2525	2525	596	0		2649	282	-262	-82	-92
7	2021 - 2022	638	203	153	186		994	372	37	409	-585		-638	-3163	3163	638	0		3287	356	-286	-303	-396
8	2022 - 2023	0	0	165	186		165	380	38	418	253		0	0	0	0	0		3287	394	-327	-141	-537
9	2023 - 2024	0	0	178	186		178	444	44	488	310		0	0	0	0	0		3287	394	-270	-84	-621
10	2024 - 2025	0	0	192	186		192	455	91	546	354		0	0	0	0	0		3287	394	-226	-40	-662
11	2025 - 2026	0	0	207	186		207	537	107	644	437		0	0	0	0	164		3123	394	-143	-122	-784
12	2026 - 2027	0	0	224	186		224	549	110	659	435		0	0	0	0	164		2958	375	-126	-104	-888
13	2027 - 2028	0	0	242	186		242	650	130	780	538		0	0	0	0	164		2794	355	-3	19	-869
14	2028 - 2029	0	0	261	186		261	666	133	799	538		0	0	0	0	164		2630	335	17	38	-831
15	2029 - 2030	0	0	282	186		282	780	156	936	654		0	0	0	0	164		2465	316	152	174	-657
16	2030 - 2031	0	0	304	186		304	798	160	958	654		0	0	0	0	164		2301	296	172	194	-463
17	2031 - 2032	0	0	344	186		344	942	188	1130	786		0	0	0	0	164		2137	276	324	346	-117
18	2032 - 2033	0	0	371	186		371	951	190	1141	770		0	0	0	0	164		1972	256	328	349	232
19	2033 - 2034	0	0	400	186		400	1109	222	1331	931		0	0	0	0	164		1808	237	508	530	762
20	2034 - 2035	0	0	432	186		432	1121	224	1345	913		0	0	0	0	164		1644	217	510	532	1294
21	2035 - 2036	0	0	467	186		467	1299	260	1559	1092		0	0	0	0	164		1479	197	709	730	2024
22	2036 - 2037	0	0	504	186		504	1312	262	1574	1070		0	0	0	0	164		1315	177	707	728	2752
23	2037 - 2038	0	0	544	186		544	1520	304	1824	1280		0	0	0	0	164		1150	158	936	958	3710
24	2038 - 2039	0	0	587	186		587	1535	307	1842	1255		0	0	0	0	164		986	138	931	953	4663
25	2039 - 2040	0	0	634	186		634	1794	359	2153	1519		0	0	0	0	164		822	118	1215	1236	5899
26	2040 - 2041	0	0	685	205	625	1310	1812	362	2174	864		0	0	0	0	164		657	99	1185	601	6500
27	2041 - 2042	0	1347	805	265	656	2808	2094	419	2513	-295		0	0	0	0	164		493	79	1364	-538	5962
28	2042 - 2043	0	0	869	265	0	869	2094	419	2513	1644		0	0	0	0	164		329	59	1320	1420	7382
29	2043 - 2044	0	0	939	265	0	939	2417	483	2900	1961		0	0	0	0	164		164	39	1657	1757	9140
30	2044 - 2045	0	0	1013	265	0	1013	2417	483	2900	1887		0	0	0	0	164		0	20	1602	1703	10842
		5877	**1550**	**11066**	**5159**	**1281**	**19774**	**28644**	**5548**	**34192**	**8.20%**	**2714**				**3163**	**3287**	**124**		**6166**	**11801**	**10842**	
											14418												

	Mumbai Metro (Andheri to Dehisar Corridor																							Table 15.14
	CAPITAL COST-FIXED			4628																				
	CAPITAL COST - CURRENT			2821																				
	DOMESTIC FUNDING - BASE CASE																	12.00%						
	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	2015 - 2016	42					42			0	-42	235	193	193	0	0	0	0	0					-235
2	2016 - 2017	300					300			0	-300	235	-65	128	0	0	0	0	0					-235
3	2017 - 2018	416					416			0	-416	235	-181	-53	53	53	0	3	56					-235
4	2018 - 2019	554					554			0	-554	235	-319	-372	372	319	0	26	401					-235
5	2019 - 2020	618		127	86		745	290	29	319	-426		-618	-990	990	618	0		1019	48	58	144	144	144
6	2020 - 2021	253	0	137	86		390	306	31	337	-53		-253	-1243	1243	253	0		1272	122	-8	78	222	78
7	2021 - 2022	638	203	153	92		994	372	37	409	-585		-638	-1881	1881	638	0		1910	153	11	-100	122	-100
8	2022 - 2023	0	0	165	92		165	380	38	418	253		0	0	0	0	191		1719	229	-68	-167	-45	-167
9	2023 - 2024	0	0	178	92		178	444	44	488	310		0	0	0	0	191		1528	206	12	-87	-133	-87
10	2024 - 2025	0	0	192	92		192	455	91	546	354		0	0	0	0	191		1337	183	79	-20	-153	-20
11	2025 - 2026	0	0	207	92		207	537	107	644	437		0	0	0	0	191		1146	160	185	86	-67	86
12	2026 - 2027	0	0	224	92		224	549	110	659	435		0	0	0	0	191		955	138	205	106	39	106
13	2027 - 2028	0	0	242	92		242	650	130	780	538		0	0	0	0	191		764	115	331	232	272	232
14	2028 - 2029	0	0	261	92		261	666	133	799	538		0	0	0	0	191		573	92	354	255	527	255
15	2029 - 2030	0	0	282	92		282	780	156	936	654		0	0	0	0	191		382	69	493	394	921	394
16	2030 - 2031	0	0	304	92		304	798	160	958	654		0	0	0	0	191		191	46	516	417	1338	417
17	2031 - 2032	0	0	344	92		344	942	188	1130	786		0	0	0	0	191		0	23	671	572	1910	572
18	2032 - 2033	0	0	371	92		371	951	190	1141	770		0	0	0	0	0		0	0	678	770	2680	770
19	2033 - 2034	0	0	400	92		400	1109	222	1331	931		0	0	0	0	0		0	0	839	931	3611	931
20	2034 - 2035	0	0	432	92		432	1121	224	1345	913		0	0	0	0	0		0	0	821	913	4524	913
21	2035 - 2036	0	0	467	92		467	1299	260	1559	1092		0	0	0	0	0		0	0	1000	1092	5616	1092
22	2036 - 2037	0	0	504	92		504	1312	262	1574	1070		0	0	0	0	0		0	0	978	1070	6686	1070
23	2037 - 2038	0	0	544	92		544	1520	304	1824	1280		0	0	0	0	0		0	0	1188	1280	7966	1280
24	2038 - 2039	0	0	587	92		587	1535	307	1842	1255		0	0	0	0	0		0	0	1163	1255	9221	1255
25	2039 - 2040	0	0	634	92		634	1794	359	2153	1519		0	0	0	0	0		0	0	1427	1519	10740	1519
26	2040 - 2041	0	0	685	111	625	1310	1812	362	2174	864		0	0	0	0	0		0	0	1378	864	11604	864
27	2041 - 2042	0	1347	805	171	656	2808	2094	419	2513	-295		0	0	0	0	0		0	0	1537	-295	11309	-295
28	2042 - 2043	0	0	869	171	0	869	2094	419	2513	1644		0	0	0	0	0		0	0	1473	1644	12953	1644
29	2043 - 2044	0	0	939	171	0	939	2417	483	2900	1961		0	0	0	0	0		0	0	1790	1961	14914	1961
30	2044 - 2045	0	0	1013	171	0	1013	2417	483	2900	1887		0	0	0	0	0		0	0	1716	1887	16801	1887
		2821	**1550**	**11066**	**2715**	**1281**	**16718**	**28644**	**5548**	**34192**	**15.39%**	**940**				**1881**	**1910**	**29**		**1584**	**18827**	**16801**		**16.04%**
											17474													

Chapter - 16

ECONOMIC APPRAISAL

16.1 INTRODUCTION

Economic benefits are social and environmental benefits which are quantified and then converted into money cost and discounted against the cost of construction and maintenance for deriving Economic Internal Rate of Return (EIRR). When actual revenue earned from fare collection, advertisement and property development are discounted against construction and maintenance cost, interest (to be paid) and depreciation cost, Financial Internal rate of Return (FIRR) is obtained. Therefore, EIRR is viewed from socio-economic angle while FIRR is an indicator of pure financial profitability and viability of any project.

Economic appraisal of a project starts from quantification of measurable economic benefits in economic money values, which are basically the savings of resource cost due to introduction of the metro line. Economic savings are derived from the difference of the cost of the same benefit components under 'with' and 'without' metro line.

In highway construction projects, 'without' is taken as "base case" and 'with' implies 'alternative case'. In 'alternative case' a portion of traffic on the road is diverted to a new road which is estimated first. Then the difference between maintenance & construction cost for 'base case' and for 'alternative case' which is known as relative road agency cost (RAC) is derived. Difference between road user cost for 'base case' and of 'alternative case' is also derived which is known as relative road user cost (RUC). Difference between RAC and RUC calculated for each year generates net benefit stream. Economic indicators (EIRR, BC Ratio, NPV) are the obtained.

In metro projects, same principal is followed but procedure is slightly different. Here, diverted traffic is nothing but the passengers shifted from road based modes to metro. Travel time saving is the difference between time which would be taking on metro and road based transports for same distance. Fuel cost saving is the difference between the cost of the fuel burnt on road based modes by the shifted passengers and the energy cost of running the metro rail which is a part of the maintenance cost. Thus benefits are directly obtained by correlating with them with the passenger km (ridership and average trip length is multiplied to get passenger km). As is done in highway projects, net benefit is obtained by subtracting the cost of the project (incurred for construction (capital) and maintenance (recurring) costs for the metro line) from the benefits derived from pass km savings in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first three (no 3-5, given in **Table 16.1**) are direct benefits due to shifting of trips to metro, but other secondary benefit components are due to decongestion effect on the road, reduction of emission, accident, saving of fuel and time by remaining road passengers and road maintenance cost.

Cost components are first estimated applying market values then distributed year wise after applying escalation factors. This is commonly known as completion cost. Tax components are added while arriving at completion cost. For financial analysis these exercises are necessary, but for economic analysis all additional cost components from the asset values are to be removed.

Values of Benefit components are mostly Economic values except fuel and vehicle maintenance cost which are estimated from market cost. Economic factors which are used for each components are also given in table 16.1. Overall economic value of benefit components is 93% of the estimated value.

Table 16.1: Cost/Benefit Components due to Metro

	Cost/Benefit Components	Economic Factors
1	Construction Cost	Derived
2	Maintenance Cost	Derived
3	Annual Time Cost Saved by Metro Passengers	100%
4	Annual Fuel Cost Saved by Metro Passengers	80%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	80%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	100%
9	Annual Fuel Cost Saved by Road Passengers	80%
10	Annual Infra Structure Maintenance Cost	100%

16.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in table 16.2.

Table 16.2: **Values adopted for some important variables**

	Values	Important variables
1	Rs. 0.51/min (2014 value)	Weighted value of Travel Time is derived[1] from cost of travel and respective vehicle operation cost for every mode used by workers and non workers (table 16.7).
2	Market rate of fuel cost	Adopted value of Petrol, Diesel and CNG.(table 16.3 bottom row)
3	Table 16.3	Vehicle Operating Cost per km (Derived from Life Cycle Cost of different passenger vehicles)
4	Table 16.4	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton).
5	Table 16.5	Accident Rate (No of fatal and all accidents per one Cr.KM). Accident costs are derived from earning in remaining life and published papers.
6	13.26%	Passenger km – Vehicle km conversion factor derived from House Hold Survey and Modal Split survey within study area
7	Graph 16.1	Fuel Consumption of vehicles at a given speed is derived from Road User Cost Study Model (CRRI-2010)
8	Rs. 0.5/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km
9	21.92 min	Weighted average Journey Time Saved for average trip length (km) journey after Shifting (Derived from modal split -Table 16.7 and speed and delay survey)
10	25.51 kmph	Average Journey Speed (Speed and delay Survey)

Table 16.3: Vehicle Operating Cost (VOC) in Rs.

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	4.84	3.78	2.22	0.93	0.88	2.40	2.99
Capital Cost	4.81	4.27	1.87	0.29	0.19	1.20	2.57
Vehicle Maintenance Cost including overhead	10.61	8.85	4.50	1.34	1.18	3.96	6.12
Fuel Cost	9.38	5.02	3.11	1.07	1.07	3.09	4.75
VOC (with fuel)	19.99	13.87	7.61	2.41	2.25	7.05	10.87

As there is substantial number of trips by local train (EMU), VOC cost of train is derived from energy (electricity) consumed which is about Rs. 175.5 per train km carrying 3000 passenger and running @33 km per hour. Energy charges is taken as Rs. 8 per KWH.

[1] Workers value of time is Rs. 1.38 and non workers value of time is Rs.0.61. 70% are work and business related trips and 30% of non work trips (source: traffic study report) Assuming workers will be metro users, same value of time is taken. For 2021 it will be Rs.2.08

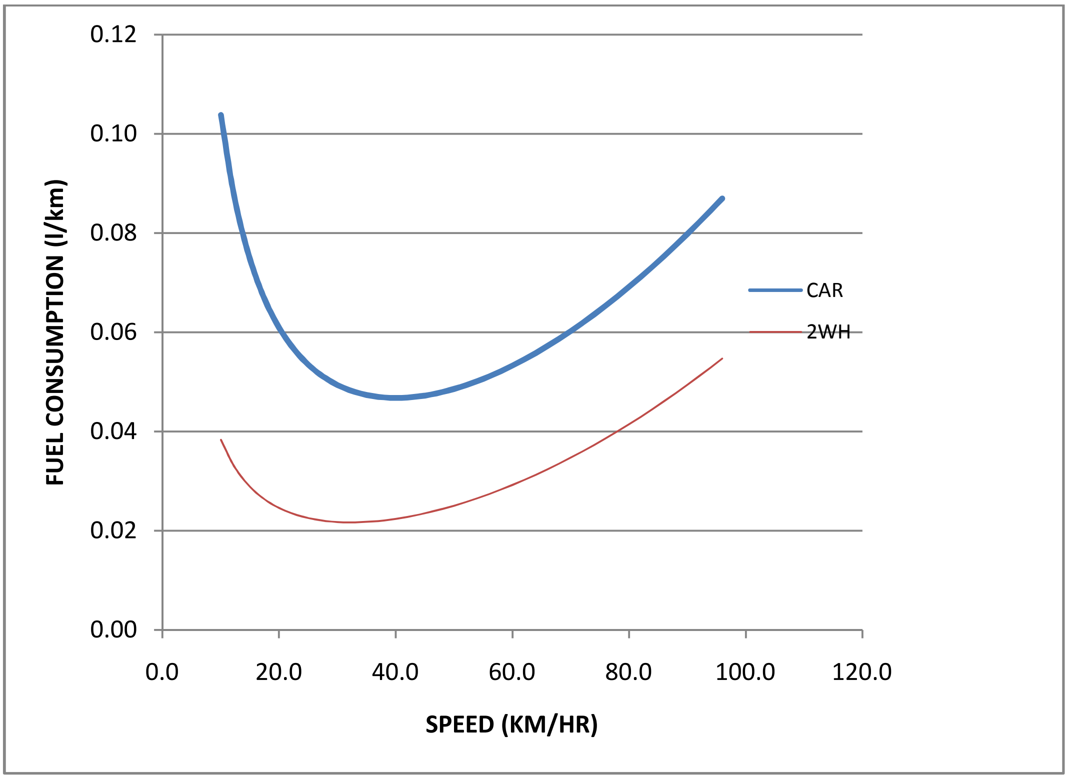
Table 16.4: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

VEHICLE	CO	HC	NOX	PM	CO	CO2
BUS	3.72	0.16	6.53	0.24	3.72	787.72
2W-2 STROKE	1.4	1.32	0.08	0.05	1.4	24.99
2W-4 STROKE	1.4	0.7	0.3	0.05	1.4	28.58
MINI BUS	2.48	0.83	8.26	0.58	2.48	358.98
4W-SMALL	1.39	0.15	0.12	0.02	1.39	139.51
4W-LARGE	0.58	0.05	0.45	0.05	0.58	156.55
TATA MAGIC	1.24	0.17	0.58	0.17	1.24	160
3W	2.45	0.75	0.12	0.08	2.45	77.89
Cost	RS. 100000 PER TON					500

Table 16.5: Accident Rate and Cost in Rs

Expected Accident Rate in the year 2021	/Cr. Vehicle KM	Average Cost in lakh Rs
All Types except Fatal.	1.82	2.30
Fatal Accident.	0.22	10.26

Figure 16.1 Fuel Consumption/against speed graph for Car and two wheeler



Traffic demand estimates used for economic analysis are given in table 16.6 and 16.7.

Table 16.6: Summary of the Ridership

Particulars	2021	2031	2041
Trips/day	528690	667698	737554
Average Trip length (km)	6.58	6.58	6.58
Passenger km	3478780	4038023	4550145
Passenger km/km	222870	258698	291508

Source: Traffic Study Report

In this area, public transport system is good (passenger - train 71.6%, Bus 19.58%). Personalised mode passenger (car, and two wheelers)-trips are 6.61% and IPT modes are carrying 2.2% passengers. Vehicular trips made by Public modes is 13% and 19% by IPT modes and 68% are private transport.*(Source: Comprehensive Transportation Study for Mumbai Metropolitan Region, April 2008, Lea Associates- derived from table 3-2)*. Mode share of shifted to metro passengers are obtained by assuming that 5% train passenger will shift to metro and from other modes it will be 33% and the share is shown in table 16.7.

Table 16.7 Mode Share in the Study Area

Modes	Vehicle	Passenger
Bus	7.53%	39.92%
Train	0.07%	27.64%
Two Wh.	37.63%	7.49%
Four Wh.	35.11%	10.60%
Three Wh.	14.96%	4.37%
Private Bus & Others	4.70%	9.98%
	100.00%	100.00%

16.3 ECONOMIC BENEFIT STREAM

For deriving the values of economic indicators (EIRR, NPV, BCR), cost and benefit stream table is constructed in terms of money value. Socio-Economic Benefits are first quantified and converted in to money cost. All Benefit component values (economic) accrued between the years 2021-2045 are shown in figure 16.2 which shows that benefits are mainly coming from saving of travel time by metro and road passengers (48.39%), fuel saving cost (39.25%), vehicle maintenance cost (10.8%) and Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 1.56%.

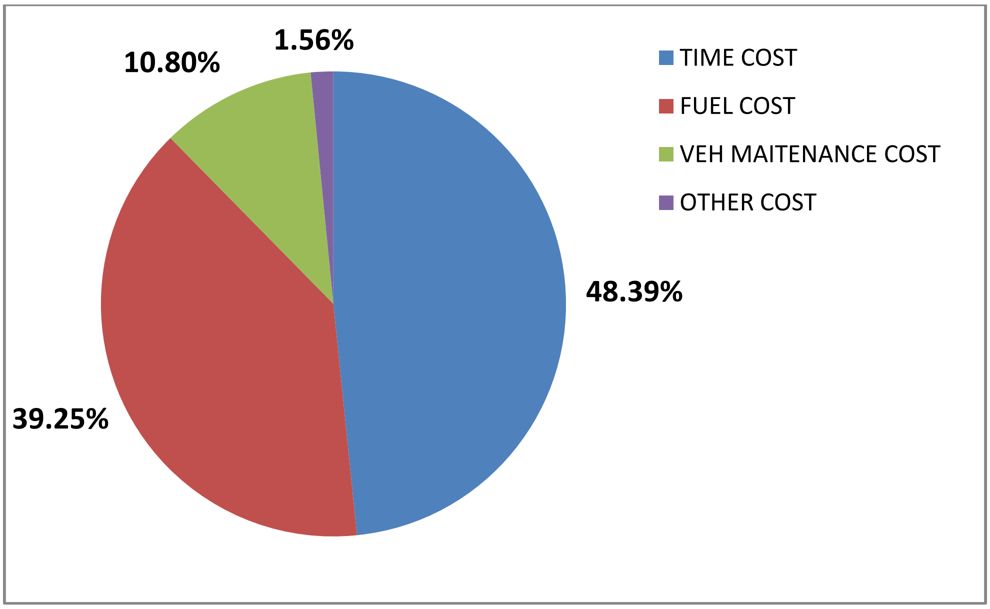


Figure 16.2 Percent of Benefits

Benefits are obtained directly from the projected passenger km saved for the horizon years (shown in table 16.6) and the values for other years are interpolated and extrapolated on the basis of projected traffic. Benefit Components Stream for proposed line is shown in table 16.8.

Table 16.8 Component wise Stream of Economic Benefit Value

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Maintenance Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2019	2020	395.70	357.32	101.18	11.08	3.22	12.33	1.00	9.58	891
2020	2021	439.78	393.74	111.34	12.19	3.54	14.24	1.25	9.90	986
2021	2022	488.77	434.37	122.51	11.51	3.89	16.30	1.52	10.23	1089
2022	2023	543.21	478.74	134.81	10.57	4.28	18.51	1.80	10.58	1203
2023	2024	603.72	527.88	148.35	11.63	4.71	18.35	2.10	10.94	1328
2024	2025	670.97	581.89	163.24	12.79	5.19	20.54	2.40	11.31	1468
2025	2026	745.71	641.26	179.63	14.08	5.71	22.91	2.73	11.69	1624
2026	2027	828.78	706.95	197.66	15.49	6.28	25.48	3.08	12.09	1796
2027	2028	921.10	778.63	217.50	17.05	6.91	28.28	3.46	12.50	1985
2028	2029	1023.70	858.49	239.34	18.76	7.61	32.02	3.97	12.92	2197
2029	2030	1122.60	932.44	259.86	20.37	8.26	35.63	4.53	13.18	2397
2030	2031	1231.05	1014.48	282.14	22.11	8.97	39.50	5.14	13.44	2617
2031	2032	1349.98	1201.45	334.19	26.19	9.74	49.36	6.30	14.96	2992
2032	2033	1480.40	1307.24	362.84	28.44	10.57	54.42	7.05	15.26	3266
2033	2034	1623.42	1418.56	393.96	30.88	11.48	59.87	7.85	15.57	3562
2034	2035	1780.25	1543.53	427.74	33.53	12.46	65.73	8.71	15.88	3888
2035	2036	1952.24	1674.38	464.42	36.40	13.53	72.04	9.63	16.20	4239
2036	2037	2183.87	1858.59	514.38	40.32	14.99	80.42	10.82	16.86	4720
2037	2038	2373.01	2001.88	553.34	43.37	16.12	87.10	11.79	17.03	5104
2038	2039	2578.53	2156.21	595.26	46.66	17.34	94.34	12.85	17.20	5518
2039	2040	2801.85	2322.44	640.35	50.19	18.66	102.18	14.00	17.38	5967
2040	2041	3044.51	2501.49	688.85	53.99	20.07	110.67	15.25	17.55	6452
2041	2042	3308.19	2694.34	741.03	58.08	21.59	119.86	16.62	17.73	6977
2042	2043	3594.71	2902.06	797.17	62.48	23.22	129.82	18.10	17.91	7545
2043	2044	3906.03	3125.79	857.55	67.22	24.98	140.61	19.73	18.09	8160
2044	2045	4244.33	3366.77	922.51	72.31	26.88	152.29	21.49	18.27	8825

16.4 METRO CONSTRUCTION COST

Total cost of metro construction (**Completion cost**) is derived after considering cost of all major component such as Relocation and Rehabilitation (RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. (**Recurring cost**) includes energy cost, maintenance cost, and operation cost. These costs are inclusive of central tax and yearly escalation cost applied on fixed cost. Analysis period is taken from 2015-16 to 2044-45 out of which 4 years (2015-2019) are marked as construction period. During the years 2021-22, additional capital will again be required for rolling stock and in 2040-41-42 major repairing and replacement cost is envisaged. Operation is expected to start in 2019-20 (4th Year).

To obtain economic cost, escalation factors (7.5%) are removed from the completion cost. Tax is removed from fixed cost which is 10.16%. After that economic factors are applied. While estimating, design charges are kept as 5% and contingency charges are kept as 3%. Following this argument, economic cost is derived. Cost stream generated for both options are shown in **Table 16.9.**

Table 16.9: Completion and Economic Cost stream

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2015	2016	229	0	206	0
2016	2017	648	0	542	0
2017	2018	1369	0	1064	0
2018	2019	1289	0	932	0
2019	2020	1108	127	745	85
2020	2021	596	137	373	86
2021	2022	841	153	490	89
2022	2023	0	165	0	89
2023	2024	0	178	0	90
2024	2025	0	192	0	90
2025	2026	0	207	0	90
2026	2027	0	224	0	91
2027	2028	0	242	0	91
2028	2029	0	261	0	92
2029	2030	0	282	0	92
2030	2031	0	304	0	92
2031	2032	0	344	0	97
2032	2033	0	371	0	97
2033	2034	0	400	0	98
2034	2035	0	432	0	98
2035	2036	0	467	0	99
2036	2037	0	504	0	99

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2037	2038	0	544	0	100
2038	2039	0	587	0	100
2039	2040	0	634	0	100
2040	2041	625	685	92	101
2041	2042	2003	805	275	110
2042	2043	0	869	0	111
2043	2044	0	939	0	111
2044	2045	0	1013	0	112

16.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **table 16.10**. Project period is 2015-2045, On the basis of completion cost, EIRR is found to be **22.06%** and B/C ratio as **4.9** and with 12 % discount, EIRR is **8.98%** and B/C ratio is **2.05**. NPV without discount is Rs **77023** Cr. and with 12% discount rate, NPV is Rs. **6174** Cr. In this case (completion cost) escalation factor of 7.5% is applied on both cost and benefit components. On the basis of economic cost, EIRR is 27.9% B/C Ratio is 14.2 and NPV is 89567, both shows that the project is economically viable.

Table 16.10: Economic Indicator Values (2044-45)

ANDHERI-DAHISAR	(Completion Cost Basis)		(Economic Cost Basis)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	19774	5883	7230	3669
Cumulative benefit(Cr.)	96797	12056	96797	12056
Benefit Cost Ratio	4.90	2.05	13.39	3.29
NPV(Cr.)	77023	6174	89567	8388
EIRR	22.06%	8.98%	27.90%	14.20%

16.6 SENSITIVITY ANALYSIS

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 16.11**. 2044-45 is taken for the year of comparison.

Table 16.11 Sensitivity of EIRR (Completion Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	22.06%	4.90	19774	8.98%	2.05	5883
-10%	0%	20.38%	4.41	19774	7.48%	1.84	5883
-20%	0%	18.61%	3.92	19774	5.90%	1.64	5883
0%	10%	20.54%	4.45	21751	7.62%	1.86	6471
0%	20%	19.21%	4.08	23729	6.44%	1.71	7059
-10%	10%	18.94%	4.01	21751	6.20%	1.68	6471
-20%	20%	16.04%	3.26	23729	3.61%	1.37	7059

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 16.04%.

16.7 QUANTIFIED BENEFITS.

Benefits which are shown in previous tables are money value of the benefits. These benefits are estimated first and the converted into money value. For brevity, only 5 year estimates are shown in **table 16.12** (Reduction of Vehicle gas Emission) and in **table 16.13** (Reduction of Fuel, Time of Travel, Vehicle on Road etc).

Table 16.12 Environmental Benefits Quantified

Tons/Year	2021	2022	2023	2024	2025
CO	433.05	443.28	453.75	389.10	321.15
HC	221.78	227.02	232.38	173.35	111.40
NOX	131.98	135.10	138.29	141.69	145.17
PM	18.43	18.86	19.31	16.77	14.10
SO2	1.19	1.22	1.25	1.17	1.10
CO2	26073	26689	27319	27964	28625
Total Emission Saved	26880	27514	28164	28687	29218

From Table 16.13, it may be seen that in 2021, due to shifting, metro passengers time saving will be 7.2 Cr. (10 million) hour, fuel saving by metro passengers will be 30.89 thousand tons. Amount of travel in terms of passenger km reduced due to shifting to Metro Rail is equivalent to reduction of 9922 vehicles from the road. About 4 fatal accidents and 30 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the area.

Table 16.13 Travel Benefits Quantified

Quantified Benefits in Horizon Years	2021	2022	2023	2024	2025
Annual Time Saved by Metro Passengers in Cr. Hr.	7.20	7.44	7.69	7.95	8.22
Annual Fuel Saved by Metro Passengers in thousand Tons.	30.89	31.82	32.67	33.63	34.54
Daily vehicles reduced (off the road)	9922	10156	10396	10642	10893
CO2 reduced in thousand tons	26.07	26.69	27.32	27.96	28.62
Other gases reduced in thousand tons	0.81	0.83	0.84	0.72	0.59
Reduced No of Fatal Accidents in Year	4.12	4.22	4.32	4.42	4.53
Reduced No of Other Accidents in year	29.60	30.30	31.01	31.74	32.49
Annual Vehicle km Reduced in Cr. Km.	18.52	18.96	19.41	19.87	20.34

CHAPTER 17

IMPLEMENTATION

17.1 Introduction

The Andheri (E)–Dahisar (E) Corridor is one of the corridors, with route length of 16.475 Kms.

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 4628 crores exclusive of State taxes and Octroi of Rs 304.13 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 5877 crores excluding State taxes and Octroi of Rs 443 Crores.

To make the project financially sustainable DMRC recommended that the all State taxes and duties fully waived for this project in which case Government of India will come forward to fund the central taxes and duties to the extent of 50% through grant by subordinate debt. The State Government will have to meet 50% of the Central taxes and duties as well. When Metro projects are taken up, total funding for the project to be kept in view and not merely the present estimated cost. For this purpose DMRC has calculated separately completion cost of this project with or without taxes assuming that the project would take 4 years for completion.

17.2 Possible models for financing a Metro project:–

1. A Build, Operate & Transfer (BOT)
2. A Private Public Partnership (PPP) and
3. Fully through Government funding i.e. Government mobilizing all the funds required for the project through equity, grants or loans borrowed by the Government.

Possibilities, implications of the 3 models mentioned above are discussed below :-

1. **BOT model:**

Under this model the project is handed to a Consortium for a specified period of time, selected through competitive bidding. The consortium will bring in all the funds required for the project, appoints consultants for design, planning and project implementation, execute the project fully and then operate and maintain the same during concession period. All the revenues from the project, fare box collections as well as non-fare box collections will go to the Consortium and in all the concession period the project is handed over to the Consortium. Here the Government responsibility is only to make available the required land and right of way and monitor the quality of services and safety standards. Building the system to the specified safety standards and obtaining the safety certificate from the competent authority will be the responsibility of the BOT operator. In this model the Government has no financial liability and all the risks are carried by the BOT operator. The Government may or may not stipulate the fares to be levied.

2. **PPP model:**

There are essentially two variants under this model.

Variant 1:- Here the Government funds the fixed infrastructure cost such as land and basic civil structures and private investor funds all the systems such as rolling stock, signalling, power supply, traction, track, fare collection system and E&M works including station architectural design. An example for this is Delhi Metro Airport line. Under this arrangement, the Government's investment will be about 40 to 45% of the total cost and the PPP Operator funds the remaining cost. The operator is selected again on competent bidding with viability gap funding who operates and maintains the system to the specified service safety levels. All the Revenues will accrue to the Operator in all the concession period till the project is handed over to the owner. Ridership for this is taken by the Operator fully or shared between the operator and the owner.

Variant 2:- Under this the Government acquires the required land and offers to the concessionaire free of cost. The private partner funds all the rest of the project, operates and maintains the system taking all the revenues and risks. His expected losses are made good through a viability Gap Funding (VGF), by the Government arrived at based on competitive bidding. At the end of concession period the system reverts to the owner. Under the PPP model, Sweeteners are sometime offered to the operator in the form of lands for commercial exploitation. Private management generally ensures better efficiency in the execution and operation of the system compared to a Government agency.

When the project is taken up on BOT or PPP model the total cost of the project generally gets hiked up by the Concessionaire adding the availing additional costs.

1. As bulk of the funds will be through borrowings. Interest during construction period will get added on to the projects costs.
2. The funds are available to a private party to which borrowing costs compared to the Government and additional funding cost will get factor to the cost of the project.
3. When a private party executes the project the refunds of the taxes and duties of the two Governments may not be possible. This alone will increase the cost of project by 18 to 20%.
4. Metro projects by themselves will not be financially viable. Commercial exploitation of surplus lands and identified Governments lands along the route has to be necessary to augment the Capex as well as revenue earnings. Making available normal land free to the Concessionaire for commercial exploitation will lead to public criticism and often end up in scandals.

Nowhere in the country a complete BOT or PPP model has so far found successful or attractive for the main reason that the fare levels have to be kept low and affordable to the common citizens.

3. Fully through Government funding:-

Here, the Government takes full responsibility for funding the project either from its own resources or through borrowings. For convenience and speedy execution a Special Purpose Vehicle is set up and given the mandate to execute the project. The Operation and maintenance of the system can be either directly by the SPV or they can engage an operator for the purpose. Usually a debt equity ratio of 2:1 is followed but there can be variations depending upon the tender's terms and the Government's ability to provide funds. The government's own investment will be in the form, of share holdings in the SPV and borrowings can be either from a Consortium of local banks or from infrastructure funding organizations such as IIFCL, IDBI, etc. or through an external bilateral loan from institutions such as ADB, World Bank, JICA etc. All the loans will need Governmental guarantee to reduce the borrowing cost. The Government can also assist the SPV with interest free subordinate loans. The SPV will have responsibility to service and pay back the loan and if SPV fails the responsibility will then devolve on the Government.

17.3 The recommended financial model for Andheri (E)–Dahisar (E) Corridor

The Andheri (E)–Dahisar (E) Corridor is one of the phase–III corridors, with route length of 16.475 Kms and its completion cost of Rs 5877 Crores**.** World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for the Andheri (E)–Dahisar (E) Corridor is **8.20%**.

The only Metro which has been implemented on BOT model so far is the Rapid Metro in Gurgaon. Financially this Metro has been a total failure since the revenues are not able to meet even the interest payment on the loans raised.

Out of the 3 PPP models in the country, Delhi Airport Line has been a total failure since the Concessionaire has voluntarily withdrawn with claims through arbitration. In the case of Bombay Metro Line No.1 which is only 11 Kms length had taken more than 6 years for completion and the cost had gone up 2 times. Concessionaire is representing to government for allowing him to charge very high fare in spite of very good ridership leading to loading the public financially.

In the case of the Hyderabad Metro the PPP Concessionaire withdrew from the project and another Concessionaire namely L&T is implementing the project. The financial performance of this project is yet to be assessed as even one section of the project is still not opened for traffic. Considering the global scenario and the experience in our own country DMRC does not recommend either the BOT model or PPP route for implementing the Andheri (E)–Dahisar (E) Corridor.

It is therefore recommended that the project is implemented fully as a Government initiative. By this route the project can be completed at the shortest time and at the lowest cost. This is important because then only ticket can be priced low, affordable to the common citizens and make the system truly a popular public transport.

17.4 Institutional arrangements

The State Govt. of Maharashtra will have to approve the implementation of the project by Mumbai Metro Rail Corporation Ltd or MMRDA.

17.5 Implementation Strategy

When the project is taken up as a Government initiative there are two ways the projects can be implemented. One is – Mumbai Metro Rail Corporation Ltd. (MMRC) /MMRDA handling the project directly with the help of General Consultants (G.C.). Further bilateral lending agencies generally insist of international consultants to engage as G.C. for assisting for the implementation of the project. International G.C. is required for planning, design, drawing up specifications, preparation of tender documents, finalisation of contract and supervision of the project during execution. To engage the G.C. globally tenders would be necessary. For finalizing such a global contract and positioning the Consultants itself takes about 9 to 12 months. G.C. will generally cost about 3½ to 4% of the project cost. Even if G.C. is engaged, still MMRC/MMRDA will need a fairly big organisation to oversee the G.C. work. It will be difficult for MMRC/MMRDA to mobilize required technical persons with experience and knowledge and the establishment cost of MMRC/MMRDA itself would be about another 3½ to 4%. Thus about 7 to 8% of the project cost will be spent on total establishment alone.

The 2nd option is MMRC/MMRDA for this project can be a very small lean organisation responsible for land acquisition and mobilisation of funds. The entire Metro project can be entrusted on turnkey basis and on deposit terms to an experienced organisation such as DMRC who has the experience and track record and competency of technical manpower. DMRC is implementing on similar basis Jaipur Metro for Rajasthan Government and Kochi Metro for Kerala Government and Greater Noida Metro project for the Greater Noida Authority. The same way the Andheri (E)–Dahisar (E) Corridor can also be handed over to DMRC on a turnkey basis for implementation. DMRC generally charges 6% of the project cost for the total turnkey implementation. This will be the cheapest and quickest way of completing the project in time.

17.6 Contract Packages for Implementation of The Andheri (E)–Dahisar (E) Corridor Project

The Andheri (E)–Dahisar (E) Corridor is one of the phase–III corridors, with route length of 16.475 Kms.

Package –1: Starting from chainage (-)450m and upto Kurar village(Including) proposed metro station.

Package – 2: Starting just after Kurar village and upto dead end of Dahisar (E).

Package - 3: Detailed design consultant for both the corridors including Depot.

Package - 4: Construction of boundary wall for depot, earth work filling and construction of workshop, inspection bay, stabling lines etc.

Package – 5 System Contracts: Supply and installation of traction power system (3rd bay) including sub-station.

Package - 6: Supply and installation of signaling system (CBTC)

Package - 7: Supply and installation of AFC System.

Package - 8: Supply and commissioning of rolling stock.

Any other small package may be decided at the time of implementation of the Project.

17.7 Implementation Schedule

A suggested project implementation schedule for Project Implementation on Turnkey Basis (Deposit Terms) is given in Table 17.1

Table 17.1 Project Implementation on Turnkey basis (Deposit Terms)

S.No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D+15 days
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D+30 days
4.	Sanction of Project by GOI	D+60 days
5.	Appoint an agency on deposit terms	D+30 days
6.	Implementation of the project	D+43 months
7.	Testing and Commissioning	D+44 months
8.	CMRS Sanction	D+45 months
9.	ROD	D+ 45 months

17.8 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 should be 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 Ltd. It is reliably learnt that for the 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.

17.9 Concession 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. With reasonable fare level, 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. Following are the taxes and duties, which have to be borne by a metro 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.

As in the case of Delhi Metro, the State Government should exempt/reimburse the Maharashtra Value Added Tax (VAT) to this Metro project. It should also exempt the following:

As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Maharashtra State Government may pursue the Central government to extend the same benefit to MMRC.

In the case of Delhi Metro project, the Union Government has granted exemption from payment of Custom Duty and Excise Duty while the Delhi Government has agreed to give exemption from payment of Sales Tax and on works contracts. Delhi Metro Rail Corporation is also pursuing with the Government for exemption from tax on electricity being consumed by Delhi Metro for its operation and maintenance.

It is recommended that similar exemptions from taxes and duties be granted by the Central Government/Maharashtra Government for Mumbai Metro. In this connection it may be mentioned that the Central Government has been encouraging infrastructure projects in the country through fiscal and non-fiscal concessions. Cities have emerged as the engines of growth and mass transport systems today are one of the most important pre-requisites for the balanced growth of the city. The Government can demonstrate the importance it attaches to this sector by granting the above concessions which would not only help reduce the initial cost of the project so that Mumbai Metro remains commercially viable during its operation phase but also send strong signals to the effect that it is committed to a safer and pollution free city. Moreover, public transport is employment-friendly and favours social balance in a sustainable way since it allows access to jobs and services to all.

17.10 Legal Cover for Mumbai Metro

Implementation of proposed **Andheri (E)–Dahisar (E)** Metro can now be done under “The Metro Railways (Amendment) Act 2009”. The copies of the Gazette notification and the amendment are put up enclosure to this chapter.

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रजिस्ट्री सं॰ डी॰ एल॰-33004/99

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असाधारण
EXTRAORDINARY

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PART II—Section 3—Sub-section (ii)

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शहरी विकास मंत्रालय
(मैट्रो रेल प्रकोष्ठ)
अधिसूचना
नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे ।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

विमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT
(Metro Rail Cell)
NOTIFICATION
New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/Bhadra 5, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[26*th August*, 2009.]

An Act further to amend the Metro Railways (Construction of Works) Act, 1978 and to amend the Delhi Metro Railway (Operation and Maintenance) Act, 2002.

BE it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

Short title and commencement

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009.

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (*3*), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area".

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

'(*ka*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (*2*), after clause (*b*), the following clauses shall be inserted, namely:— Amendment of section 6.

"(*ba*) develop any metro railway land for commercial use;

(*bb*) provide for carriage of passengers by integrated transport services or any other mode of transport;".

9. Section 7 of the Delhi Metro Railway Act shall be renumbered as sub-section (*1*) thereof and after sub-section (*1*) as so renumbered, the following sub-section shall be inserted, namely:— Amendment of section 7.

"(*2*) The Commissioner shall function under the administrative control of the Chief Commissioner of Railway Safety appointed under section 5 of the Railways Act, 1989.". 24 of 1989.

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:— Substitution of new section for section 12.

"12. The Chief Commissioner of Railway Safety shall, for each financial year, prepare in such form, and within such time, as may be prescribed, an annual report giving a full account of the activities of the Commissioners during the financial year immediately preceding the financial year in which such report is prepared and forward copies thereof to the Central Government.". Annual report.

11. In section 13 of the Delhi Metro Railway Act, for the word "Commissioner", the words "Chief Commissioner of Railway Safety" shall be substituted. Amendment of section 13.

12. In section 23 of the Delhi Metro Railway Act, in sub-section (*1*), for the words "Hindi and English", the words "Hindi, English and official language of the State in which such station is located" shall be substituted. Amendment of section 23.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted. Amendment of section 26.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:— Amendment of section 34.

"(4) The Central Government and the State Government shall nominate one member each to the Fare Fixation Committee:

Provided that a person who is or has been an Additional Secretary to the Government of India or holds or has held an equivalent post in the Central Government or the State Government shall be qualified to be nominated as a member.".

Amendment of section 38.

15. In section 38 of the Delhi Metro Railway Act, in sub-section (*2*), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted.

Amendment of section 85.

16. In section 85 of the Delhi Metro Railway Act,—

(*i*) in sub-section (*1*), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted;

(*ii*) in sub-section (*2*), for the words "Government of the National Capital Territory of Delhi in the Delhi Gazette", the words "State Government" shall be substituted.

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Secretary to the Govt. of India.

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CHAPTER–18

CONCLUSIONS AND RECOMMENDATIONS

18.1 Mumbai is the Commercial Capital of India and it's fast growth especially in the suburbs is causing heavy stress on all infrastructure, especially the Transport. Being a linear city, the existing suburban rail services are very effective and the modal split in favour of public transport is about 88%, which is very high. Since the existing transport infrastructure has been heavily loaded, it has been observed that the population of private vehicles is increasing and it was also predicted that, the modal split in favour of public transport may also recede. Hence, it is proposed by MMRDA to introduce a rail based Mass Transportation System in Greater Mumbai and a master plan has been prepared for the same. It is proposed to take up the Andheri (E)–Dahisar (E) Corridor with route length of 16.475 Kms immediately for implementation**. It is also proposed that extension of this corridor from Andheri end to Domestic Airport of Mumbai should closely follow for which DPR may be got prepared by the consultants. Prima facie the extension to Domestic Airport , Mumbai is feasible with some portion elevated and underground thereafter. By doing so it will give connectivity to the public coming from Dahisar(E) end to Colaba with one interchange at Domestic Airport.**

Metro Projects are highly capital intensive on account of the high costs involved. Due to the need to maintain a fare structure within the affordable reach of ordinary citizens, metro projects are ordinarily not financially viable. However considering the economic gain to the society and the fact that city with a population of more than ten million cannot survive without an efficient Metro System, implementation of Metro System and this particular corridor is strongly recommended.

The corridor is proposed to start from junction of Western Express Highway and M.V. Road in Andheri (East). The corridor will end at Dahisar (East) after travelling through Jogeshwari, Goregaon, Malad, Kandivali and Borivali.

The proposal of this corridor is technically feasible but involves acquisition of land as well as rehabilitation of some hutments and shops.. This is a socio-economic problem and has to be tackled for execution of the project.

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 4628 crores exclusive of State taxes and Octroi of Rs 304.13 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 5877 crores excluding State taxes and Octroi of Rs 443 Crores.

18.2 A detailed Environmental Impact Assessment Study was carried out for the project by M/S Span Consultants. As a part of this Study, comprehensive environmental baseline data was collected, and both positive and negative impacts of the project were assessed in detail. The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc, with a few negative impacts (especially during implementation phase of the project) for which Environmental Management Plan has been suggested.

18.3 After examining the various options for execution of Andheri (E)–Dahisar (E) Metro Project, it has been recommended that the project should be got executed through a SPV on DMRC funding pattern.

18.4 The fare structure has been prepared based on prevailing fare structure in different PT/IPT modes as indicated in the Finance Chapter. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 15% every two years.

18.5 As in the case of Delhi Metro, the State Government should exempt/reimburse the Maharashtra Value Added Tax (VAT) to MMRC. It should also exempt the following:

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

18.6 As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Maharashtra State Government may pursue the Central Government to extend the same benefit to MMRC.

18.7 While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **8.20%**, the Economic Internal Rate of Return (EIRR) works out to **22.06%**

18.8 It is recommended to hand over the project to an agency having the experience of planning, implementing, commissioning and operating on turnkey basis as was done by Rajasthan and Kerala Governments in regard to Jaipur and Kochi Metro projects respectively to complete it within the time period of about three and half year. The second option may be through General Consultants which may take about 8 to 9 months more as compared to turn key Consultancy.

18.9 Meanwhile the State Government should freeze all future developments along the proposed route of Andheri (E)–Dahisar (E) Metro to avoid in-fructuous expenditure.

18.10 It is recommended the State Govt. should set up a non-lapsible, non-fungible Transit Fund to fund the project out of revenues from

- Increased FAR along the Metro corridors.
- A Metro cess on the sale of petrol and diesel in the State.
- Levy of additional charges on the registration of vehicles.
- Levy of additional cess on the Property Tax.
- A onetime green cess on existing vehicles.
- Property development on Government land.