DETAILED PROJECT REPORT

EXTENSION OF MUMBAI METRO LINE-4 FROM KASARVADAVALI TO GAIMUKH

MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY (MMRDA)

Prepared By

DELHI METRO RAIL CORPORATION LTD.

October, 2017

DETAILED PROJECT REPORT

EXTENSION OF MUMBAI METRO LINE-4
FROM KASARVADAVALI TO GAIMUKH

MUMBAI METROPOLITAN REGION
DEVELOPMENT AUTHORITY (MMRDA)

Prepared By

DELHI METRO RAIL CORPORATION LTD.

October, 2017

Contents

Salient Features

1 Gauge

2 Route Length

3 Number of Stations

4 Traffic Projection

5 Train Operation

6 Speed

7 Traction Power Supply

8 Rolling Stock

9 Maintenance Facilities

10 Signaling, Telecommunication and Train Control

11 Fare Collection

12 Structure

13 Cost

14. Indices

Executive Summary

Chapter 1 - Introduction

Chapter 2- Traffic Demand Forecast

Chapter 3- System Design

Chapter 4- Civil Engineering

Chapter 5 – Station Planning

5.1 Station Planning

5.2 Station Types

5.3 Proposed Station Configuration

5.4 Station Standards

5.5 Passenger Amenities

5.6 Information Displays

5.7 Advertisement

5.8 Station Constraints

Chapter 6–Train Operation Plan

Chapter 7 – Maintenance Depot

Chapter 8 –Power Supply Arrangements

Chapter 9 – Environment & Social Impact Assessment

9.1. **Legal, Policy and Institutional Frame Work**

9.2 **Project Area**

9.3 **Environmental Scoping**

9.4 **Water Environment**

9.5 **Meteorology**

9.6 **Socio- Economic Conditions**

9.7 **Social Economic Survey**

9.8 **Archaeological Sites**

9.9 **Environmental Impacts Assessment**

9.10 **Positive Environmental Impacts**

9.11 **Checklist of Impacts**

9.12 **Analysis of Alternatives and Public Consultation and Information Disclosure**

9.13 **Public Consultation and Disclosure**

9.14 **Environmental Management Plan**

9.15 **Summary of Environmental Management Plan (EMP)**

9.16 **Environmental Monitoring Plan**

9.17 **Establishment of an Environmental Division**

9.18 **Cost Estimates**

9.19 **Conclusion**

Chapter 10 – Multi Modal Traffic Integration at Metro Stations

10.1 Introduction

10.2 Present Condition of Transport on City Roads

10.3 Impact of Bus/Clusters in Mode Share

10.4 Balancing Act of Metro

10.5 Way Forward

Chapter 11- Friendly Features For Differently Abled

Chapter 12 - Security Measures for a Metro Rail System

Chapter 13- Disaster Management Measures

13.1 Introduction

13.2 Need for Disaster Management Measures

13.3 Objectives

13.4 List of Serious Incidents Requiring Use of Provisions of the Disaster Management Measures

13.5 Provisions under Disaster Management Act, 2005.

13.6 Provisions at Metro Stations/Other Installations

13.7 Preparedness for Disaster Management

13.8 Communication with State Disaster Management Cell

Chapter 14 - Cost Estimates

Chapter 15- Financing Options, Fare Structure and Financial Viability

Chapter 16 - Economic Appraisal

Chapter 17- Implementation

Chapter 18 - Conclusions and Recommendations

Appendix

SALIENT FEATURES

1. GAUGE (NOMINAL): 1435 mm

2. ROUTE LENGTH: 2.668 km (Entirely Elevated)

3. NUMBER OF STATIONS: 2 (All Elevated)

4. TRAFFIC PROJECTION:

Entire Corridor (Wadala – Kasarvadavali – Gaimukh)

YEAR	TOTAL TRIP	AVERAGE LEAD (KM)	MAXIMUM PHPDT
2021	10,02,777	10.27	27,570
2031	13,43,979	8.796	30,708

Extension from Kasarvadavali to Gaimukh

YEAR	TOTAL TRIP
2021	1,32,579
2031	1,30,802

5. TRAIN OPERATION:

For entire Wadala – Kasarvadavali – Gaimukh corridor

Particulars	2021	2031
Cars/trains	8	8
Head way (Minutes)	5.00	4.25
Max. PHPDT Demand	27570	30708
PHPDT Capacity Available	28224 (36000*)	33205 (42353*)

* @ 8 persons per square meter of standee area

Year	Headway (min)	Total No. of Rakes	Rake Consist	Total No. of Cars**	Provision for No. of cars in DPR of May'16	Additional No. of cars for Extension of Line- 4#
2021	5.00	29	8	232	216	16
2031	4.25	33		264	264	0

*** Total No. of cars shown above are the total cars calculated as per PHPDT data.*

 # Additional cars requirement for Line-4 extension has been calculated after subtracting provision for no. of cars in previous Line-4 (Wadala-Kasarvadavali) DPR (May 2016) from the total car requirements.

6. i. Design speed — 90 Kmph
ii. Maximum operating speed — 80 Kmph
iii. Schedule (Booked) Speed — 35 Kmph

7. TRACTION POWER SUPPLY:

a.	Traction system voltage	25 kV AC
b.	Current Collection	Over Head Catenary
c.	Receiving Sub Station	At Gaimukh Depot.

Power Demand Estimation (MVA)

Load	Year	
	2021	2031
Traction	2.21 MVA	2.59 MVA
Auxiliary	0.62 MVA	0.74 MVA
Total	**2.82 MVA**	**3.34 MVA**

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 8 coach unit With 6 standees / sq. m	2352
e.	Class of accommodation	One (Air conditioned)

9. MAINTENANCE FACILITIES:

Maintenance Depot has been proposed near Gaimukh Station. Area of depot land will be about 23.1 Ha. This depot will serve entire corridor from Wadala to Gaimukh.

10. SIGNALLING, TELECOMMUNICATION AND TRAIN CONTROL:

a) Type of Signalling — 'CATC' (Continuous Automatic Train Control System) based on "CBTCS" (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 twin ‘U’ girders on Single pier with pile / Open foundations upto radius 300m and flatter, for sharper curves and location of Points & Crossings I-Girder.

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

13. COST:

i)	Estimated Cost with Land and all Taxes & Duties (At June 2017 prices)	**Rs.786.00 Crore.**
ii)	Completion Cost with Land and all Taxes & Duties (by March 2022 at 5.00% p.a. escalation)	**Rs.940.00 Crore.**

14. INDICES:

i)	FIRR	**12.68%**
ii)	EIRR (on completion cost basis)	**18.35%**

EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Background

Mumbai has a very good transportation system but has not been able to keep pace with rising demand. The carrying capacity of the bus and rail system has increased considerably but has been always on lower side than what is needed. Though metro for Mumbai had been talked for last 50-60 years, but something concrete did not come up till MMRDA got prepared Master Plan of Mumbai Metro network in 2003. Master Plan was totaling to 146.5 km comprising the under-mentioned corridors:

Table 0.1

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

DMRC prepared the DPRs for Line-1: Varsova – Andheri – Ghatkopar – 2005, Line-2: Colaba – Bandra – Charkop – 2008, Line – 3: Bandra – Kurla - Mankhurd – 2006. Subsequently, the corridors 2 & 3 were rearranged and DMRC prepared another DPR for the corridor between Charkop – Bandra – Mankhurd

Inspite of above, the implementation of Mumbai metro remained very slow. So far only one line between Varsova – Andheri – Ghatkopar could be implemented. Another corridor presently under implementation is between Colaba and Aarey Colony via International Airport measuring to about 30 kms.

- Colaba to Aarey Colony via International Airport. 30.00km
- Dahisar (E) to DN Nagar 18.60km
- Dahisar (E) to Andheri(E) 16.48km
- DN Nagar to Mandale 23.64km

- Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali 32.32km
- Swami Samarth Nagar to Vikhroli(EEH) 14.48km

Total 135.52km

The status for other lines is as under:
In November/December, 2009, MMRDA awarded the work of preparing DPRs for the following corridors to the agencies as indicated herein:

Table 0.2

S. No.	Corridor	Length (Km)	Agency
1.	Charkop – Dahisar	7.5	M/s SPAN Consultants Pvt. Ltd.(August, 2010)
2.	Andheri(E)-Dahisar(E)	18.00	M/s SPAN Consultants Pvt. Ltd.(May, 2010)
3.	Mahim – BKC - Kanjurmarg	12.5	M/s RITES & LASA (Sept, 2011)
4.	Ghatkopar-Mulund	12.50	M/s Consulting Engineering Services
5.	Bhakti Park- Wadala – Ghatkopar -Kasarvadavali	32	M/s RITES (following LBS Road) (September, 2014)
6.	Wadala – Ghatkopar – Kasarvadavali	30.00	M/s CES (following Eastern Expressway) (March, 2013)
7.	Wadala – Carnac Bandar	13.1	M/s RITES (December, 2012)

The Government of Maharashtra is keen to implement expeditiously the Master Plan Corridors recommended by DMRC on a fast track mode and to complete them in the next 3-4 years. To start with, it is decided to take up the task of updation of DPRs and also preparation of new DPRs for the following potential elevated metro corridors:

Table 0.3

Sr. No.	Alignment	Length in km
A*	**Updation of DPRs for Mumbai Metro Master Plan Corridors**	
	(a) D.N. Nagar – Dahisar	18.00
	(b) Dahisar (E) –Andheri (E) (Along WEH)	18.00
	(c) Bandra – Mankhurd (Via BKC)	13.00
	(d) Wadala – Ghatkopar – Thane	22.00
	(e) Thane - Kasarvadavali	10.00
	(f) Wadala – GPO along R.A. Kidwai Rd. – Barrister Nath Pai Rd. – P.D. Mello Rd	8.00
B	**Review of Metro alignment and updation /preparation of DPRs**	
	(a) D.N. Nagar - BKC	10.00
	(b) Jogeshwari Vikhroli Link Road – SEEPZ – Kanjur Marg	10.00
	(c) Andheri (E) – BKC (Via WEH)	9.00
	Total	**118.00**

0.1.2 Demographic Profile and Transport Scenario

Mumbai, the financial capital of India, has witnessed phenomenal growth in population and employment and the trend is expected to continue in the future. The job opportunities it offers have served as a major attraction for immigration from hinterland of Maharashtra as well as from all parts of the Country.

Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. It comprises of 7 municipal corporations, 13 municipal councils and 996 villages and extends over an area of 4,355 sq. km MMR is projected to have population and employment (both formal and informal) as 34.0 million and 15.3 million respectively in the year 2031

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

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

0.2 TRAFFIC FORECAST

0.2.1 The daily ridership, peak hour station loads and peak hour section loads for the proposed Metro Corridor are given in **Table 0.4** and **0.5**.

Table 0.4: Peak Hr. Ridership for Metro Line - 4 (Wadala – Kasarvadavali – Gaimukh) for Horizon year 2021

Alighting	Boarding	Volume Gaimukh to Wadala	Station Name	Volume Wadala to Gaimukh	Boarding	Alighting
12158	0	0	BHAKTI PARK METRO	3887	3887	0
5509	479	12158	WADALA TT	6124	2925	689
1111	354	17188	ANIK NAGAR BUS DEPOT	6648	698	174
1824	260	17945	SUMAN NAGAR	8240	1691	99
5845	655	19508	SIDDHARTH COLONY	11137	3332	434
2623	234	24698	AMAR MAHAL JUNCTION	13585	2550	102
582	231	27087	GARODIA NAGAR	13896	499	188
99	93	27439	PANT NAGAR	13917	77	57
465	340	27445	LAXMI NAGAR	14007	521	430
4133	12641	27570	SHREYES CINEMA	12743	3172	4436
1265	595	19061	GODREJ COMPANY	13460	968	251

Alighting	Boarding	Volume Gaimukh to Wadala	Station Name	Volume Wadala to Gaimukh	Boarding	Alighting
859	1730	19731	VIKHROLI METRO	12464	496	1491
377	651	18860	SURYA NAGAR	12392	157	230
1667	2154	18586	GANDHI NAGAR	11998	1482	1875
0	145	18099	NAVAL HOUSING	11964	0	34
2792	8	17954	BHANDUP MAHAPALIKA	14263	2323	24
264	1046	20738	BHANDUP METRO	14284	423	402
4589	1808	19956	SHANGRILA	16217	2746	813
582	831	22738	SONAPUR	16110	552	657
50	201	22489	MULUND FIRE STATION	16214	151	48
1070	622	22338	MULUND NAKA	15944	547	818
851	1625	22786	TEEN HAATH NAKA (THANE)	15546	742	1139
1446	4014	22012	RTO THANE	13734	1235	3048
1251	1533	19443	MAHAPALIKA MARG	14012	1315	1036
143	450	19161	CADBURY JUNCTION	13376	41	677
1212	1922	18854	MAJIWADA	13214	969	1132
761	1844	18144	KAPURBAWDI	11485	619	2348
671	1710	17062	MANPADA	11011	615	1090
2876	2184	16023	TIKUJI-NI-WADI	12512	2108	607
1370	2694	16714	DONGARI PADA	10726	697	2484
1052	2619	15390	VIJAY GARDEN	10050	717	1394
617	2261	13823	KASARVADAVALI	8962	459	1547
831	1145	12179	GOWNIWADA	8558	619	1022
0	11864	11864	GAIMUKH	0	0	8558
60944	60944	**27570**	**PHPDT**	**16217**	39334	39334
100278		**Peak Hour Ridership**			**100278**	
1002777		**Daily Ridership**			**1002777**	

Table 0.5 Peak Hr. Ridership for Metro Line -4 (Wadala – Kasarvadavali – Gaimukh) for Horizon year 2031

Alighting	Boarding	Volume Gaimukh to Wadala	Station Name	Volume Wadala to Gaimukh	Boarding	Alighting
11571	0	0	BHAKTI PARK METRO	3694	3694	0
4646	308	11571	WADALA TT	5861	2459	292
1034	207	15910	ANIK NAGAR BUS DEPOT	6281	575	155
2831	1413	16736	SUMAN NAGAR	7905	1943	319
4032	556	18154	SIDDHARTH COLONY	10981	3369	293
1622	521	21629	AMAR MAHAL JUNCTION	12708	2023	296
198	4491	22731	GARODIA NAGAR	12113	246	841

Alighting	Boarding	Volume Gaimukh to Wadala	Station Name	Volume Wadala to Gaimukh	Boarding	Alighting
430	164	18439	PANT NAGAR	12306	337	143
881	547	18704	LAXMI NAGAR	12467	737	575
14120	5248	19038	SHREYES CINEMA	17599	7333	2202
2023	1178	27910	GODREJ COMPANY	16468	1053	2183
939	2181	28755	VIKHROLI METRO	15815	888	1542
522	981	27514	SURYA NAGAR	15452	494	856
4834	1457	27055	GANDHI NAGAR	17330	3173	1295
901	834	30432	NAVAL HOUSING	17975	800	155
284	959	30500	BHANDUP MAHAPALIKA	17777	227	425
1833	950	29825	BHANDUP METRO	18233	1217	761
822	7137	30708	SHANGRILA	17972	1883	2144
439	137	24394	SONAPUR	18120	361	213
755	1816	24697	MULUND FIRE STATION	18258	1083	945
507	400	23636	MULUND NAKA	18169	238	326
1151	2101	23743	TEEN HAATH NAKA (THANE)	18256	1695	1609
3330	2509	22793	RTO THANE	17168	2045	3133
1161	1251	23614	MAHAPALIKA MARG	16601	884	1451
1837	3122	23525	CADBURY JUNCTION	15922	1455	2134
944	2996	22240	MAJIWADA	14734	924	2113
506	2574	20189	KAPURBAWDI	12852	729	2612
10968	4067	18121	MANPADA	20415	9710	2147
1044	3205	25022	TIKUJI-NI-WADI	18800	869	2483
1457	4660	22861	DONGARI PADA	17793	966	1973
0	3077	19658	VIJAY GARDEN	15634	0	2159
753	6	16580	KASARVADAVALI	16328	695	0
1008	1509	17328	GOWNIWADA	15780	907	1455
0	16827	16827	GAIMUKH	0	0	15780
79386	79386	30708		20415	55012	55013
134398			**Peak Hour Ridership**		**134398**	
1343979			**Daily Ridership**		**1343979**	

0.3 SYSTEM DESIGN

0.3.1 Permanent Way

0.3.1.1 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. Even Delhi Metro which started with Broad Gauge has switched over to 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.
- 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.
- 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.

0.3.1.2 Track Structure

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.

0.3.2 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.

0.3.3 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.

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.

0.3.4 Telecommunication

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

0.3.5 Automatic Fare Collection

0.3.5.1 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.

0.3.5.2 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.

0.3.5.3 Choice of Control Gates

Retractable Flap type Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern metros internationally. Tripod turnstile type gates offer less throughput and require more maintenance and hence are not proposed. All these Gates will have a functionality of Auto Top on Smart cards in case balance goes below the threshold Value (As per User Choice/Business Rules)

0.3.5.4 Ticket Vending Machine (TVM)

At all stations, Passenger Operated Ticket Vending Machines (Automatic Ticket Vending Machines) are proposed. The TVM's will provide convenience to passengers to avoid standing in queues at ticket booths and provide them international standard service.

0.3.5.5 Ticket Reader/Add Value Machines

These machines will be used to know the Card/Token balance and can also be used as Add value device in case payment for Card top up is made through alternate Internet based channel like net banking, Credit/Debit card (Payment gateway) etc.

0.3.5.6 Recharge Card Terminal Machine (RCTM)

RCTM will be used to recharge the Card using Credit Card /Debit card /Pre Paid card as well as bank Note

0.3.5.7 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.

0.3.6 Rolling Stock

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 a Mass Rapid Transit System (MRTS).

0.3.6.1 The following optimum size of the coach has been chosen for this corridor

Table 0.6 - 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*

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted.

Following train composition is recommended:

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

Table 0.6A shows the carrying capacity of Medium Rail Vehicles.

Table 0.6A Carrying Capacity of Medium Rail Vehicles

	Driving Motor car		Trailer car/Motor car		8 Car Train	
	Normal	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**
Seated	42	42	50	50	384	384
Standing	120	240	124	248	984	1968
Total	162	282	174	298	1368	2352

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

The recommended performance parameters are:

Maximum Design Speed:	90 kmph
Maximum Operating Speed:	80 kmph
Max. Acceleration:	1.0 m/s2 (with AW3 load)
	1.2 m/s2 (with AW2 load)
Max. Deceleration:	1.1 m/s^2 (with AW3 load)
	1.1 m/s^2 (with AW2 load)
	>1.35 m/s2 (Emergency brake)

0.3.6.2 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
- 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.

0.4 CIVIL ENGINEERING:

0.4.1 Geometric Design Norms

0.4.1.1 The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80kmph. The design parameters related to the Metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole.

Desirable 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.

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

0.4.1.2 Gradients

Normally stations should be on a level stretch. In limiting cases, stations may be on a grade of 0.1%. In this corridor all stations are on level gradient.

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

0.4.1.3 Design Speed

The maximum Design speed has been proposed as 90 kmph and maximum operating speed 80 kmph. The booked speed has been taken as 35kmph.

0.4.2 Alignment

0.4.2.1 First station of Line-4 extension from Kasarvadavali to Gaimukh is named as Gowniwada and last station is Gaimukh.

0.4.2.2 It is the extension of Mumbai Metro Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali corridor) at Kasarvadavali end. Thus start chainage of this extension is same as the dead end chainage given in DPR of Line-4 i.e. 31872.088 m.

0.4.2.3 Total length of this extension is 2.668 km. The entire metro extension proposed is elevated. It runs in South to North-West direction.

0.4.2.4 Two stations have been proposed on this extension. Names of stations are Gowniwada and Gaimukh. 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; stations could not be located at one km distance apart. The maximum and minimum inter station distances are 1384.9 m and 1283.1 m respectively. Depot for entire Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali – Gaimukh) has been planned at Gaimukh.

0.4.3 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport such as Railway Stations, Bus Terminals, etc. However effort has also been made to propose station locations, such that inter station distances are as uniform as possible.

0.4.3.1 All stations will be two level stations. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. All the stations have been planned cantilever leaving 10.5m road width either side of the median.

0.4.4 Terminals

As this is the extension of Mumbai Metro Line-4, thus there is only one terminal station as detailed below.

- **Gaimukh Terminal**

  This Station is proposed along the road. Scissors crossovers are proposed at the rear end of station and crossover is provided at the front end of the station.

0.4.5 Scissors Crossovers

Scissors Crossovers will be provided at the terminal station. Crossover is also proposed at the front end of the terminal station.

0.4.6 Depot

It is proposed to provide depot at Gaimukh, in the Government land identified by MMRDA. Area of depot land will be about 23.1 Ha. Already an area of 30 Ha was considered for Depot in Line-4 DPR.

0.4.7 Viaduct–Elevated Structure

The proposed Viaduct Structure is fully elevated. Generally four types of Superstructure are used for construction of elevated section of Metro Corridor, i.e. (i) Segmental Box Girder, (ii) Segmental U Girder, (iii) I Girder and (iv) Double U Girder, depending upon characteristic of the corridor such as traffic congestion on roads, available working space, etc.

In case of this extension of Mumbai Metro Line-4, it is suggested to use Double U-Girder in the superstructure upto radius 300m and for Radius less than 300 m and at locations where point and crossing are to be provided, it is suggested to use I-Girder.

0.4.8 Geo Technical Investigations

No fresh Geotechnical Investigation has been carried out by DMRC. The data given in the DPR submitted for Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali) has been reproduced. As this is a small extension of Line-4, thus more or less the ground profile will be same. Originally the Geological Investigations were carried out from Wadala to Kasarvadavali during preparation of combined DPR for Wadala – Kasarvadavali by M/s CES Pvt. Ltd.

0.4.8.1 Summary and Recommendations

Type of Foundation -Considering the nature of soil, type of proposed structures and expected loads on foundations, and the recommended type of foundations is generally Pile Foundation, except at few locations where open foundation can be provided, where rock level is up to 6 m below GL.

Depth of Foundation-A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Keeping in view the type of the proposed structure and the subsoil strata, the length of pile may be about 7.5 to 15 m as the piles are to be socketted in rock.

Pile Foundation-For the prevailing soil conditions and type of structures, bored cast-in-situ piles of 1200 to 1500 mm diameter may be adopted.

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

0.4.9 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 or bridged. Details are given in chapter 5 on Civil Engineering.

0.4.10 Land

In order to minimise land acquisitions and to provide good accessibility form either directions, the metro alignments are located mostly along the road, which lie on the corridor. But, at some locations the geometrics of the roads especially at road turnings may not match with geometric parameters required for metro rail systems. In such cases, either the alignment will be off the road or some properties abutting the road would get affected. Further, some land is required for various purposes as detailed below.

Land Requirement for following Major Components

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Radio Towers
- Temporary Construction Depots and work sites.
- Staff quarters, office complex and operation control centre(OCC)

.

0.4.10.1 Summary of Land Requirements

Abstract of land requirements for different components of this extension is given in **Table 0.7**. No land is proposed for temporary acquisition for this metro extension.

Table 0.7 Summary of Permanent Land Requirement (All figures in Sq. m)

S. No.	Description	Govt.	Pvt.
1	Stations	0	1926.055
2	Running Section	0	0
3	Depot	231000	0
4	Staff Quarter	0	0
5	Office Complex and OCC	0	0
6	RSS	0	0
	Total (Area in sq m)	**231000**	**1926.055**

Total Permanent Land	**=**	**23.2926 ha**
Permanent Land (Govt.)	**=**	**23.1 ha**
Permanent Land (Pvt.)	**=**	**0.1926 ha**

0.4.11 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.

0.4.11.1 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.

0.5 STATION PLANNING

The Proposed metro rail extension of Mumbai Metro Line-4 runs from Kasarvadavali to Gaimukh.

The length of the proposed extension from Kasarvadavali to Gaimukh is approximately 2.668 km. Along this extension of the proposed Line-4, 2 stations have been planned and both are elevated. The locations of the stations have been identified taking into consideration the constraints in land acquisition and congestion issue. Stations are proposed in such a way so as to attract the maximum demand from the traffic nodal points.

0.5.1 Salient features

Salient features of a Metro Rail station are as follows:

i) Both the stations have two unpaid area.
ii) The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
iii) The plat form 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 1.100m above the rail level. This would make the platforms in an elevated situation at least 13.5m aboveground.
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) The DG set, bore well, pump house, underground water tank and refuge collection would be located at street level.

ix) 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 0.8.

Table 0.8 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	
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.

xii) 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 minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers.

xiii) 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).

0.5.2 Station Types

Both stations planned in this extension are elevated and have side platforms. Average inter-station distance is approximately 1.334 km varying from 1283.1 to 1384.9 m depending upon the site, Operational and traffic constrains. The sequence of stations with their respective chainages, Inter station distance and platform characteristics is presented in Table 0.9

Table 0.9 List of Stations

S. No.	Station Name	Chainage(m)	Inter Distance Between Two Stations.	Station Type
	KASARVADAVALI	31422.088		Elevated
	START CHAINAGE	31872.088		
1	GOWNIWADA	32807.032	1384.944	Elevated
2	GAIMUKH	34090.120	1283.088	Elevated
	DEAD END	34540.120		

0.6 TRAIN OPERATION PLAN

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.
- Optimization of train's reliability for achieving best possible availability on line.
- A train consists of 8 coaches.
- Multi-tasking of train operation and maintenance staff.

List of stations for the Mumbai Metro Line-4 (Wadala to Gaimukh) is given below:

Table 0.10 - Details of Stations

S. No.	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type
	DEAD END	-450		
1	BHAKTI PARK METRO	0		Elevated
2	WADALA TT	1000	1000	Elevated
3	ANIK NAGAR BUS DEPOT	1861.61	861.61	Elevated
4	SUMAN NAGAR	2939.997	1078.387	Elevated
5	SIDDHARTH COLONY	3994.43	1054.433	Elevated
6	AMAR MAHAL JUNCTION	5338.012	1343.582	Elevated
7	GARODIA NAGAR	5936.538	598.526	Elevated
8	PANT NAGAR	7569.215	1632.677	Elevated
9	LAXMI NAGAR	8646.73	1077.515	Elevated
10	SHREYES CINEMA	9267.54	620.81	Elevated
11	GODREJ COMPANY	10430.356	1162.816	Elevated
12	VIKHROLI METRO	11153.477	723.121	Elevated
13	SURYA NAGAR	12158.246	1004.769	Elevated

S. No.	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type
14	GANDHI NAGAR	13160.357	1002.111	Elevated
15	NAVAL HOUSING	13852.242	691.885	Elevated
16	BHANDUP MAHAPALIKA	14631.584	779.342	Elevated
17	BHANDUP METRO	15680.41	1048.826	Elevated
18	SHANGRILA	16524.058	843.648	Elevated
19	SONAPUR	17914.818	1390.76	Elevated
20	MULUND FIRE STATION	19027.799	1112.981	Elevated
21	MULUND NAKA	20375.897	1348.098	Elevated
22	TEEN HAATH NAKA(THANE)	21612.245	1236.348	Elevated
23	RTO THANE	22290.786	678.541	Elevated
24	MAHAPALIKA MARG	23326.751	1035.965	Elevated
25	CADBURY JUNCTION	24119.463	792.712	Elevated
26	MAJIWADA	24943.751	824.288	Elevated
27	KAPURBAWDI	26333.014	1389.263	Elevated
28	MANPADA	27198.395	865.381	Elevated
29	TIKUJI-NI-WADI	27974.044	775.649	Elevated
30	DONGARI PADA	29439.645	1465.601	Elevated
31	VIJAY GARDEN	30348.515	908.87	Elevated
32	KASARVADAVALI	31422.088	1073.573	Elevated
33	GOWNIWADA	32807.03	1384.94	Elevated
34	GAIMUKH	34090.12	1283.09	Elevated
	Dead End	34540.12	450.00	

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 projected traffic demand, the possibility of running trains with composition of 8 Car trains with different headways has been examined.

Composition

DMC : Driving Motor Car
MC : Motor Car
TC : Trailer Car

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)
8 Car Train : 2352 (384 seated + 1968 standing)

The PHPDT capacity provided on this corridor in different years of operation is given in Table 0.11:

Table 0.11 PHPDT Capacity Provided

Particulars	2021	2031
Cars/trains	6	6
Head way (Minutes)	5	4.25
Max. PHPDT Demand	27570	30708
PHPDT Capacity Available	28224 (36000*)	33205 (42353*)

* @ 8 persons per square meter of standee area

0.6.3 Year-Wise Rake Requirement

Based on Train formation and headway as given above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and has been tabulated below in Table 0.12:

Table 0.12: Year wise Rake requirement

Corridor	Year	Headway (min)	Total No. of Rakes	No. of car per rake	Total No. of Cars**	Provision for No. of cars in DPR of May'16	Additional No. of cars for Extension of Line- 4#
Wadala to Gaimukh	2021	5	29	8	232	216	16
	2031	4.25	33		264	264	0

*** Total No. of cars shown above are the total cars calculated as per PHPDT data.*
 # Additional cars requirement for Line-4 extension has been calculated after subtracting provision for no. of cars in previous Line-4 (Wadala-Kasarvadavali) DPR (May 2016) from the total car requirements.

0.7 MAINTENANCE DEPOT

It is proposed to establish one depot- cum- workshop at Gaimukh for entire Line-4 from Wadala to Gaimukh.

0.7.1 Depot- Cum- Workshop

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.

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 8- Car each and space earmarked for future provision.
(iii) All Stabling lines are designed to accommodate one trains of 8- 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 (preferably as close to depot as possible) to cater to the required stability facilities.

(v) In case of space constraint for depot, two storeyed Stabling lines can also be planned.

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.

0.7.2 Maintenance Philosophy

- ➢ Monitoring of the performance of all key Rolling Stock equipment by suitable advanced condition monitoring techniques available. 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.
- ➢ Increase in the periodic maintenance intervals with predictive maintenance based on condition monitoring.
- ➢ Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- ➢ Periodic review of maintenance practices to update replacement cycle of critical components based on experience.
- ➢ Energy conservation is given due attention.

0.8 POWER SUPPLY

0.8.1 Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting & air-conditioning 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 at Pantograph/ Current Collector – 50 kWh/1000 GTKM for 25 kV ac system and 60 kWh/GTKM for 750 V dc system as per MOUD guideline.

(ii) Elevated/at –grade station load – initially 250 kW, which will increase to 300 kW in the year 2031.

(iii) Depot auxiliary load - initially 2000 kW, which will increase to 2200 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 2021 and 2031 are summarized in table 0.13 below:

Table 0.13 Power Demand Estimation (MVA)

	Load	Year	
		2021	**2031**
Extension of Line-4 from Kasarvadavali to Gaimukh (2 Elevated Station, 2.668 km)	Traction	2.21 MVA	2.59 MVA
	Auxiliary	0.62 MVA	0.74 MVA
	Total	**2.82 MVA**	**3.34 MVA**

0.8.2 Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in brief. The city has 220, 110 and 100 kV network to cater to various types of demand in vicinity of this extension of Line-4.

Keeping in view the shifting of Depot from Kasarvadavali Depot to Gaimukh, Receiving Sub-stations proposed to be set up at Kasarvadavali Depot earlier is proposed to be shifted to Gaimukh Depot. Power supply for this section from Kasarvadavali to Gaimukh Station will be taken care by Gaimukh Depot RSS. In the event of failure of RSS located at Gaimukh depot, the power supply will be extended from the RSS of Line-4 (Wadala to Kasarvadavali) and vice versa. 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 M/s MSETCL at 220, 110 & 100 kV voltage through cable feeders:

Table 0.14 Sources of Power Supply

	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length b/w GSS & RSS
1	Extension of Line-4 (Wadala to Kasarvadavali) from Kasarvadavali to Gaimukh	220/100kV GSS of M/s MSETCL at Kolshet	RSS at Gaimukh depot.	4km

DMRC has done a joint survey/ meeting with M/s MMRDA, M/s Reliance Infrastructure Ltd, M/s TATA Power Company Ltd and M/s MSETCL on 07.08.2016 to 09.02.2016 for this corridor for feasibility of Power Supply.

The 100 kV power supply will be stepped down to 3 Φ 33 kV and 1 Φ 25 kV level at the RSS located at Gaimukh depot of metro authority. The 1 Φ 25 kV will be fed to the OHE to cater to traction load and the 33 kV power will be distributed along the alignment through 33 kV Ring main cable network for feeding auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of this RSS of the line on fault or input supply failure, train services can be maintained from RSS of Line-4 (Wadala to Kasarvadavali). 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.

0.8.3 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 for extension of Line-4. This is 95% available indigenously.

0.8.4 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 160 kVA capacity at the elevated station to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system
(vi) Air-conditioning system etc.

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

0.8.5 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.

0.8.6 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.

0.8.7 Electric Power Tariff

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 30-38% 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 9.89 million units in initial years 2021, which will be about 11.70 million Units in the year 2031, for the extension of Line – 4 from Kasarvadavali to Gaimukh. 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 100 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 M/s MSETCL for FY 2017 – 18 demand charges **Rs 250/ kVA** per month and energy charges Rs **9.16/ kWh**. 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.

0.9 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

0.9.1 Objective and Scope of the Study

The objective of the Environment and Social Impact Assessment study is to facilitate the Mumbai Metropolitan Region Development Authority (MMRDA) evaluate the environmental impacts of its proposed activity. MMRDA proposes to apply for loan to seek financial support from ADB. Thus, the objective of the study is to conduct Environmental Impact Assessment as per requirement of ADB. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of Kasarvadavali to Gaimukh Metro extension at Mumbai. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles.

0.9.2 Approach and Methodology

The MMRDA has considered different alternative corridors. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are minimum private land acquisition, least disturbance to properties, minimum disturbance to ecology/biodiversity. In the analysis of alternatives, a comparison of scenario with and without the project has also been made. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the alignment proposed by MMRDA. The approach is to follow the sequence of steps adopted in an EIA study. The basic concept is to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The identification of parameters for data generation and impact assessment are important. The analysis of assessment depends upon the reliable data generated/ available on environmental attributed. This study has documented the baseline data for various parameters of physical, ecological and environmental pollution (air, water and noise). The impacts are assessed for various phases of project cycle namely:

- Impacts due to project location,
- Impacts due to project design,
- Impacts due to project construction, and
- Impacts due to project operation.

0.9.3 Environmental Scoping

Baseline environmental status in and around the proposed project depicts the existing environmental conditions of the location. Baseline data was collected for various/environmental attributes so as to compute the impacts that are likely to arise due to proposed project.

The scope of the present study includes detailed characterization of following environmental components, which are most likely to be influenced by the proposed project:

- ❖ Land Environment
- ❖ Water Quality (Surface + Ground water)
- ❖ Meteorological conditions
- ❖ Ambient Air Quality
- ❖ Noise Levels
- ❖ Biodiversity
- ❖ Socio Economic studies.

0.9.4 Impacts due to Project Location

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems,
- Socio-economic impacts;
- Impact on Historical and Cultural Monuments

0.9.5 Impacts due to Project Design

Considered impacts, due to project designs are:

- Lighting,
- Risk Due to Earthquake.

.

0.10 MULTI MODAL TRAFFIC INTEGRATION:

The extension of Mumbai Metro Line-4 from Kasarvadavali to Gaimukh will cover 2.668 km length in the Kasarvadavali and Gaimukh area. Line-4 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.

0.10.1 Way Forward

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.

0.11 FRIENDLY FEATURES FORDIFFERENTLY ABLED:

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 in Chapter-11 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.

0.11.1 Contents:

1. Metro Rail 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

2. Street Design
    - Footpath (Sidewalk)
    - Kerb Ramp
    - Road Intersection

- Median/Pedestrian Refuge
- Traffic Signals
- Subway and Foot Over Bridge

3. Alighting and Boarding Area
   - Approach
   - Car Park
   - Drop-off and Pick-up Areas
   - Taxi/Auto Rickshaw Stand
   - Bus Stand/Stop

0.12 SECURITY MEASURES FOR A METRO RAIL SYSTEM:

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.

0.12.1 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
(iii) Technology

0.12.2 Phases of Security

There are three phases of security as under:

(i) Prevention
(ii) Preparedness
(iii) Recovery

0.13 DISASTER MANAGEMENT MEASURE

0.13.1 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.

0.13.2 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.

0.13.3 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.

0.13.4 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.

0.14 COST ESTIMATE

Project Cost estimates for the Mumbai Metro Corridor No. 04 extension from Kasarvadavali to Gaimukh has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction etc. at June 2017 price level.

The overall Capital Cost for the extension of Mumbai Metro Line-4 (Wadala - Ghatkopar - Mulund - Thane –Kasarvadavali) from Kasarvadavali to Gaimukh at June 2017 price level works out to **Rs.655 Crores** excluding applicable Taxes & Duties of **Rs. 131 crores** as tabulated hereunder.

Table 0.15 –Summary of Cost Estimate

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Extension of Mumbai Metro Line-4 from Kasarvadavali to Gaimukh	655	131	786

Table 0.16 - Capital Cost Estimate

June 2017 level

S. No.	Item	Amount (Rs. in Cr.) Without taxes
1.0	**Land and R & R**	**32.05**
2.0	**Alignment and Formation**	**137.36**
3.0	**Station Buildings**	**101.97**
5.0	**P-Way**	**29.91**

S. No.	Item	Amount (Rs. in Cr.) Without taxes
6.0	Traction & power supply incl. OHE , ASS etc. Excl. lifts & Escalators	35.42
7.0	Signalling and Telecom.	66.02
8.0	Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection	28.35
9.0	Rolling Stock (3.2 m wide Coaches)	163.20
10.0	Capital expenditure on security	1.07
11.0	Staff quarter for O & M	6.38
12.0	Capital expenditure on Multimodal Traffic Integration	5.10
13.0	**Total of all items except Land**	**587.83**
14.0	General Charges incl. Design charges @ 5 % on all items except land	29.39
15.0	Total of all items including G. Charges except land	617.22
16.0	Contingencies @ 3 %	18.52
17.0	Gross Total	635.74
	Cost without land	636
	Cost with land including contingencies on land	655

Table 0.17 - Details of Taxes and Duties

Basic Customs duty =	5.1500 %
CGST Customs Duty =	9.4635 %
SGST Customs Duty =	9.4635 %
Total Customs Duty =	**24.0770 %**
General IGST =	18 %
General CGST =	9 %
General SGST =	9 %

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated, at grade & entry to Depot	137.36		24.73	**24.73**
2	**Station Buildings**				
	Elevated station - civil works	72.27		13.01	**13.01**
	Elevated station - EM works	18.94	0.91	2.73	**3.64**
3	**P-Way**	29.91	5.76	1.08	**6.84**
4	**Traction & power supply**				
	Traction and power supply	35.42	3.41	5.95	**9.36**
5	**S and T Works**				

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
	S & T	53.92	10.39	3.02	**13.41**
	AFC	12.10	2.18	0.85	**3.03**
	PSD	10.76	2.07	0.60	**2.68**
6	**R & R hutments**	13.05		2.35	**2.35**
7	**Misc.**				
	Civil works	30.40	0.00	5.47	**5.47**
	EM works	10.50	0.00	2.94	**2.94**
8	**Rolling stock**	163.20	34.58	3.53	**38.10**
9	**Rent on Temporary Land**	0.00		0.00	**0.00**
10	**GST on General Charges**	29.39		5.29	**5.29**
	Total	**617.22**	**59.31**	**71.53**	**130.84**
	Total taxes & Duties				**131**
Rate of Taxes & Duties on Total cost without taxes & duties					**21.20%**
Total Central GST & Basic Customs duty					**71.76**
Total State GST					**59.08**
Total State Taxes & Duties					**130.84**

0.15 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

The Mumbai Metro Rail Project for extension of Line no. 4 from Kasarvadavali to Gaimukh is proposed to be constructed at an estimated cost of Rs.727.00 Crore with central taxes and land cost. The route length of the proposed metro rail system and estimated cost at June-2017 price level with Land & without taxes, with Land & central taxes and with land & all taxes are placed in table 0.18 as under:

Table 0.18 Cost Details

Sr. No.	Name of Corridor	Distance (km)	Estimated cost with land & without taxes (Rs/Crore)	Estimated cost with land & Central taxes (Rs/Crore)	Estimated cost with land & all taxes (Rs/Crore)
1	Kasarvadavali to Gaimukh	2.668	655.00	727.00	786.00

The estimated cost at June-2017 price level includes an amount of Rs.1.07 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 taken in to account in the FIRR calculation since providing required security at metro stations shall be the responsibility of state police.

It is assumed that the construction work will start on 01.04.2018 and is expected to be completed on 31.03.2022 with Revenue Opening Date (ROD) as 01.04.2022 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 –0.19 as below.

Table 0.19 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Estimated Cost including cost of land and all taxes & duties at June -2017 Price Level	Completion Cost including cost of land and all taxes & duties
2018-19	54.50	56.00
2019-20	91.50	100.00
2020-21	151.00	173.00
2021-22	226.00	272.00
2022-23	151.00	190.00
2023-24	112.00	149.00
Total	**786.00**	**940.00**

Fare Structure

The fare structure for the FY 2022-23 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 fare structure has been escalated by using @12.00% once in every two years. The fare structure for the FY 2022-23 as per the proposed fare slabs is shown in the table 0.20 below:

Table 0.20 Fare Structure in 2022-23

Sr. No.	Distance (km)	Proposed Fare (Rs.)
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
8	>18	30

The above fare structure has been taken as furnished by MMRDA with the approval GOM. DMRC proposed that the under mentioned fare structure in a multiple of Rs. 10 be adopted at the time of commissioning of this Line to have convenience in making use of ticket vending machine and eliminate the problems of non-availability of changes for tendering changes to the passengers.

Year 2022-23	
SLAB	**FARE (Rs)**
0-3 km	10.00
3-12 km	20.00
12-18 km	30.00
18 km and More	40.00

The **Financial Internal Rate of Return (FIRR)** obtained costs for 30 years business model including construction period is **12.68%.**

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), and
(ii) Built, Operate & Transfer (BOT)

SPV Model: - The State Government has already formed a fully owned SPV in the name of Mumbai Metro Rail Corporation (MMRC), which is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The funding pattern under this model (SPV) is placed in table 0.21 as under:

Table 0.21 Funding pattern under SPV model (with all taxes and land)
(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	**% of contribution**
Equity By GOI	123.50	14.83%
Equity By GOM	123.50	14.83%
SD for CT by GOM	43.50	5.22%
SD for CT by GOI	43.50	5.22%
2.13% Loan from Multilateral/Overseas Development Agencies (ODA) or 12% Domestic Market Borrowings	499.00	59.90%
Total	833.00	100.00%
SD for Land by GOM	35.00	
SD/Exemption/Reimbursement for State Taxed by GOM	72.00	
Total	940.00	
PTA for Interest During Construction @2.13% (*)	9.00	
Grand Total	949.00	

(*) In the case of loan @12% from domestic borrowings, the IDC works out to Rs.16 crore.

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. The extension of Line 4 of Mumbai Metro project is of 2.668 km only. Accordingly, the BOT operator may not be interested for construction, operation and maintenance of such a small interchange extension.

0.15.1 Recommendations

The FIRR of the corridor with all taxes and land is 12.68%. Considering the positive FIRR, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern given in Table 0.23.

0.16 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.

0.16.1 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.

0.16.2 Economic Performance Indicators

On the basis of **completion** cost, EIRR is **18.35%,** B/C Ratio is 4.08 and NPV is 8080 Cr, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **23.06%,** B/C ratio as 8.36 and NPV as 9421 Cr. With 12 % discount, EIRR (completion cost) is **5.67%** and B/C ratio is 1.59. NPV is Rs. 534 Cr. and with 12% discount rate, EIRR (economic cost) is **9.88%** and B/C ratio is 2.30. NPV is Rs. 812 Cr.

Table 0.22: Economic Indicator Values (2044-45)

Kasarvadavali - Gaimukh	(Completion Cost Basis)		(Economic Cost)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	2621	904	1280	626
Cumulative benefit(Cr.)	10701	1438	10701	1438
Benefit Cost Ratio	4.08	1.59	8.36	2.30
NPV(Cr.)	8080	534	9421	812
EIRR	18.35%	5.67%	23.06%	9.88%

0.17 IMPLEMENTATION PLAN

World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for this corridor is **12.68%.**

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.

0.17.1 Implementation Schedule

MMRDA has already initiated the work of Mumbai Metro Line-4 from Wadala to Kasarvadavali. As this is an extension of Line-4, thus it can be implemented along with that corridor.

0.17.2 Institutional Arrangements

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

0.17.3 Legal Cover for Mumbai Metro

Implementation of proposed corridor can now be done under “The Metro Railways (Amendment) Act 2009”.

0.18 CONCLUSIONS

0.18.1 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 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. It is proposed to take a new Metro Rail Corridor from Wadala - Ghatkopar - Mulund - Thane – Kasarvadavali – Gaimukh immediately for implementation.

0.18.2 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.

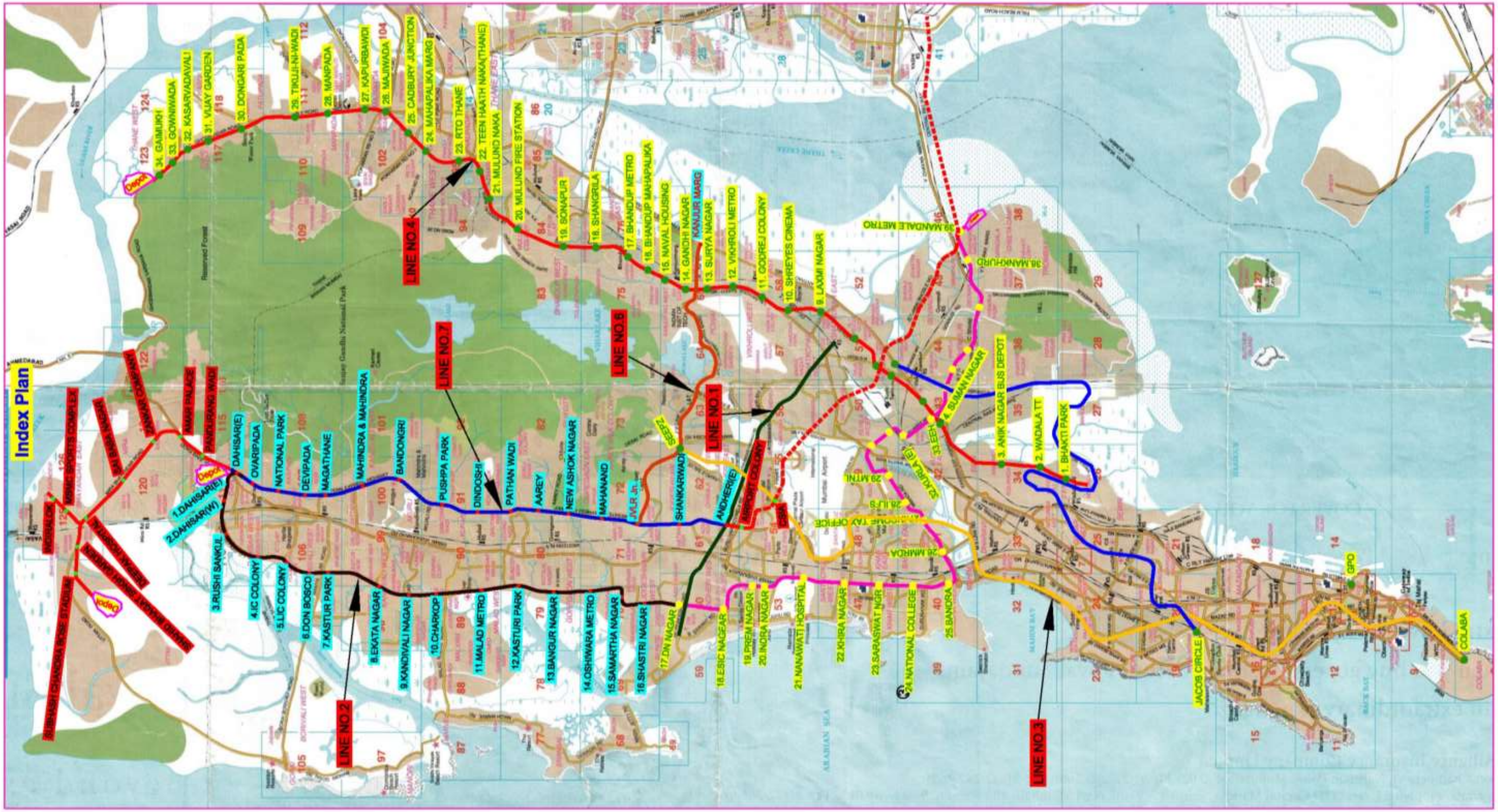
0.18.3 Cost

Estimated Cost of this extension at June 2017 price level is 786.00 Crore with all the taxes and duties including land and completion cost at 5.0% p.a. escalation is estimated to be Rs.940 Crores including all the taxes & duties and land cost.

0.18.4 After examining the various options for execution of the project, it has been recommended that the project should be got executed through a SPV on DMRC funding pattern.

0.18.5 Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR)

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **12.68%.** The Economic Internal Rate of Return (EIRR) works out to **18.35%.**


Index Plan
LINE NO.1
LINE NO.2
LINE NO.3
LINE NO.4
LINE NO.6
LINE NO.7

Chapter – 1

INTRODUCTION

1.1 BACKGROUND

Mumbai has a very good transportation system but has not been able to keep pace with rising demand. The carrying capacity of the bus and rail system has increased considerably but has been always on lower side than what is needed. Though metro for Mumbai had been talked for last 50-60 years, but something concrete did not come up till MMRDA got prepared Master Plan of Mumbai Metro network in 2003. Master Plan was totaling to 146.5 km comprising the under-mentioned corridors:

S. No.	Corridor	Length (km)		
		Total	Elev	U.G
1.	Varsova – Andheri – Ghatkopar	15.00	15.00	-
2.	Colaba – 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

DMRC prepared the DPRs for Line-1: Varsova – Andheri – Ghatkopar – 2005, Line-2: Colaba – Bandra – Charkop – 2008, Line – 3: Bandra – Kurla - Mankhurd – 2006. Subsequently, the corridors 2 & 3 were rearranged and DMRC prepared another DPR for the corridor between Charkop – Bandra – Mankhurd

In spite of above, the implementation of Mumbai metro remained very slow. So far only one line between Varsova – Andheri – Ghatkopar could be implemented. Other corridors presently under implementation are

- Colaba to Aarey Colony via International Airport. 30.00km
- Dahisar (E) to DN Nagar 18.60km
- Dahisar (E) to Andheri(E) 16.48km
- DN Nagar to Mandale 23.64km
- Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali 32.32km
- Swami Samarth Nagar to Vikhroli(EEH) 14.48km

Total 135.52km

In November/December, 2009, MMRDA awarded the work of preparing DPRs for the following corridors to the agencies as indicated herein:

S. No.	Corridor	Length (Km)	Agency
1.	Charkop – Dahisar	7.5	M/s SPAN Consultants Pvt Ltd.(August, 2010)
2.	Andheri(E)-Dahisar(E)	18.00	M/s SPAN Consultants Pvt Ltd.(May, 2010)
3.	Mahim – BKC - Kanjurmarg	12.5	M/s RITES & LASA (Sept, 2011)
4.	Ghatkopar-Mulund	12.50	M/s Consulting Engineering Services
5.	Bhakti Park- Wadala – Ghatkopar -Kasarvadavali	32	M/s RITES (following LBS Road) (September, 2014)
6.	Wadala – Ghatkopar – Kasarvadavali	30.00	M/s CES (following Eastern Expressway)(March, 2013)
7.	Wadala – Carnac Bandar	13.1	M/s RITES (December, 2012)

The Government of Maharashtra is keen to implement expeditiously the Master Plan Corridors recommended by DMRC on a fast track mode and to complete them in the next 3-4 years. To start with, it is decided to take up the task of updation of DPRs and also preparation of new DPRs for the following potential elevated metro corridors:

Sr. No.	Alignment	Length in km
A*	**Updation of DPRs for Mumbai Metro Master Plan Corridors**	
	(a) D.N. Nagar – Dahisar	18.00
	(b) Dahisar (E) – Andheri (E) (Along WEH)	18.00
	(c) Bandra – Mankhurd (Via BKC)	13.00
	(d) Wadala – Ghatkopar – Thane	22.00
	(e) Thane - Kasarvadavali	10.00
	(f) Wadala – GPO along R.A. Kidwai Rd. – Barrister Nath Pai Rd. – P.D. Mello Rd	8.00
B	**Review of Metro alignment and updation /preparation of DPRs**	
	(a) D.N. Nagar - BKC	10.00
	(b) Jogeshwari Vikhroli Link Road – SEEPZ – Kanjur Marg	10.00
	(c) Andheri (E) – BKC (Via WEH)	9.00
	Total	**118.00**

Out of 118km Master Plan network, the work of implementation of about 106km has already been started by MMRDA.

1.2 DEMOGRAPHIC PROFILE AND TRANSPORT SCENARIO OF MMR:

Mumbai, the financial capital of India, has witnessed phenomenal growth in population and employment and the trend is expected to continue in the future. The job opportunities it offers have served as a major attraction for immigration from hinterland of Maharashtra as well as from all parts of the Country.

Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. It comprises of 7 municipal corporations, 13 municipal councils and 996 villages and extends over an area of 4,355 sq. km MMR is projected to have population and employment (both formal and informal) as 34.0 million and 15.3 million respectively in the year 2031.

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

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

The population of MMR has increased from 7.73 million in 1971 to 18.77 million in the year 2011 (**Table 1.1**). However, the annual compound growth rate for population in MMR has declined from 3.71% during 1971-81 to 2.58% in 1991-2001.

TABLE 1.1: POPULATION GROWTH OF MMR DURING 1971-2011

Sr. No.	Area	Population					Annual Compound growth rate (%)			
		1971	1981	1991	2001	2011*	1971-1981	1981-1991	1991-2001	2001-2011
	Municipal Corporation									
A	Greater Mumbai	5.97	8.24	9.93	11.91	**12.48**	3.28	1.88	1.83	**0.47**
	Thane	0.26	0.47	0.79	1.26	**1.82**	6.1	5.33	4.78	**3.75**
	Kalyan - Dombivali	0.24	0.44	0.82	1.19	**1.25**	6.25	6.42	3.79	**0.49**
	Navi Mumbai	0.12	0.2	0.39	0.7	**1.12**	5.24	6.91	6.02	**4.81**
	Mira Bhayandar	0.03	0.07	0.18	0.52	**0.81**	8.84	9.9	11.19	**4.53**
	Bhiwandi - Nizampur	0.08	0.12	0.38	0.6		4.14	12.22	4.67	
	Ulhasnagar	0.17	0.27	0.37	0.47	**0.51**	4.73	3.2	2.42	**0.82**
	Sub Total (A)	**6.87**	**9.81**	**12.86**	**16.65**		**4.01**	**2.81**	**2.68**	
	Municipal Council									
	Thane District									
	Ambernath	0.06	0.1	0.13	0.2	**0.25**	5.24	2.66	4.4	**2.26**
	Kulgaon - Badlapur			0.05	0.1	**0.17**			7.18	**5.45**
	Nalasopara			0.07	0.18				9.9	
B	Vasai			0.04	0.05				2.26	
	Virar			0.05	0.12				9.15	
	Navghar Manikpur			0.06	0.12				7.18	
	Sub Total (B)	**0.06**	**0.1**	**0.40**	**0.77**		**5.24**	**14.87**	**6.77**	
	Raigad District									

Sr. No.	Area	Population					Annual Compound growth rate (%)			
		1971	1981	1991	2001	2011*	1971-1981	1981-1991	1991-2001	2001-2011
C	Alibag		0.01	0.02	0.02			7.18	0	
	Kajrat			0.02	0.03				4.14	
	Khopoli	0.02	0.03	0.05	0.06		4.14	5.24	1.84	
	Matheran	0.0034	0.004	0.0048	0.0052		1.64	1.84	0.8	
	Panvel	0.03	0.04	0.06	0.1		2.92	4.14	5.24	
	Pen		0.01	0.02	0.03		0	7.18	4.14	
	Uran			0.02	0.03		0		4.14	
	Sub Total (C)	**0.053**	**0.09**	**0.19**	**0.28**		**5.82**	**7.56**	**3.52**	
C	**Urban MMR (A+B+C)**	**6.98**	**10.00**	**13.45**	**17.70**		**4.04**	**3.08**	**2.84**	
D	**Rural MMR**	**1.08**	**1.25**	**1.16**	**1.05**		**1.47**	**-0.74**	**-0.99**	
E	**Grand Total**	**8.06**	**11.25**	**14.61**	**18.75**		**3.71**	**2.71**	**2.58**	

Source: CTS for MMR, Final Report, July 2008

Note: Figures highlighted in Grey forms Greater Mumbai (UA) as per Census 2001 and 2011

* http://www.census2011.co.in/census/metropolitan/305-mumbai.html

There is a continuous growth of population in absolute number however, the annual compound growth rate has reduced from that of 3.28% during 1971-81 to 1.83% in 1991-2001 to further 0.47% in 2001-2011.

1.3 ENVISAGED TRANSPORT NETWORK OF MMR

Comprehensive Transportation Study (CTS) for Mumbai Metropolitan Region estimated total daily demand of 34.3 million trips by all modes - of which 60% are by walk. Among the total trips by mechanized modes, 73% trips are by public transport and 9% by para-transit modes and balance 18% by private transport mode.

Mumbai Suburban rail system is still the major source of long distance inter – intra region travel whereas BEST buses provide for the cross movements. Para Transit modes offer door to door service.

Due to extensive reach across the Mumbai Metropolitan Region, and intensive use by the local urban population, the Mumbai Suburban Railway suffers from severe overcrowding. Over 4,500 passengers are packed into a 9-car rake during peak hours, as against the rated carrying capacity of 1,700, having Dense Crush Load of 14 to 16 standing passengers per square metre of floor space.

To decongest the existing suburban rail systems and provide connecting at macro and micro level within MMR, MMRDA envisaged a transit network of about 667 km in 32 transit links, **Figure 1.1**.

-	Metro Network	251 km
-	Monorail Network	179 km
-	Suburban Rail Network	237 km
	Total	667 km

Of the total network, the metro corridors are being by MMRDA/MMRC are shown in Figure **1.2**.

1.4 STUDY OBJECTIVES

The objective of the assignment is to review, update & prepare Detailed Project Report (DPR) for the proposed Wadala (Bhakti Park) to Kasarvadavali Metro Corridor with a view of cost reduction and speedy implementation.

1.5 SCOPE OF WORK

Phase-I: Review, update & prepare Detailed Project Report (DPR)

The services to be rendered under the proposed detailed study will include:

i. Traffic & Transportation surveys for estimation of Transport Demand and projection of sectional and station traffic loads for various horizon years. (Demand forecast will be provided by MMRDA)

ii. Preparation of alternative routes on Satellite Map/available standard maps in consultation with MMRDA. (Only for JVLR and D.N. Nagar to BKC)

iii. Multi modal Traffic integration, Station Area Traffic Dispersal Plans, planning for feeder bus service, public bike sharing and pedestrianisation in the influence area of stations as available in the existing DPRs; however the cost of updation shall be reimbursed on actuals in addition to fee stated in para 4.10.

iv. Filed Surveys and preparation of topographical survey plans for route alignments and assessment of land requirement for facilities like station areas, Electric sub stations (TSS and RSS) Maintenance Depot and Construction Depots, casting yard, labour camps, firefighting facilities etc.

v. Field Surveys for identification of major above-ground utilities along the proposed Metro routes requiring diversion/relocation. Details of underground utilities shall be supplied by State Govt. through the concerned utility agencies. (Majority of Utilities are identified during earlier preparation of DPRs.)

vi. Geometric design of the route alignments covering horizontal as well as vertical profiles

vii. Identification of depots & preparation of its general layout plans, covering all facilities)

viii. Location of stations and general layout plans for stations and integration areas.

ix. EIA & SIA studies and preparation of EMP for negative impacts including air, noise, water if any.

x. Geo-technical investigations along the identified corridors, wherever earlier data is not available.

xi. Technology Selection – Board details of Traction and Signalling system, rolling stock, track, etc.

xii. Conceptual Plan for the rolling stock maintenance depots.

xiii. Laying down norms for disable friendly features to ensure accessibility to persons with disabilities.

xiv. Traffic Control, safety & diversion plans during construction stage and arrangement.

xv. Security measures and to ensure security for metro system.

xvi. Disaster management features and emergency evacuation plans for metro system plan.

xvii. Preparation of detailed Implementation Schedule including pre-construction, construction stage includes civil, system work.

xviii. Estimation of construction costs, operation and maintenance costs.

xix. Study on the Fare Structure.

xx. A separate note on underground vs. elevated metro system in Mumbai Scenario.

xxi. Financial and Economic analysis for the project.

xxii. Evolving a Funding Plan and Institutional arrangement for the Project.

xxiii. Preparation and submission of Detailed Project Report and executive summary.

1.6 STRUCTURE OF REPORT

The report is structured in under mentioned 18 chapters:

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

ii. Chapter two consists of travel characteristics in the study area, the traffic demand forecast carried out in CTS and ridership assessment on the Study Corridor.

iii. Chapter three is on system design and includes components like permanent way, traction system, signalling, telecommunication, fare collection and rolling stock.

iv. Chapter four presents civil engineering design.

v. Chapter five consists Station Planning and horizontal & vertical alignment of the proposed corridor.

vi. Chapter six presents the train operation plan.

vii. Chapter seven discusses the maintenance facilities /depots.

viii. Chapter eight relates to power supply and traction system.

ix. Chapter nine presents the environment impact assessment and social impact assessment of the proposed metro rail corridor.

x. Multi Model Traffic integration at metro station is presented in chapter ten.

xi. Chapter eleven consists friendly features for differently abled.

xii. Chapter twelve is on Security Measures for a metro system

xiii. Chapter thirteen is on Disaster Management Measures.

xiv. Cost estimate is in chapter fourteen.

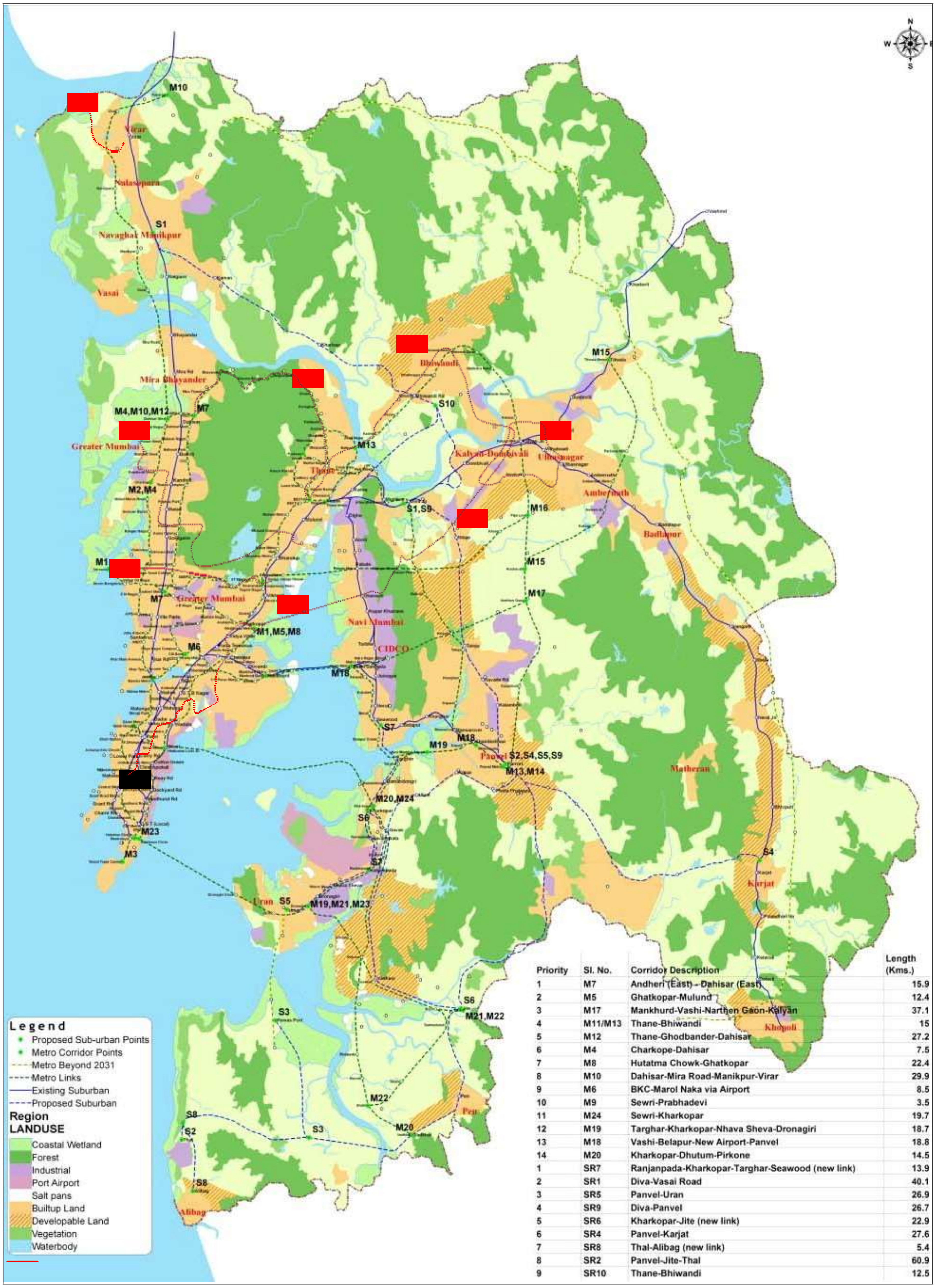
xv. Chapter fifteen presents the financial analysis, financial viability, financing options.

xvi. Chapter sixteen is on economic appraisal

xvii. Chapter seventeen is on implementation strategies.

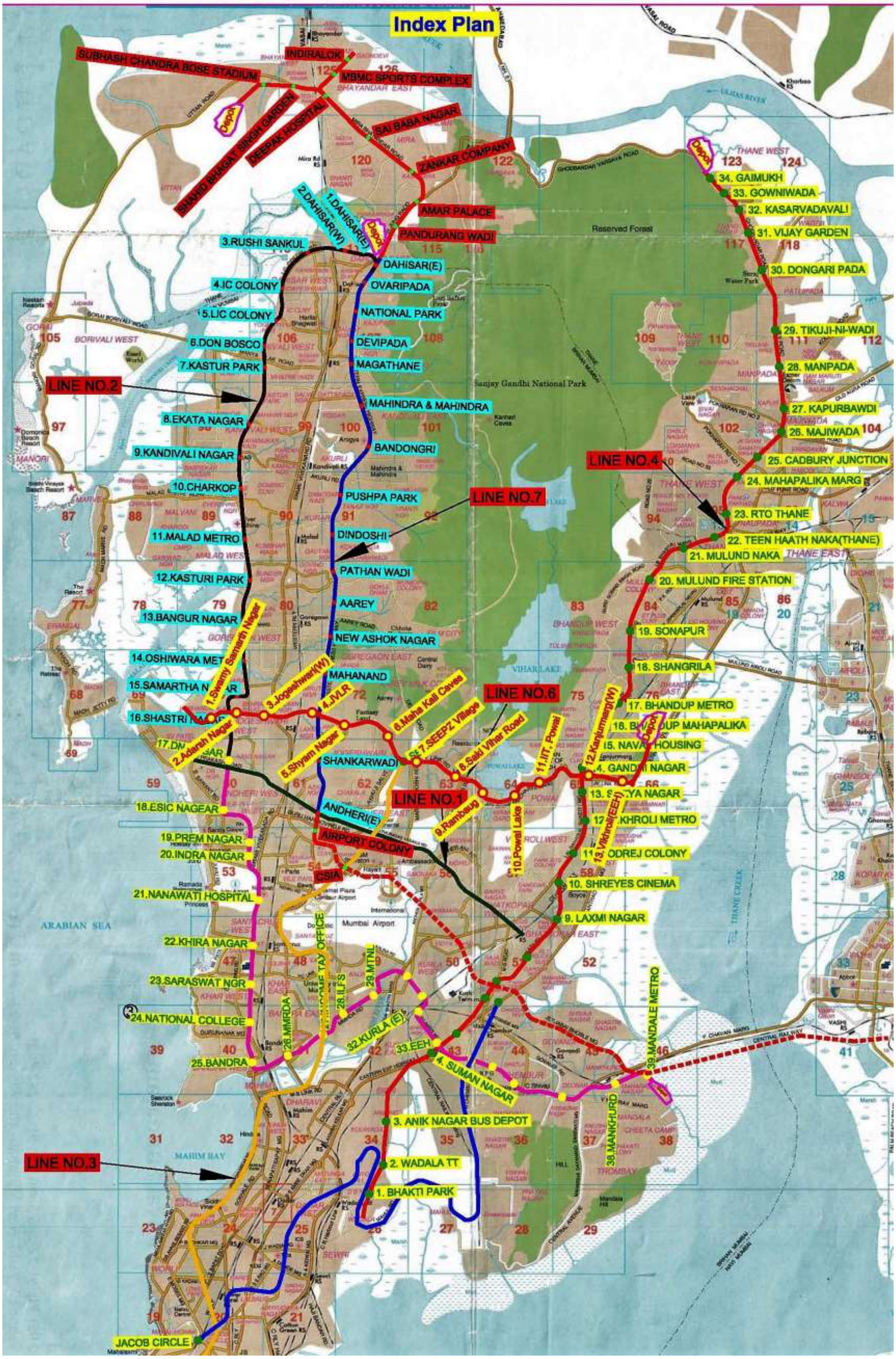
xviii. Chapter eighteen consists conclusions and recommendations

Figure 1.1



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

Figure 1.2


Index Plan
LINE NO.2
LINE NO.3
LINE NO.4
LINE NO.6
LINE NO.7
LINE NO.1
SUBHASH CHANDRA BOSE STADIUM
INDIRALOK
MBMC SPORTS COMPLEX
SAI BABA NAGAR
DEEPAK HOSPITAL
SHAHID BHAGAT SINGH GARDEN
ZANKAR COMPANY
AMAR PALACE
PANDURANG WADI
1.DAHISAR(E)
2.DAHISAR(W)
3.RUSHI SANKUL
4.IC COLONY
5.LIC COLONY
6.DON BOSCO
7.KASTUR PARK
8.EKATA NAGAR
9.KANDIVALI NAGAR
10.CHARKOP
11.MALAD METRO
12.KASTURI PARK
13.BANGUR NAGAR
14.OSHIWARA METRO
15.SAMARTHA NAGAR
16.SHASTRI NAGAR
17.DN NAGAR
18.ESIC NAGEAR
19.PREM NAGAR
20.INDRA NAGAR
21.NANAWATI HOSPITAL
22.KHIRA NAGAR
23.SARASWAT NGR
24.NATIONAL COLLEGE
25.BANDRA
26.MMRDA
28.ILFS
29.MTNL
32.KURLA (E)
33.EEH
DAHISAR(E)
OVARIPADA
NATIONAL PARK
DEVIPADA
MAGATHANE
MAHINDRA & MAHINDRA
BANDONGRI
PUSHPA PARK
DINDOSHI
PATHAN WADI
AAREY
NEW ASHOK NAGAR
MAHANAND
SHANKARWADI
ANDHERI(E)
AIRPORT COLONY
CSIA
1.Swamy Samarth Nagar
2.Adarsh Nagar
3.Jogeshwari(W)
4.JVLR
5.Shyam Nagar
6.Maha Kali Caves
7.SEEPZ Village
8.Saki Vihar Road
9.Ramabaug
10.Powai Lake
11.IIT, Powai
12.Kanjurmarg(W)
13.Vikhroli(EEH)
34. GAIMUKH
33. GOWNIWADA
32. KASARVADAVALI
31. VIJAY GARDEN
30. DONGARI PADA
29. TIKUJI-NI-WADI
28. MANPADA
27. KAPURBAWDI
26. MAJIWADA
25. CADBURY JUNCTION
24. MAHAPALIKA MARG
23. RTO THANE
22. TEEN HAATH NAKA(THANE)
21. MULUND NAKA
20. MULUND FIRE STATION
19. SONAPUR
18. SHANGRILA
17. BHANDUP METRO
16. BHANDUP MAHAPALIKA
15. NAVAL HOUSING
14. GANDHI NAGAR
13. SURYA NAGAR
12. KHROLI METRO
11. GODREJ COLONY
10. SHREYES CINEMA
9. LAXMI NAGAR
4. SUMAN NAGAR
3. ANIK NAGAR BUS DEPOT
2. WADALA TT
1. BHAKTI PARK
38.MANKHURD
39.MANDALE METRO
JACOB CIRCLE
Depot
Sanjay Gandhi National Park
Reserved Forest
ARABIAN SEA
MAHIM BAY
THANE CREEK
VIHAR LAKE
Mumbai Airport

Chapter – 2

Traffic Demand Forecast

2.1 PLANNING PARAMETERS

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

The CTS has examined a range of alternatives for distribution of population and employment in the MCGM and Rest of the Region (RoR) in order to determine the sensitivity of the road and transit system networks, in terms of both need and priorities, to significantly different land development options or strategies as summarized in **Table 2.1.**

TABLE 2.1: RANGE OF POPULATION AND EMPLOYMENT LEVELS

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

Source: CTS for MMR, MMRDA

The major changes expected in socio economic parameters which will affect the overall development as well as transportation for the horizon year 2031 are summarized in the **Table 2.2.**

TABLE 2.2: EXPECTED CHANGES (2005-2031) IN SOCIO ECONOMICS FACTORS

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

Source: CTS for MMR, MMRDA

The difference in work travel characteristics is shown in **Table 2.3** with the office workers travelling more than twice the distance than other employment. Over 70% of office workers use public transit as compared to 53% for the employees in industry and 37% for other types of employment.

TABLE 2.3: TRAVEL CHARACTERISTICS OF EXISTING EMPLOYMENT

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

Source: CTS for MMR, MMRDA

In order to sustain a population level of 34 million and an employment of 15.3 million, the economy of Mumbai must be more broad-based and it was concluded that the Industrial proportion of 30% of the future total employment was appropriate and reasonable in terms of both landuse need and transportation planning. **Table 2.4** gives the expected changes in employment characteristics during 2005-2031.

TABLE 2.4: EXPECTED CHANGE IN EMPLOYMENT CHARACTERISTICS 2005-2031

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

Source: CTS for MMR, MMRDA

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

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

On comparative evaluation and short listing, P2E2, P3E3, P4E4 were shortlisted by MMRDA as the appropriate options to be carried forward in completing TRANSFORM, on the planning principle that the long term transportation strategies should respond to several futures rather than reflect a single development future. The ranking of these scenarios is given in **Table 2.5.** The P3E3 population/ employment scenario has been subsequently adopted as the preferred strategy.

TABLE 2.5: COMPARATIVE EVALUATION OF GROWTH SCENARIOS

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

Source: CTS for MMR, MMRDA

2.2 MODEL DEVELOPMENT

The base year model (2014) was developed by first of all building a "best estimate" of the trip matrices (for both road-based personal vehicles and public transport). This was based on a combination of data from previous studies carried by MVA and recently collected traffic and trip making data. A process of matrix estimation was then used to further refine these matrices to match the observed vehicle and passenger flows as derived from the survey data and other sources.

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

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

The base matrices for road-based vehicles were initially developed from the previous MVA Study and information available from recent studies such as the CTS. A matrix estimation process was then used to produce updated matrices for the base year (2014) using traffic survey data. Trip length distribution and journey times were monitored in this process.

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

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

2.2.1 Public Transport Assignment

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

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

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

- Public Transport GC = (In-Vehicle Time x In-vehicle time Factor)
  + (Walk Time x Walk Time Factor)
  + (Wait Time x Wait Time Factor)
  + (Number of Transfers x Interchange Penalty)
  + Fare / Value of Time (willingness to pay)

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

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

TABLE 2.6: PUBLIC TRANSPORT MODEL - KEY PARAMETERS (2014)

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

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

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

2.2.2 Future Model Development

The model is developed for future benchmark years which for this study have been selected as 2021 and 2031. This section describes the model structure for the future years and then the forecasting assumptions prepared for the benchmark years.

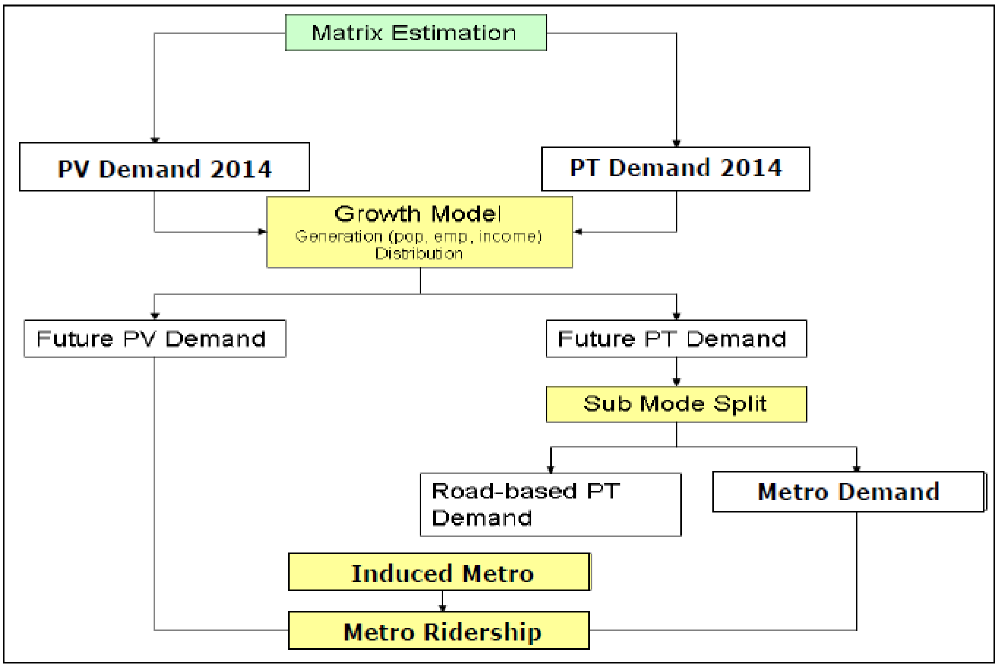
Figure 2.1 shows the progression of the model structure from the 2014 structure in which separate demand matrices for private and public transport were developed from observed data.

The basis for the future year travel demands is the growth model shown in the above figure between the 2014 and future model application. The model is calibrated in 2014 to develop a relationship between land use data (population and employment), income/vehicle ownership and trip making. This relationship is then used in the future to forecast total trip making and modal share between private and public transport in the future. Within public transport, the share between road and rail- based travel is then calculated. The costs for this split are derived from the detailed public transport sub-model.

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

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

FIGURE 2.1: OUTLINE OF FORECAST YEAR MODEL STRUCTURE



The public transport sub-model structure then becomes quite complex as shown in **Figure 2.2** as the different costs of alternatives (which combine to form Level of Service – LOS – or generalized cost), by different income groups needs to be considered.

The parameters feeding into the generalized cost (or LOS) calculation are largely the same as those shown in **Table 2.6**. The exceptions to this are the future year value-of-time some adjustments to the in-vehicle-time factors for buses to reflect the improvements in bus service provision (eg. better information, bus priority measures etc). Furthermore, it can be expected that in the future more of the bus fleet will be air conditioned compared to today.

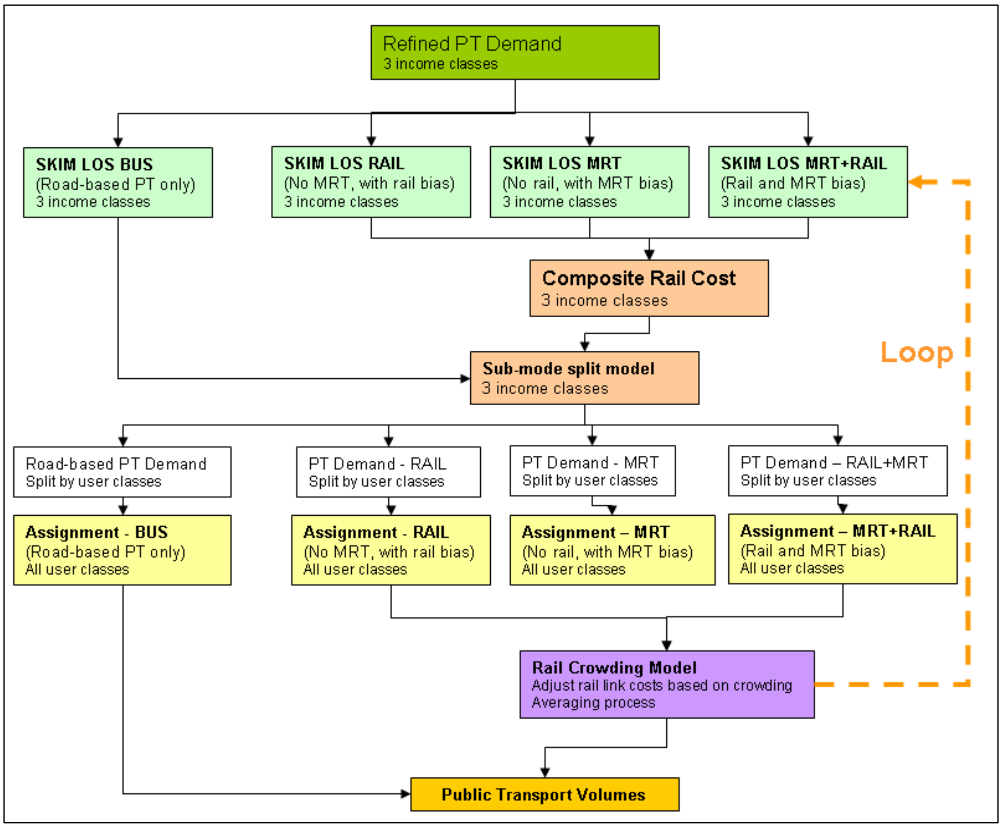
Road Network Assumptions

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

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

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

FIGURE 2.2: FUTURE YEAR APPLICATION OF PUBLIC TRANSPORT SUB-MODEL



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

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

Public Transport Network Assumptions

Out of the total envisaged mass transit network in MMR, the assumed operational network in the transport model is set out in **Table 2.7**.

TABLE 2.7: RAILWAY NETWORK ASSUMPTIONS

Year	Rail Network Development
2014	Metro Line 1: Versova – Andheri – Ghotkopar Monorail Phase 1: Jacob Circle – Wadala – Chembur
2015	MUTP Rail Improvements
2021	Metro Line 3: Colaba – Bandra-SEEPZ
2021	Metro Line 2: Dahisar – Charkop – Bandra – Mankhurd
2022	Metro Line 5: Wadala – Ghatkopar – Thane – Kasarvadavali
2021	M 7: Dahisar – Andheri
2031	M10: Dahisar – Mira Road – Manikpur – Virar
2031	Mo6: Thane – Dahisar
2031	Mo 3: Mulund – Goregaon – Gorai

2.3 RIDERSHIP ON PROPOSED WGTKG METRO CORRIDOR

While estimating the ridership figures for the proposed Metro corridor, following important considerations have been made:

- P3E3 landuse scenario is considered. This scenario allocates growth to MCGM and RoR in equal proportion.
- Future road and rail/ metro network as detailed in the previous section.
- Interchanges with other mass transit corridors have been considered;

  - Monorail at Wadala
  - Monorail at Chembur
  - Lokmanya Tilak Terminus with LTT Metro
  - Suburban Stations at Vikhroli and Kanjur Marg
  - Metro at Kanjur Marg
  - Monorail/Metro at Kasarvadavali

- Metro Fare is considered as 1.5 times the ordinary bus fare.
- Speed of the metro is taken as 35 Kmph.
- Peak Hour Frequency of metro service is considered as 3.5 minutes for 2031.

The daily ridership, peak hour station loads and peak hour section loads for the proposed Metro Corridor are given in **Table 2.8** and **2.9**.

Table 2.8 Peak Hr. Ridership for Metro Line -4 (Wadala – Kasarvadavali - Gaimukh) for Horizon year 2021

Alighting	Boarding	Volume Gaimukh to Wadala	Station Name	Volume Wadala to Gaimukh	Boarding	Alighting
12158	0	0	BHAKTI PARK METRO	3887	3887	0
5509	479	12158	WADALA TT	6124	2925	689
1111	354	17188	ANIK NAGAR BUS DEPOT	6648	698	174
1824	260	17945	SUMAN NAGAR	8240	1691	99
5845	655	19508	SIDDHARTH COLONY	11137	3332	434
2623	234	24698	AMAR MAHAL JUNCTION	13585	2550	102
582	231	27087	GARODIA NAGAR	13896	499	188
99	93	27439	PANT NAGAR	13917	77	57
465	340	27445	LAXMI NAGAR	14007	521	430
4133	12641	27570	SHREYES CINEMA	12743	3172	4436
1265	595	19061	GODREJ COMPANY	13460	968	251
859	1730	19731	VIKHROLI METRO	12464	496	1491
377	651	18860	SURYA NAGAR	12392	157	230
1667	2154	18586	GANDHI NAGAR	11998	1482	1875
0	145	18099	NAVAL HOUSING	11964	0	34
2792	8	17954	BHANDUP MAHAPALIKA	14263	2323	24
264	1046	20738	BHANDUP METRO	14284	423	402
4589	1808	19956	SHANGRILA	16217	2746	813
582	831	22738	SONAPUR	16110	552	657
50	201	22489	MULUND FIRE STATION	16214	151	48
1070	622	22338	MULUND NAKA	15944	547	818
851	1625	22786	TEEN HAATH NAKA (THANE)	15546	742	1139
1446	4014	22012	RTO THANE	13734	1235	3048
1251	1533	19443	MAHAPALIKA MARG	14012	1315	1036
143	450	19161	CADBURY JUNCTION	13376	41	677
1212	1922	18854	MAJIWADA	13214	969	1132
761	1844	18144	KAPURBAWDI	11485	619	2348
671	1710	17062	MANPADA	11011	615	1090
2876	2184	16023	TIKUJI-NI-WADI	12512	2108	607
1370	2694	16714	DONGARI PADA	10726	697	2484
1052	2619	15390	VIJAY GARDEN	10050	717	1394
617	2261	13823	KASARVADAVALI	8962	459	1547
831	1145	12179	GOWNIWADA	8558	619	1022
0	11864	11864	GAIMUKH	0	0	8558
60944	60944	**27570**	**PHPDT**	**16217**	39334	39334
100278		**Peak Hour Ridership**			**100278**	
1002777		**Daily Ridership**			**1002777**	

Trip Length Distribution for Gaimukh-Kasarwadvali-Thane-Ghatkopar-Wadala Metro 2021		
Stage(km)	**Number of Trips**	**Percentage**
0 to 2	5443	5.43
2 to 4	12939	12.90
4 to 6	9398	9.37
6 to 9	26302	26.23
9 to 12	12406	12.37
12 to 15	11222	11.19
15 to 18	7726	7.70
18 to 21	6370	6.35
21 to 24	3763	3.75
24 to 27	2523	2.52
>27	2187	2.18
Total	**100278**	**100**

Table 2.9 Peak Hr. Ridership for Metro Line -4 (Wadala – Kasarvadavali - Gaimukh) for Horizon year 2031

Alighting	Boarding	Volume Gaimukh to Wadala	Station Name	Volume Wadala to Gaimukh	Boarding	Alighting
11571	0	0	BHAKTI PARK METRO	3694	3694	0
4646	308	11571	WADALA TT	5861	2459	292
1034	207	15910	ANIK NAGAR BUS DEPOT	6281	575	155
2831	1413	16736	SUMAN NAGAR	7905	1943	319
4032	556	18154	SIDDHARTH COLONY	10981	3369	293
1622	521	21629	AMAR MAHAL JUNCTION	12708	2023	296
198	4491	22731	GARODIA NAGAR	12113	246	841
430	164	18439	PANT NAGAR	12306	337	143
881	547	18704	LAXMI NAGAR	12467	737	575
14120	5248	19038	SHREYES CINEMA	17599	7333	2202
2023	1178	27910	GODREJ COMPANY	16468	1053	2183
939	2181	28755	VIKHROLI METRO	15815	888	1542
522	981	27514	SURYA NAGAR	15452	494	856
4834	1457	27055	GANDHI NAGAR	17330	3173	1295
901	834	30432	NAVAL HOUSING	17975	800	155
284	959	30500	BHANDUP MAHAPALIKA	17777	227	425
1833	950	29825	BHANDUP METRO	18233	1217	761
822	7137	30708	SHANGRILA	17972	1883	2144
439	137	24394	SONAPUR	18120	361	213
755	1816	24697	MULUND FIRE STATION	18258	1083	945
507	400	23636	MULUND NAKA	18169	238	326
1151	2101	23743	TEEN HAATH NAKA (THANE)	18256	1695	1609
3330	2509	22793	RTO THANE	17168	2045	3133
1161	1251	23614	MAHAPALIKA MARG	16601	884	1451
1837	3122	23525	CADBURY JUNCTION	15922	1455	2134
944	2996	22240	MAJIWADA	14734	924	2113
506	2574	20189	KAPURBAWDI	12852	729	2612
10968	4067	18121	MANPADA	20415	9710	2147
1044	3205	25022	TIKUJI-NI-WADI	18800	869	2483
1457	4660	22861	DONGARI PADA	17793	966	1973
0	3077	19658	VIJAY GARDEN	15634	0	2159
753	6	16580	KASARVADAVALI	16328	695	0
1008	1509	17328	GOWNIWADA	15780	907	1455
0	16827	16827	GAIMUKH	0	0	15780
79386	79386	30708		20415	55012	55013
134398		**Peak Hour Ridership**			**134398**	
1343979		**Daily Ridership**			**1343979**	

Trip Length Distribution for Wadala – Kasarvadavali - Gaimukh for Horizon year 2031		
Stage	**Number of Trips**	**Percentage**
0 to 2	16720	12.44
2 to 4	19202	14.29
4 to 6	22821	16.98
6 to 9	26161	19.46
9 to 12	13286	9.89
12 to 15	10689	7.95
15 to 18	7122	5.30
18 to 21	10416	7.75
21 to 24	4184	3.11
24 to 27	2360	1.76
>27	1437	1.07
Total	**134399**	**100**

Chapter – 3

SYSTEM DESIGN

3.0 INTRODUCTION

The extension of Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali) starts from Kasarvadavali and runs Northward up to Gaimukh. Total length of this extension is 2.668 km and it is completely elevated. Maintenance Depot has been proposed at Gaimukh end station on Land identified by MMRDA.

3.1 PERMANENT WAY

3.1.1 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. Even Delhi Metro which started with Broad Gauge has switched over to Standard Gauge. It is advantageous for many reasons 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.

3.1.2 TRACK STRUCTURE

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro Systems should be long lasting and 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.**3.1**). 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 pedestals 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. 3.2**).

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. 3.3**).

The Scissors crossovers on Main Lines (1 in 9 type) will be with a minimum track centre of 4.5 m (shown in **Fig. 3.4**).

- 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 section, 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.

3.1.3 RAIL STRUCTURE INTERACTION

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

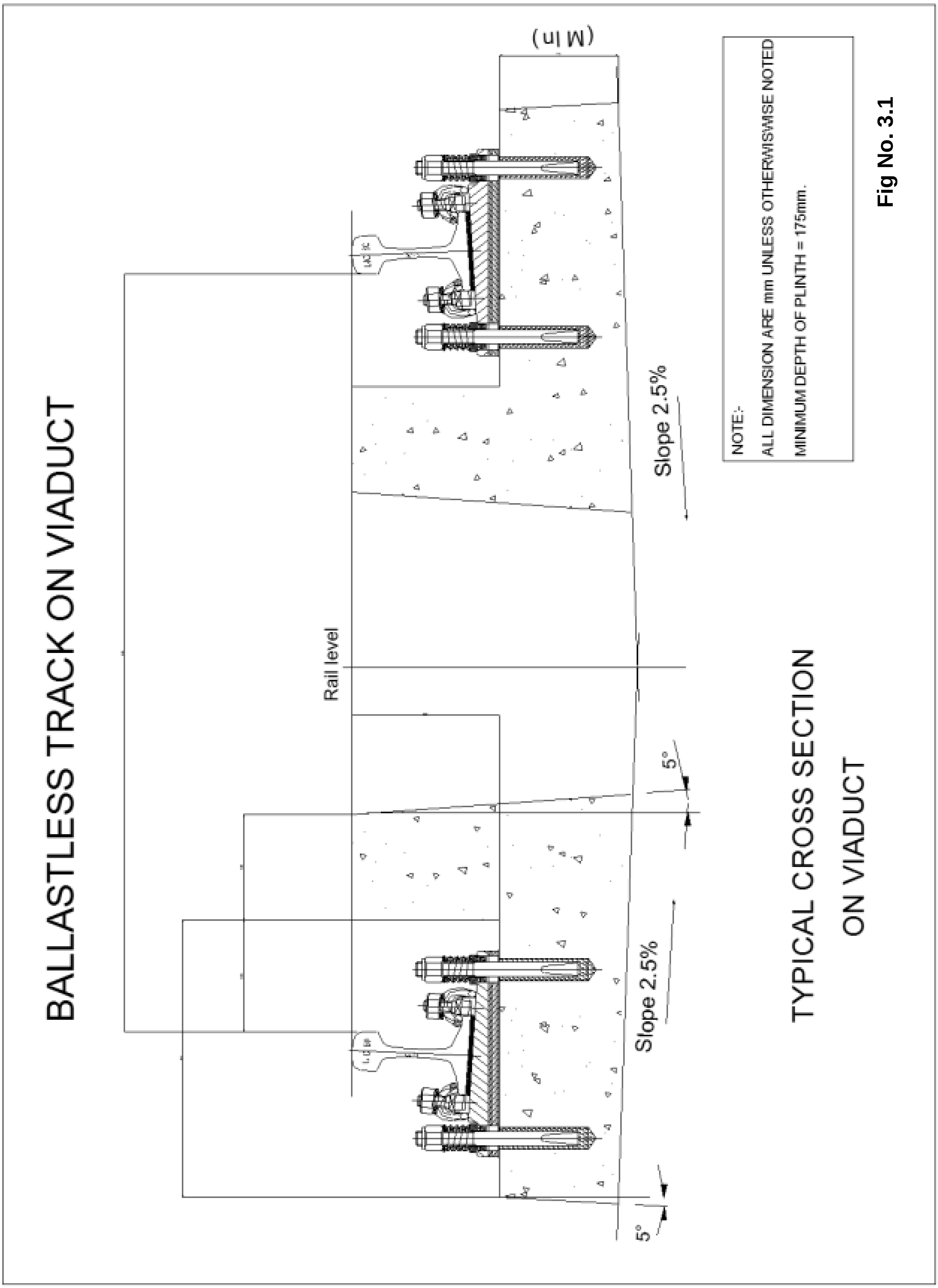
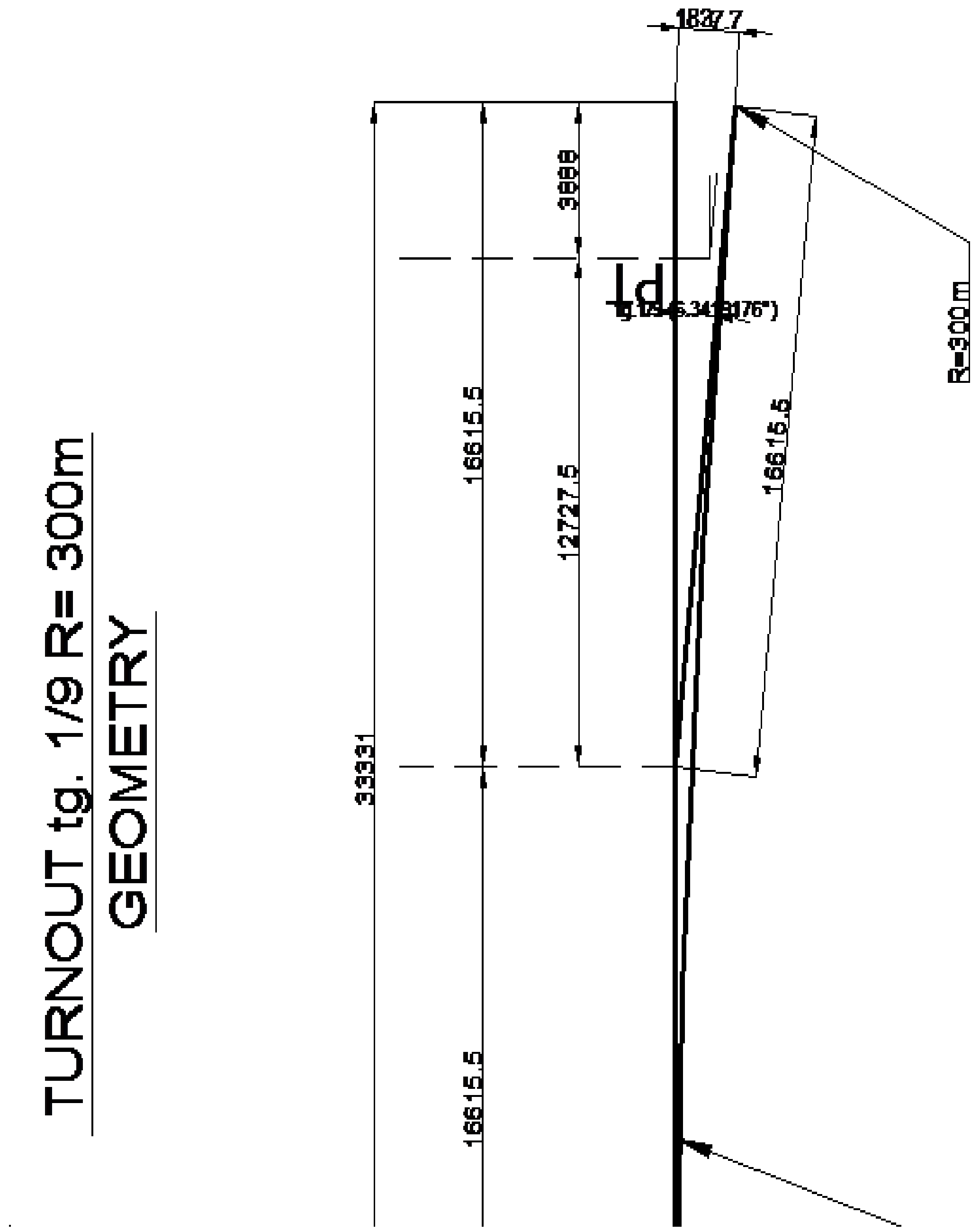

BALLASTLESS TRACK ON VIADUCT
Rail level
Slope 2.5%
Slope 2.5%
5°
5°
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWSE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.
TYPICAL CROSS SECTION
ON VIADUCT

Fig No. 3.1

Fig No. 3.2


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

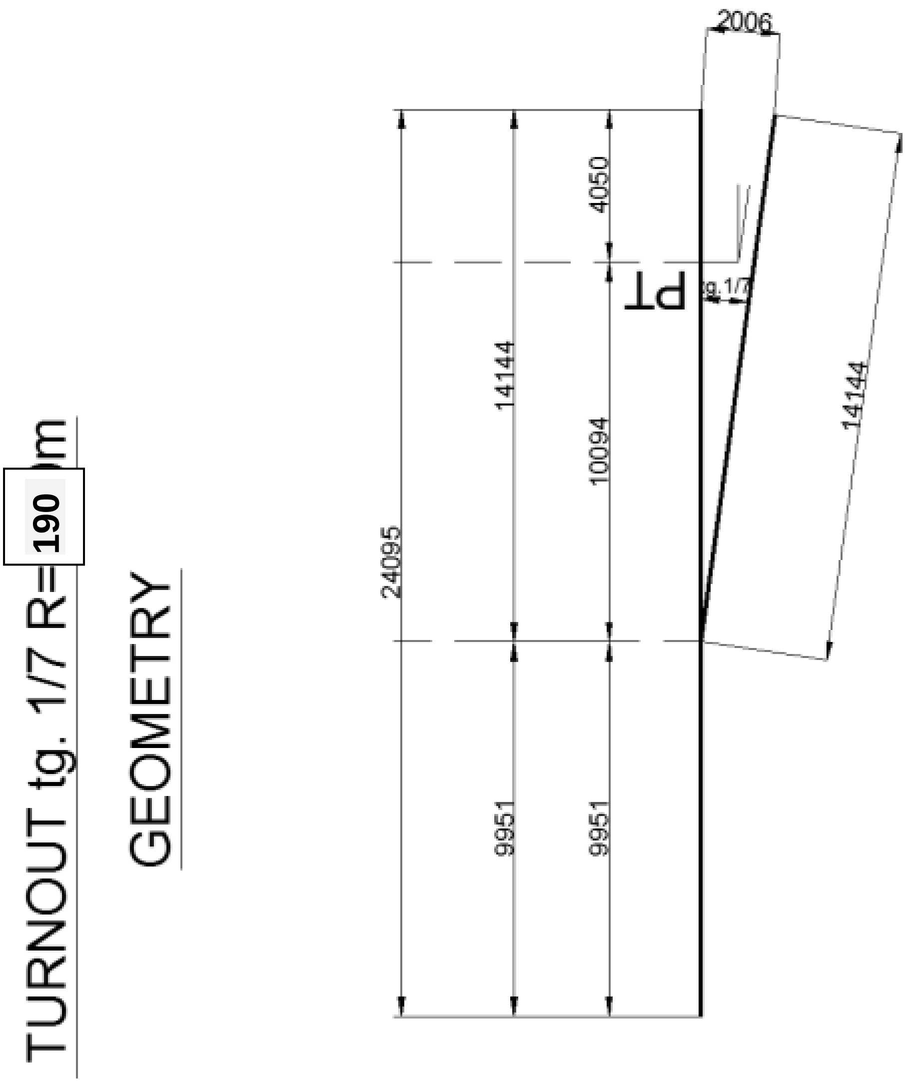

TURNOUT tg. 1/7 R=190m
GEOMETRY
2006
4050
PT
tg.1/7
14144
10094
24095
14144
9951
9951

Fig No. 3.3

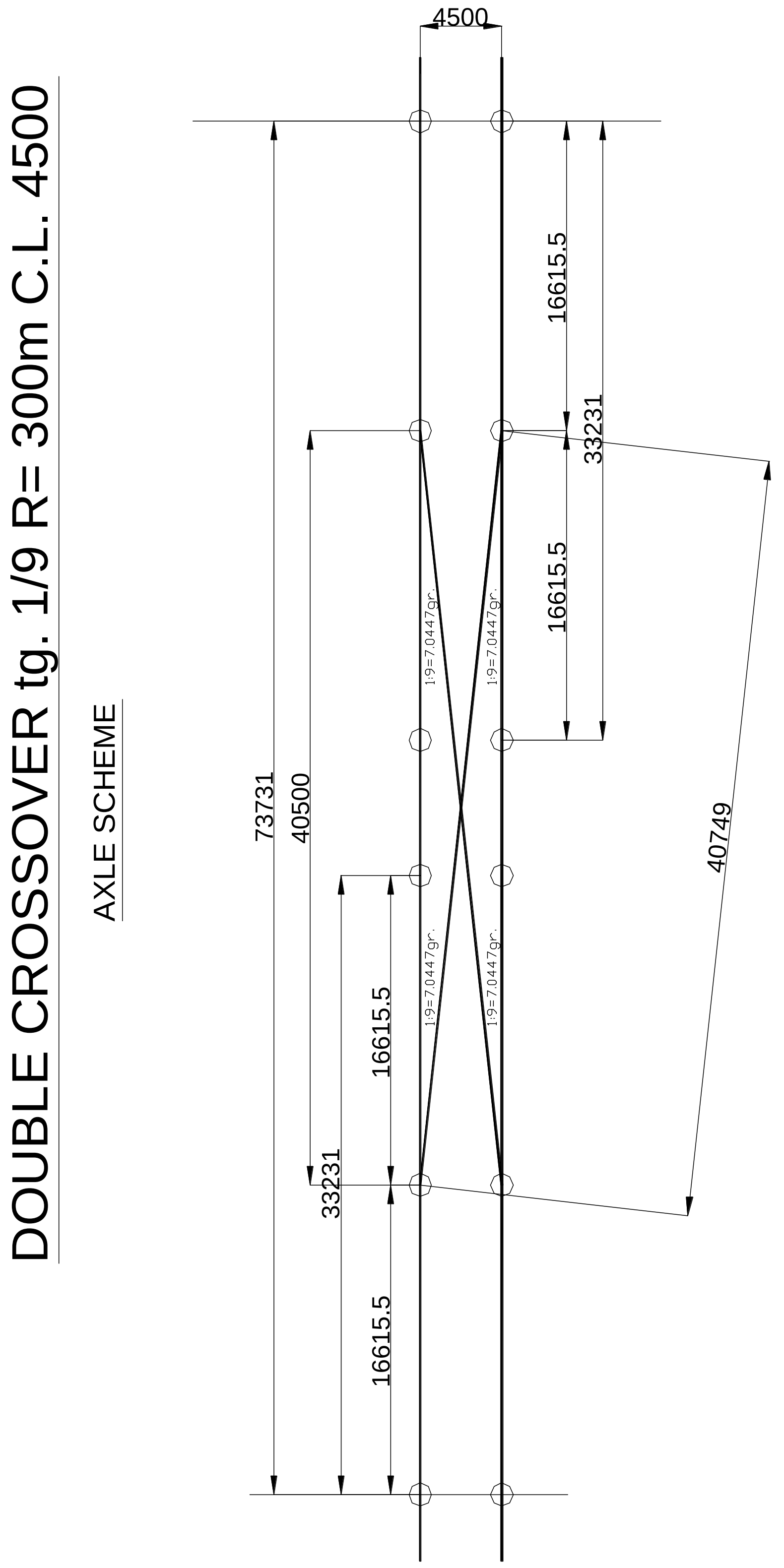

DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500
AXLE SCHEME
4500
73731
40500
33231
16615.5
16615.5
16615.5
16615.5
33231
40749
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.

Fig No. 3.4

3.2 TRACTION SYSTEM

3.2.1 INTRODUCTION

3.2.1.1 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.

3.2.1.2 The alignment of the proposed corridor from Wadala to Kasarvadavali 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.

3.2.1.3 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.

3.2.2 SALIENT FEATURES OF THE SYSTEM

3.2.2.1 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. 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.

3.2.2.2 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). 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.

3.2.2.3 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.

3.2.2.4 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.

3.2.3 EARTHING ARRANGEMENTS

3.2.3.1 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.

3.2.3.2 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.

3.2.3.3 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.

3.2.3.4 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.

3.2.4 OHE SECTIONING

3.2.4.1 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.

3.3 SIGNALLING AND TRAIN CONTROL

3.3.1 Introduction

3.3.2 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.

3.3.3 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:

3.3.3.1 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:

3.3.3.1.1 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.

3.3.3.1.2 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.

3.3.3.1.3 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.

3.3.3.2 Interlocking System

3.3.3.2.1 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.

3.3.3.2.2 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.

3.3.3.2.3 Signals

Multi Aspect Colour Light (LED) type Line side signals shall be installed on the Main Line at stations with point and crossing for point protection catering for bidirectional working and depot entry/ exit.

.

3.3.3.2.4 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.

3.3.3.3 Train Depot: Signalling

All depot lines except the one which is used for shunting and lines 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.

3.3.3.4 Interface for PSD

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

3.3.4 Standards

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

Table 3.1

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	All data transmission on telecom cables/OFC/Radio. All Signalling and

Description	Standards
Interface.	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.

3.3.5 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.

3.3.6 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.

3.4 TELECOMMUNICATION

3.4.1 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.

3.4.2 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.

3.4.3 Telecommunication System and Transmission Media

3.4.3.1 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-16) based system shall be adopted with SDH nodes at every station, depot and OCC. The SDH equipment shall be equipped with Ethernet card to provide channels to other interfacing contractors of SCADA,PA/PIDS etc. 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.

3.4.3.2 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. Alternatively only for non-operational (other than Direct Line Communication) a separate IP Based Phone System can be implemented.

3.4.3.3 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 9 sites with rooftop towers with Base Stations shall be required along the proposed Wadala-Kasarwadavli Metro Corridor.

3.4.3.4 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. .

3.4.3.5 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.

3.4.3.6 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.

3.4.3.7 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.

3.4.3.8 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.

3.4.3.9 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.

3.4.4 Technology

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

Table 3.2 TECHNOGIES FOR TELECOMMUNICATION SYSTEMS

System	Standards
Transmission Media	Optical Fibre system as the main bearer for bulk of the Telecommunication network

System	Standards
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 on Elevated and LED Panels in concourse 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.

3.4.5 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.

3.4.6 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.

3.5 AUTOMATIC FARE COLLECTION SYSTEM

3.5.1 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 Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern metros internationally. Tripod turnstile type gates offer less throughput and require more maintenance and hence are not proposed. All these Gates will have a functionality of Auto Top on Smart cards in case balance goes below the threshold Value (As per User Choice/Business Rules)

D. Ticket Vending Machine (TVM)

At all stations, Passenger Operated Ticket Vending Machines (Automatic Ticket Vending Machines) are proposed. The TVM's will provide convenience to passengers to avoid standing in queues at ticket booths and provide them international standard service. This will be used for

1. Dispensing Smart Tokens for single journey
2. Add Value in Smart card by paying money using Bank Notes or through Credit Card /Debit card /Pre-Paid card.
3. Return the remaining money through Bank Notes and Coins (Min 2 types)

E. Ticket Reader/Add Value Machines

These machines will be used to know the Card/Token balance and can also be used as Add value device in case payment for Card top up is made through alternate Internet based channel like net banking, Credit/Debit card (Payment gateway) etc.

F. Recharge Card Terminal Machine (RCTM)

RCTM will be used to recharge the Card using Credit Card /Debit card /Pre Paid card as well as bank Note.

3.5.2 AFC Equipment Requirement

The AFC equipment required at various locations of Mumbai Metro corridor are tabulated at Annexure 3.1. However the exact number and type shall depend on the final station layout and traffic being catered to.

3.5.3 Standards

The standard proposed for AFC system are as under:

Table 3.3

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.

Standards	Description
Gates	Computer controlled retractable flap / turnstile type automatic gates at entry and exit. There will be following types of gates : - **Entry** - **Exit** - **Reversible** - **Disabled** – Wide reversible gate for disabled people.
Station computer, central computer and AFC 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. Also TVM's shall be provided for Automatic Ticket Vending.
Ticket Readers	**Ticket Reader** shall be installed near EFO for passengers to check information stored in the token / cards.
Portable ticket decoder(PTD)	**PTD** will be used to check the card/token during travel
Recharge card terminal machine	**RCTM** will be used to recharge the card using bank note/debit card/credit card/pre paid card
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.

3.5.4 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.

Fig 3.1 Entry/Exit Gates

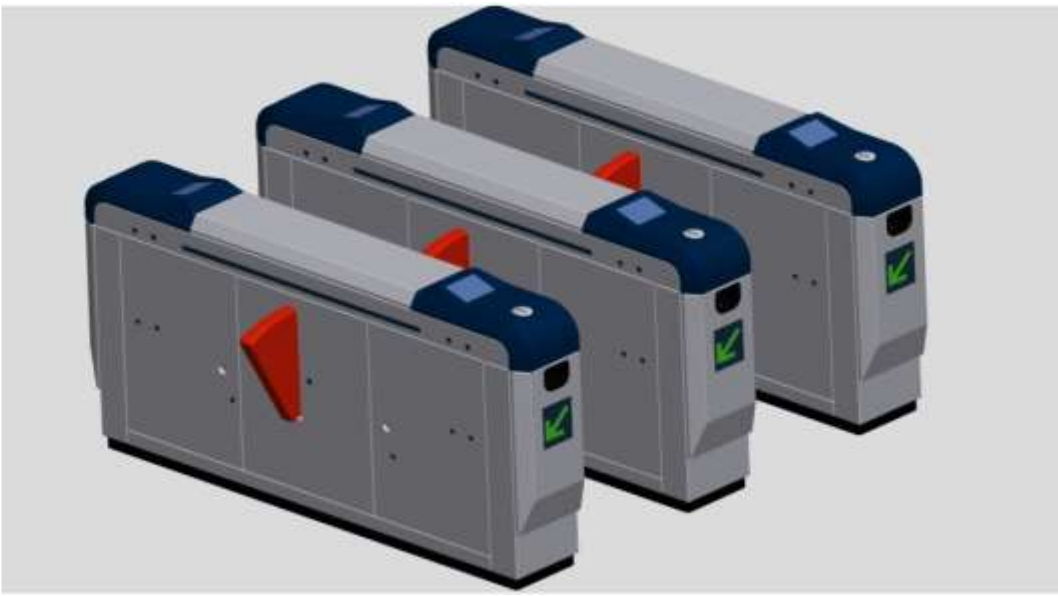


Fig 3.2: Ticket Office Machine

Fig 3.3: Ticket vending machine

Fig. 3.4 Ticket Reader/Add Value Machine

Annexure 3.1

A) AFC Equipments for Metro line - 4 from Wadala – Gaimukh (Projection for 2021)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	BHAKTI PARK	3887	12158	65	203	3	8	3	2	4	2	2
2	TROMBAY IND AREA	3404	6198	57	103	2	4	3	2	4	2	2
3	PRATIKSHA NAGAR BUS DEPOT	1052	1285	18	21	2	2	2	2	4	2	2
4	SOMAN NAGAR	1951	1923	33	32	2	2	2	2	4	2	2
5	SIDDHARTH COLONY	3987	6279	66	105	3	4	3	2	4	2	2
6	RC MARG/CHEMBUR	2784	2725	46	45	2	2	2	2	4	2	2
7	NEELKANTH VALLEY	730	770	12	13	2	2	2	2	4	2	2
8	MHDA COLONY	170	156	3	3	2	2	2	2	4	2	2
9	GHATKOPAR BUS DEPOT	861	895	14	15	2	2	2	2	4	2	2
10	R-CITY	15813	8569	264	143	11	6	13	2	4	2	2
11	GODREJ COLONY	1563	1516	26	25	2	2	2	2	4	2	2
12	VIKHROLI	2226	2350	37	39	1	2	2	2	4	2	2
13	SURYA NAGAR	808	607	13	10	2	2	2	2	4	2	2
14	GANDHI NAGAR	3636	3542	61	59	2	2	3	2	4	2	2
15	NAVAL HOUSING	145	34	2	1	2	2	2	2	4	2	2
16	JANTA MARKET	2331	2816	39	47	2	2	2	2	4	2	2
17	BHANDUP	1469	666	24	11	2	2	2	2	4	2	2
18	SHANGRILA	4554	5402	76	90	3	4	4	2	4	2	2
19	SONAPUR	1383	1239	23	21	2	2	2	2	4	2	2
20	JOHNSON & JOHNSON	352	98	6	2	2	2	2	2	4	2	2
21	MULUND NAKA	1169	1888	19	31	2	2	2	2	4	2	2
22	THANE TEEN HAATH NAKA	2367	1990	39	33	2	2	2	2	4	2	2
23	RTO THANE	5249	4494	87	75	3	3	4	2	4	2	2
24	MAHAPALIKA MARG	2848	2287	47	38	2	2	2	2	4	2	2
25	CADBURY JUNCTION	491	820	8	14	2	2	2	2	4	2	2
26	MAJIWADA	2891	2344	48	39	2	2	2	2	4	2	2
27	KAPURBAWDI	2463	3109	41	52	2	2	2	2	4	2	2
28	MANPADA	2325	1761	39	29	2	2	2	2	4	2	2
29	TIKUJI-NI-WADI	4292	3483	72	58	3	2	4	2	4	2	2
30	WAGHBIL	3391	3854	57	64	2	3	3	2	4	2	2
31	ANAND NAGAR	3336	2446	56	41	2	2	3	2	4	2	2
32	KASARWADAVLI	2720	2164	45	36	2	2	2	2	4	2	2
33	GOWNIWADA	1764	1853	29	31	2	2	2	2	4	2	2
34	GAIMUKH	11864	8558	198	143	8	2	10	2	4	2	2
	TOTAL					**88**	**86**	**99**	**68**	**136**	**68**	**68**

B) AFC Equipments for Metro line - 4 from Wadala – Gaimukh (Projection for 2031)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	BHAKTI PARK	3694	11571	62	193	2	8	3	2	4	2	2
2	TROMBAY IND AREA	2767	4938	46	82	2	3	2	2	4	2	2
3	PRATIKSHA NAGAR BUS DEPOT	782	1189	13	20	2	2	2	2	4	2	2
4	SOMAN NAGAR	3356	3150	56	53	2	2	3	2	4	2	2
5	SIDDHARTH COLONY	3925	4325	65	72	3	3	3	2	4	2	2
6	RC MARG/CHEMBUR	2544	1918	42	32	2	2	2	2	4	2	2
7	NEELKANTH VALLEY	4737	1039	79	17	3	2	4	2	4	2	2
8	MHDA COLONY	501	573	8	10	2	2	2	2	4	2	2
9	GHATKOPAR BUS DEPOT	1284	1456	21	24	2	2	2	2	4	2	2
10	R-CITY	12581	16322	210	272	8	11	11	2	4	2	2
11	GODREJ COLONY	2231	4206	37	70	2	3	2	2	4	2	2
12	VIKHROLI	3069	2481	51	41	2	2	3	2	4	2	2
13	SURYA NAGAR	1475	1378	25	23	2	2	2	2	4	2	2
14	GANDHI NAGAR	4630	6129	77	102	3	4	4	2	4	2	2
15	NAVAL HOUSING	1634	1056	27	18	2	2	1	2	4	2	2
16	JANTA MARKET	1186	709	20	12	2	2	2	2	4	2	2
17	BHANDUP	2167	2594	36	43	2	2	2	2	4	2	2
18	SHANGRILA	9020	2966	150	49	6	2	8	2	4	2	2
19	SONAPUR	498	652	8	11	2	2	2	2	4	2	2
20	JOHNSON & JOHNSON	2899	1700	48	28	2	2	2	2	4	2	2
21	MULUND NAKA	638	833	11	14	2	2	2	2	4	2	2
22	THANE TEEN HAATH NAKA	3796	2760	63	46	3	2	3	2	4	2	2
23	RTO THANE	4554	6463	76	108	3	4	4	2	4	2	2
24	MAHAPALIKA MARG	2135	2612	36	44	2	2	2	2	4	2	2
25	CADBURY JUNCTION	4577	3971	76	66	3	3	4	2	4	2	2
26	MAJIWADA	3920	3057	65	51	3	2	3	2	4	2	2
27	KAPURBAWDI	3303	3118	55	52	2	2	3	2	4	2	2
28	MANPADA	13777	13115	230	219	9	9	12	2	4	2	2
29	TIKUJI-NI-WADI	4074	3527	68	59	3	2	3	2	4	2	2
30	WAGHBIL	5626	3430	94	57	4	2	5	2	4	2	2
31	ANAND NAGAR	3077	2159	51	36	2	2	3	2	4	2	2
32	KASARWADAVLI	701	753	12	13	2	2	2	2	4	2	2
33	GOWNIWADA	2416	2463	40	41	2	2	2	2	4	2	2
34	GAIMUKH	16827	15780	280	263	11	2	14	2	4	2	2
	TOTAL					**104**	**98**	**124**	**68**	**136**	**68**	**68**

Assumptions:

A. Each Station has only 2 access

B. Minimum AFC equipments at a station with "2 access-1 for entry , 1 for exit": 2 entry gates, 2 exit gates, 2 EFO, 2 TOM, 4 AVM/TR, 2 TVM

C. One Disabled gate at each station

D. Thoughput of gate: 25 passengers per minute, TOM : One per access

E. 50% passenger are assumed on Smart card and 50% on single journey token

3.6 ROLLING STOCK

3.6.1 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 a Mass Rapid Transit System (MRTS).

- **Optimization Of Coach Size**

  The following optimum size of the coach has been chosen for this corridor as mentioned in Table 3.4.

Table 3.4 - 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 = 23 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/Motor car is envisaged.

  Following train composition is recommended:
  8-car Train: DMC+TC+MC+MC+MC+MC+TC+DMC

  Table 3.5 shows the carrying capacity of Medium Rail Vehicles.

Table 3.5 - Carrying Capacity of Medium Rail Vehicles

Particulars	Driving Motor car		Trailer car / Motor car		8 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush
Seated	42	42	50	50	384	384
Standing	120	240	124	248	984	1968
Total	162	282	174	298	1368	2352

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

- **Weight**

  The weights of driving motor car, trailer car and motor car have been estimated as in Table 3.6, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 3.6 - Weight of Light Rail Vehicles (TONNES)

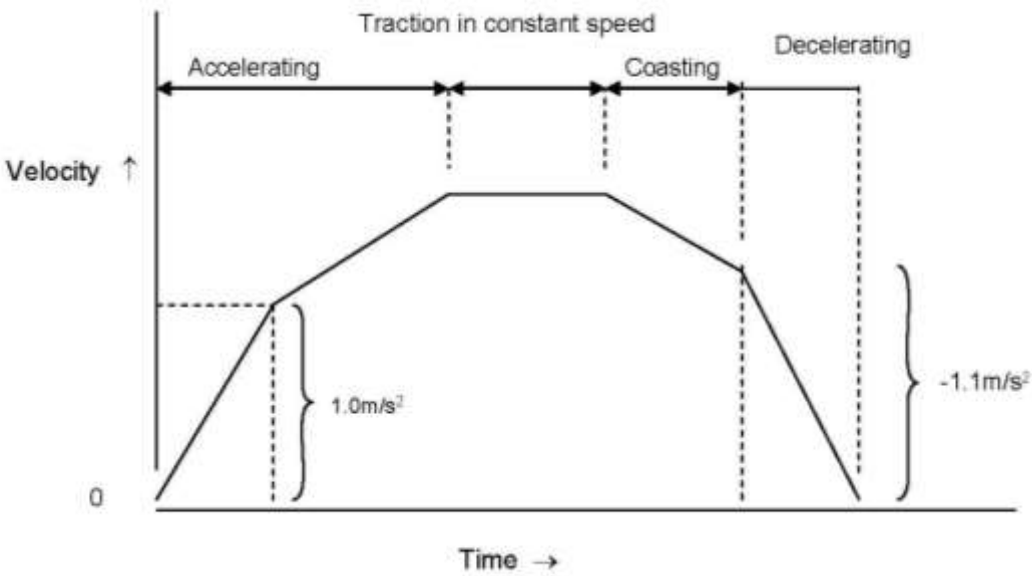
	DMC	TC	MC	8 Car Train
TARE (maximum)	42	43	42	338
Passenger				
(Normal)	10.53	11.31	11.31	88.92
(Crush @6p/sqm)	18.33	19.37	19.37	152.88
(Crush @8p/sqm)	23.40	24.70	24.70	195.00
Gross				
(Normal)	52.53	54.31	53.31	426.92
(Crush @6p/sqm)	60.33	62.37	61.37	490.88
(Crush @8p/sqm)	65.40	67.70	66.70	533.00
Axle Load @6 person/sqm	15.08	15.59	15.34	
Axle Load @8 person/sqm	16.35	16.92	16.68	

The axle load @ 6persons/sqm of standing area works out in the range of 15.08T to 15.59T. 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.**

3.6.2 PERFORMANCE PARAMETERS

The recommended performance parameters are:

Maximum Design Speed	:	90 kmph
Maximum Operating Speed	:	80 kmph
Max. Acceleration	:	1.0 m/s^2 (with AW3 load)
		1.2 m/s^2 (with AW2 load)
Max. Deceleration	:	1.1 m/s^2 (with AW3 load)
		1.1 m/s^2 (with AW2 load)
		>1.35 m/s^2 (Emergency brake)



3.6.3 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.

3.6.4 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 aluminium for carbody.

The car bodies with aluminium require long and complex extruded sections which are still not manufactured in India. Therefore, aluminium car body has not been considered for use. Stainless steel sections are available in India and therefore stainless steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during 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 helical coil spring/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 improves the curve running performance by reducing lateral forces through application of helical coil spring / conical rubber spring. Helical springs is preferred over conical rubber spring based upon DMRC experience. 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 tread brake.

3.6.5 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.

3.6.6 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. Some equipments may be mounted in the under seat cubicles to have more standing capacity in the gangway.

3.6.7 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

3.6.8 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 60% 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.

3.6.9 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 has been provided at the center of the front side of each cabin which has an easy operation with one handle type master controller.

3.6.10 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.

3.6.11 Noise and Vibration

The trains will pass through heavily populated urban area. The noise and vibration for a metro railway become an important criterion from public acceptance view point. The sources of noise are (i) rail-wheel interaction (ii) noise generated from equipment like Blower, Compressor, air conditioner, door, Inverter etc. (iii) traction motor in running train. For elimination and reduction of noise following feature are incorporated: -

- Provision of anti-drumming floor and noise absorption material.
- Low speed compressor, blower and air conditioner.
- Mounting of under frame equipments on anti-vibration pad
- Smooth and gradual control of door.
- Provision of GRP baffle on the via-duct for elimination of noise transmission.
- Provision of sound absorbing material in the supply duct and return grill of air conditioner.
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes.
- Provision of wheel flange and top of rail lubrication to reduce squealing noise.
- Provision of noise attenuators (Hypno dampers) on wheels to reduce noise due to rail wheel interaction.

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

3.6.12 Passenger Safety Features

(i) ATP/ATO/UTO

The rolling stock is provided with Continuous Automatic Train Protection 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 stock) 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.

Gangways

(vi) Obstruction deflection device(ODD):

ODD shall be mounted on front bogie of each driving car(DMC) which shall be able to deflect obstacles such as metal block, wooden block or plastic bottle with water etc. After detection and deflection of obstacle emergency brake shall be applied to stop the train automatically.

The salient features of the proposed Rolling Stock are enclosed as Attachment- I

Attachment 3.1

Salient Features of 3.2m wide SG Rolling Stock for MRTS

S.No.	Parameter	Details
1	**Gauge** (Nominal)	1435mm
2	**Traction system**	
2.1	Voltage	25 kV AC
2.2	Method of current collection	Overhead Current Collection System
3	**Train composition:**	
3.1	8 car trainset	DMC+TC+MC+MC+MC+MC+TC+DMC
4	**Coach Body**	Stainless Steel/Aluminium
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	3.2 m
5.3	Length over body (approx)	
	- Driving Motor Car (DMC)	21.84 m
	- Trailer Car (TC)	21.74 m
	- Motor Car (MC)	21.74 m
	Maximum length of coach over couplers/buffers:	*22 to 23m (depending upon Kinematic Envelop and SOD)*
5.4	Locked down Panto height (if applicable)	4048 mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	2
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity- @ 6 standees/sqm**	
7.1	Coach carrying capacity	
	DMC	282 (seating - 42; standing - 240)
	TC	298 (seating - 50; standing - 248)
	MC	298 (seating - 50; standing - 248)
7.2	Train Carrying capacity	
	8 car train	2352 (seating - 384; standing - 1968)
8	**Weight (Tonnes)**	
8.1	Tare weight (maximum)	
	DMC	42
	TC	43
	MC	42
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DMC	18.33 (@ 6 persons per sqm of standee area)
	TC	19.37 (@ 6 persons per sqm of standee area)
	MC	19.37 (@ 6 persons per sqm of standee area)

S.No.	Parameter	Details
8.3	Gross weight in tons (@ 6 persons per sqm of standee area)	
	DMC	60.3
	TC	62.4
	MC	61.4
9	**Axle load(T) (@ 8 persons per sqm of standee area)**	**17 (System should be designed for 17T axle load)**
10	**Maximum Train Length - Approximate**	
10.1	8 car trainset	≈184
11	**Speed**	
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	(a) All cars except in driving console	LpAEq 20sec 68 dB(A)
	(b) Driving console	LpAEq 20sec 68 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	LpAEq 20sec 67 dB(A)
13.2	Running at 75 kmph (Elevated and at grade)	
13.2.1	(a) All cars except in driving console	LpAEq 20sec 75 dB(A)
	(b) Driving console	LpAEq 20sec 70 dB(A)
13.2.2	External (at 7.5 mtr from centre line of track)	LpAEq 20sec 82 dB(A)
14	**Traction Motors Ventilation**	Self
15	**Acceleration on level tangent track**	1.0 m/sec^2 @ AW3 1.2 m/sec^2 @ AW2
16	**Deacceleration on level tangent track**	1.1 m/sec^2 @ AW3 1.1 m/sec^2 @ AW2 (>1.35 m/sec^2 during emergency)
17	**Type of Bogie**	Fabricated
18	**Secondary Suspension springs**	Air

S.No.	Parameter	Details
19	**Brakes**	- An electro-pneumatic (EP) service friction brake - An electric regenerative service brake - Provision of smooth and continuous blending of EP and regenerative braking - A fail safe, pneumatic friction emergency brake - A spring applied air-release parking brake - Tread Brakes - Brake Electronic Control Unit (BECU) - Independent for each bogie
20	**Coupler**	Auto
	Driving Cab end of cars (DMC)	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
	Between two units of a train	Automatic coupler with mechanical, pneumatic and electrical coupling head
21	**Detrainment Door**	Front
22	**Type of Doors**	Sliding
23	**Lighting**	LED based with dimmer control
24	**Passenger Seats**	Stainless Steel
25	**Cooling**	
25.1	Transformer	Forced
25.2	CI & SIV	Self/Forced
25.3	TM	Self-ventilated
26	**Control System**	Train based Monitor & Control System (TCMS)
27	**Traction Motors**	3 phase VVVF controlled
28	**Temperature Rise Limits**	
28.1	Traction Motor	Temperature Index **minus** 70° C
28.2	CI & SIV	10° C temperature margin for Junction temperature
28.3	Transformer	IEC specified limit **minus** 20° C
29	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load.
30	**PA/PIS including PSSS (CCTV)**	Required
31	**Passenger Surveillance**	Required
32	**Battery**	Ni-Cd
33	**Headlight type**	LED

S.No.	Parameter	Details
34	**Coasting**	8% (Run time with 8% coasting shall be the 'Run Time in All out mode **plus** 8%')
35	**Gradient (max)**	4%
36	**Sharpest Radius**	Bogie shall be able to negotiate 100m (in Mainline) and 90m (in depot)
37	**Train Operation**	UTO(GoA4) with CBTC signaling system

Chapter – 4

CIVIL ENGINEERING

4.1 GEOMETRIC DESIGN NORMS

4.1.1 General

The proposed corridors will be implemented with track on Standard Gauge (SG) 1435mm.

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80kmph. Planning for any higher speed is not desirable as the average inter-station distance is kept close to one km and trains will not be able to achieve higher speed.

The elevated tracks will be carried on twin-U girders supported on single circular piers, generally spaced at 28-m centres and located on the median or on the space available between main carriageway and service road to the extent possible. The horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road and ground levels followed by the alignment.

The design parameters related to the Metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole.

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- 4.1

4.1.2 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 300 m or more is 80 km/h. Minimum radius of 125m has been used (on entire line-4 including this extension) having speed potential upto 40 km/h.

Horizontal Curves:

Table 4.1- Horizontal Curves

Description	Elevated Section
Desirable Minimum radius	200m
Absolute minimum radius	125m
Minimum curve radius at stations	1000m
Maximum permissible cant (C_a)	125 mm
Maximum desirable cant	110mm
Maximum cant deficiency (C_d)	85mm

Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth riding on the curves and to counter act centrifugal force. Due to change in gradients at various locations in the corridor, it is necessary to provide frequent vertical curves along the alignment. In case of ballast less track, it is desirable that the vertical curves and transition curves of horizontal curves do not overlap. These constraints may lead to reduced lengths of transition curves at certain locations. The transition curves have 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 (in case of reverse curves): either 25 m or Nil.
- Minimum straight between two Transition curves (in case of same flexure curves): either 25 m or both curves should be converted in to the compound curve by introducing single transition between the two circulars.
- Minimum curve length between two transition curves: 25 m

4.1.3 Vertical Alignment and Track Centre

(a) Elevated Sections

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level as mandatory requirement of Indian Road Congress (IRC). For meeting this requirement with the ‘U’ shaped pre-stressed concrete girders, the rail level will be about 9.8 m above the road level. However, at stations which are located above central median, the rail level will be 13.5 m above the road level with concourse at mezzanine. These levels will, however, vary marginally depending upon where the stations are located.

The track centre on the elevated section is kept as 5.03 m uniform throughout the corridor to standardize the superstructure.

(b) Gradients

Normally the stations shall be on level stretch. In exceptional 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% or for Switch Over Ramps gradient up to 4% (compensated) can 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.

(d) Radius of vertical curves:

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

4.1.4 Design Speed

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

Table 4.2 - Cant, Maximum Speed & Minimum track centre for Curves

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM TRACK CENTRE (ELEVATED & AT-GRADE)
m	mm	kmph	mm
3000	15	80	3650
2800	15	80	3650
2400	20	80	3650
2000	20	80	3650
1600	25	80	3650
1500	30	80	3650
1200	35	80	3650
1000	45	80	3700
800	55	80	3700
600	70	80	3750
500	85	80	3750
450	95	80	3800
400	105	80	3800
350	110	75	3800

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM TRACK CENTRE (ELEVATED & AT-GRADE)
m	mm	kmph	mm
300	110	70	3850
200	110	55	3950
150	110	45	4050
150*	0	30	4050
120	110	40	4150
120*	0	25	4150

*The curves of 120 and 150 meters radii are used without transitions.

Notes: (a) The track spacing is without any column/structure between two tracks and is with equal cant for both outer and inner tracks.

(b) Track spacing shown is not applicable to stations which should be calculated depending on specific requirement.

(c) Figures for any intermediate radius of curvature may be obtained by interpolating between two adjacent radii. For higher radii, values may be extrapolated.

4.1.5 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.

4.1.6 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.

4.2 ALIGNMENT

4.2.1 Introduction

4.2.1.1 First station of Line-4 extension from Kasarvadavali to Gaimukh is named as Gowniwada and last station is Gaimukh.

4.2.1.2 It is the extension of Mumbai Metro Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali corridor) at Kasarvadavali end. Thus start chainage of this extension is same as the dead end chainage given in DPR of Line-4 i.e. 31872.088 m.

4.2.1.3 Total length of this extension is 2.668 km. The entire metro extension proposed is elevated. It runs in South to North-West direction.

4.2.1.4 Two stations have been proposed on this extension. Names of stations are Gowniwada and Gaimukh. 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; stations could not be located at one km distance apart. The maximum and minimum inter station distances are 1384.9 m and 1283.1 m respectively. Depot for entire Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali – Gaimukh) has been planned at Gaimukh.

4.2.2 Station Locations

4.2.2.1 Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport such as Railway Stations, Bus Terminals, etc. However effort has also been made to propose station locations, such that inter station distances are as uniform as possible.

4.2.2.2 All stations will be two level stations. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. All the stations have been planned cantilever leaving 10.5m road width either side of the median.

4.2.3 Terminal

As this is the extension of Mumbai Metro Line-4, thus there is only one terminal station as detailed below.

Gaimukh Terminal

This Station is proposed along the road. Scissors crossovers are proposed at the rear end of station and crossover is provided at the front end of the station.

4.2.4 Scissors Crossovers

Scissors Crossovers will be provided at the terminal station. Crossover is also proposed at the front end of the terminal station.

4.2.5 Depot

It is proposed to provide depot at Gaimukh, in the Government land identified by MMRDA. Area of depot land will be about 23.1 Ha. Already an area of 30 Ha was considered for Depot in Line-4 DPR.

4.2.6 Description of Alignment

4.2.6.1 Horizontal Alignment

Proposed extension starts from CH: 31872.088 m and continues along the road median. First station on this extension is Gowniwada at chainage 32807.032m which is on straight alignment. Hereafter also the alignment continues along the road median and reaches last station of this extension i.e. Gaimukh at chainage 34090.12m. This station is the terminal station of Ghatkopar – Mulund – Thane – Kasarvadavali – Gaimukh corridor (Mumbai Metro Line-4). Dead end of this extension is at CH: 34540.12m. Depot is located after Gaimukh station.

4.2.6.2 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 8.4m 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 or overlapping with the transition length of Horizontal curves. 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 gradient. The maximum gradient used in this extension is not steeper than 1.634%. Detailed description of vertical alignment is as follows:

The proposed rail levels for this extension are given in **Table 4.3** and abstracts of gradients are given in **Table 4.4.**

Table 4.3: Proposed Gradients of Rail Track (Vertical Curve Details)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	31289.875	31600.000	310.125	27.200	27.200	0.000%	LEVEL
2	31600.000	32010.000	410.000	27.200	20.500	-1.634%	FALL
3	32010.000	32340.000	330.000	20.500	21.000	0.152%	RISE
4	32340.000	32680.000	340.000	21.000	24.000	0.882%	RISE
5	32680.000	32930.000	250.000	24.000	24.000	0.000%	LEVEL
6	32930.000	33450.000	520.000	24.000	20.000	-0.769%	FALL
7	33450.000	33685.585	235.585	20.000	21.414	0.600%	RISE
8	33685.585	33820.000	134.415	21.414	20.500	-0.680%	FALL
9	33820.000	34649.347	829.347	20.500	20.500	0.000%	LEVEL

Table 4.4: Abstract of Gradients

S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. Total Alignment length
1	Level	3	1389.47	41.36%
2	> 0% to = 1%	5	1560.00	46.44%
3	> 1% to = 2%	1	410.00	12.20%
4	> 2% to = 3%	0	0	0.00%
5	> 3% to = 4%	0	0	0.00%
	Total	**9**	**3359.47**	**100.00%**

4.2.7 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 200 m to reduce the property acquisition. Total 7 Nos. of curves have been provided in this extension of Line-4 from Kasarvadavali to Gaimukh. The details of curves and abstracts of horizontal curves for this extension of Line-4 are indicated in Table 4.5 and 4.6 respectively.

Table 4.5 Details of Horizontal Curves

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		651.356
1	Left	1020	104.635	35	35	05	52	39	52.364	199.93
2	Left	400	103.019	50	50	14	45	23	51.796	415.216
3	Right	800	132.093	40	40	09	27	37	66.197	428.945
4	Right	1020	253.775	30	50	14	15	18	127.546	0
5	Left	300	161.916	55	55	30	55	25	82.982	0
6	Right	450	26.776	45	45	03	24	33	13.392	0
7	Left	200	43.834	55	55	12	33	26	22.005	751.541

Table 4.6 Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL(m)	% w. r. t. total curved length
1	>200m - 500m	4	745.545	50.85%
2	>500m - 1020m	3	720.503	49.15%
3	>1020m - 1500m	0	0	0%
4	>1500m - 2500m	0	0	0%
5	>2500m - 5000m	0	0	0%
6	>5000m	0	0	0%
	Total	**7**	**1466.048**	**100.00%**

4.3 CIVIL STRUCTURE AND CONSTRUCTION METHODOLOGY

4.3.1 Viaduct – Elevated Structure

4.3.1.1 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.

Generally four types of Superstructure are used for construction of elevated section of Metro Corridor, i.e. (i) Segmental Box Girder, (ii) Segmental U Girder, (iii) I Girder and (iv) Double U Girder, depending upon characteristic of the corridor such as traffic congestion on roads, available working space, etc.

Being an extension of Mumbai Metro Line-4, same superstructure is proposed. Therefore it is suggested to use Double U-Girder in the superstructure upto radius 300m. Following are its merits:

- It is an efficient and economical method.
- Its construction permits a reduction of construction time as it may be manufactured while substructure work proceeds and assembled rapidly thereafter.
- This method of construction protects the environment as only space required for foundation and sub-station is required at site. The superstructure is manufactured at a place away from busy areas and placement of superstructure is done at site.
- Girders are easy to stack in the casting yard/stacking yard in more than one layer, thereby saving in requirement of space.
- Interference to the traffic during construction is significantly reduced.
- It contributes towards aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

For Radius less than 300 m and at locations where point and crossing are to be provided, it is suggested to use I-Girder.

4.3.2 Pre-Cast Construction

4.3.2.1 Casting of U-Girder

It requires a casting yard for pre-casting Double U-Girders for viaducts. The construction depot will have facilities for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.0 ha to 2.5 ha is required for each construction depot.

The girders are cast in casting moulds with pre-tensioning. The girders are water cured for a period of 14 days from the date of casting.

4.3.2.2 Erection of U-Girder

The U-girders are transported from stacking yard to erection point with the means of Hydraulic Multi Axle trailers.

The erection of precast U-Girder is done by means of two mobile cranes of capacity not less than 300 MT each. After erection of U-Girder, bearing pedestal will be concreted for placement of bearing.

4.3.3 Structural System of Viaduct

4.3.3.1 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. These details will be worked out at detailed design stage.

Normally two U-Girders having a soffit width of about 3.8 m (approx) each, accommodates two tracks situated at 5.03 m center to center (c/c). The U-Girder superstructure for almost all the simply supported standard spans will be constructed by precast pre-stressed construction.

The standard length (c/c of piers) of simply supported spans, constructed by precast construction technique, has been proposed as 28.0m. The standard length of U-Girder will be around 28m and usually up-to 35m length can be managed with the help of extended pier cap. For shorter span or at sharper curves (less than 300m), I-Girders will be used.

For major crossings having span greater than 35 m, special continuous units (normally of 3 span construction or steel girders) have been envisaged. All these continuous units (in case provided at obligatory location) will be constructed by cast-in-situ balanced cantilever construction technique.

4.3.3.2 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 soffit of the girder. 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 a situation, the minimum height of rail above the existing road is about 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 its exact dimension to be decided by the DDC).

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. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

4.3.4 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 cross section there will be single viaduct column in the station area, which will be located on the median/footpath and supporting the concourse girders by a cantilever arm to eliminate the columns in the right of way.

4.3.5 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 structure	-	M -30

For all the main structures, permeability test on concrete sample is recommended to ensure impermeable concrete.

4.3.6 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).

4.3.7 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.

4.4 GEOTECHNICAL INVESTIGATIONS

No fresh Geotechnical Investigation has been carried out by DMRC. The data given in the DPR submitted for Line-4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali) has been reproduced. As this is a small extension of Line-4, thus more or less the ground profile will be same. Originally the Geological Investigations were carried out from Wadala to Kasarvadavali during preparation of combined DPR for Wadala – Kasarvadavali by M/s CES Pvt. Ltd.

4.4.1 General Geology & Related Characteristics

a) **Physiography and Climate-** The highest temperature in this city is around 35^{o}C and the minimum temperature is around 15^{o}C. The period between January to April and December is the dry period in this region. The Southwest monsoon period, between June and October, is the main rainy season. The average annual rainfall is about 2000mm.

b) **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.

Marine Clays of Mumbai

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

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

4.4.3 Field Investigations - Wadala to Kasarvadavali

4.4.3.1 Bore Hole Locations

The details of boreholes along the corridor are shown in Table 4.7.

TABLE 4.7: DETAILS OF BOREHOLES

BH No.	Ground R.L. (m)	DEPTH OF INVESTIGATION		
		In SOIL	In ROCK (soft/hard)	TOTAL
BH 1	4.15	7.3	15.90	23.20
BH 2	3.25	6.0	14.66	20.66
BH 3	-	4.5	8.1	12.60
BH 4	1.40	4.15	5.0	9.15
BH 5	1.55	2.71	3.94	6.65
BH 6	2.40	-	8.40	8.40
BH 7	3.80	4.5	5.0	9.50
BH 8	3.65	4.5	6.0	10.50
BH 9	-	4.0	11.0	15.00

4.4.3.2 Design Parameters

The sub-soil strata at the proposed sites comprise of six types of layers. Description of each layer along with various engineering parameters is as shown in Table 4.8 and 4.9.

TABLE 4.8: LAYER TYPE AND DESCRIPTION

Layer	Description	Classified as per IS: 1498-1970	Relative Density/Consistency	Observed in Bore Hole Nos.
I	Filled up material	-	-	BH7, BH8, BH9
	Over burdened	-	-	BH1 to BH5
	Moderately weathered basalt	Rock	-	BH6

Layer	Description	Classified as per IS: 1498-1970	Relative Density/Consistency	Observed in Bore Hole Nos.
II	Boulder filling			BH8
	Hard yellowish brown silty clay	CH	Medium stiff to stiff	BH7
	Dark Brown medium stiff sandy clay mix with few types of gravel	-		BH9
	Moderately/highly weathered basalt	Rock		BH2
	Highly weathered basalt	Rock		BH1, BH4
	Porphyritic highly weathered basalt	Rock		BH3
	Amygdaloidal basalt green white infilling (ABGWI)	Rock		BH5
	Porphyritic basalt green infilling/white infilling (PBGIWI)	Rock		BH6
III	Completely weathered basalt	Rock		BH7, BH8, BH9
	Porphyritic basalt (PB)	Rock		BH1, BH2
	Amygdaloidal basalt green infilling (ABG/GI)	Rock		BH3
	Amygdaloidal basalt white infilling (ABGWI)	Rock		BH4, BH5, BH6
IV	Highly weathered brownish basalt	Rock		BH7
	Moderately weathered blackish grey basalt	Rock		BH8
	Porphyritic basalt green infilling (PBGI)	Rock		BH1
	Moderately/highly weathered basalt (MHW)	Rock		BH4
	Brown Highly weathered jointed and fractured basalt	Rock		BH9
V	Slightly weathered blackish gray basalt with white and green infillings.	Rock		BH8
	Slightly weathered to fresh blackish gray basalt	Rock		BH7
	Brownish grey moderately jointed and fractured basalt	Rock		BH9
VI	Fresh blackish grey Basalt with white and green infilling	Rock		BH8
	Grey Black jointed and fractured basalt	Rock		BH9

TABLE 4.9: BORE LOG SOIL DETAILS BELOW GL

Layer	Description of layer below GL	BH 1	BH2	BH 3	BH 4	BH5	BH6	BH 7	BH 8	BH 9
		(depth of layer in m)								
I	Filled up material	1.5						**2.0**	**1.0**	**2.0**
I	Over burdened	7.3	5.997	4.5	4.154	2.706				

Layer	Description of layer below GL	BH 1	BH2	BH 3	BH 4	BH5	BH6	BH 7	BH 8	BH 9
I	Moderately						5.405			
II	Boulder filling								3.5	
II	Brownish loam/hard yellowish brown silty clay							2.5		
II	Dark Brown medium stiff sandy clay mix with few types of gravel.									2.0
II	Moderately / highly weathered basalt		2.40							
II	Highly weathered basalt	7.95			2.6					
II	Porphyritic Highly weathered basalt			1.65						
II	Porphyritic basalt green infilling /white infilling (PBGWI)						1.25			
II	Amygdaloidal basalt green/white (ABGWI)					0.644				
III	Completely weathered basalt							1.5	1.0	2.15
III	Brownish highly weathered basalt									
III	Amygdaloidal basalt green/white infilling (ABGWI)									
III	Porphyritic basalt (PB)	4.75	12.257							
III	Amygdaloidal basalt green infilling (ABG/GI)			6.45						
III	Amygdaloidal basalt white infilling (ABWI)				0.95	3.300	1.745			
IV	Brownish moderately weathered basalt with white infilling									
IV	Highly weathered brownish basalt							0.50		
IV	Moderately weathered blackish grey basalt								0.5	
IV	Brown Highly weathered jointed and fractured basalt									2.85
IV	Porphyritic basalt green infilling (PBGI)	3.2								
IV	Moderately/highly weathered basalt				1.45					
V	Grayish fresh basalt with white infilling									
V	Slightly weathered blackish gray basalt with white and green infillings								1.50	
V	Slightly weathered to fresh blackish gray basalt							3.0		
V	Brownish grey moderately jointed and fractured basalt									4.0
VI	Fresh blackish grey Basalt with white and green infilling.								3.0	

Layer	Description of layer below GL	BH 1	BH2	BH 3	BH 4	BH5	BH6	BH 7	BH 8	BH 9
VI	Grey Black jointed and fractured basalt									2.0

4.4.3.3 Summary and Recommendations

Type of Foundation -Considering the nature of soil, type of proposed structures and expected loads on foundations, and the recommended type of foundations is generally Pile Foundation, except at few locations where open foundation can be provided, where rock level is up to 6 m below GL.

Depth of Foundation-A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Keeping in view the type of the proposed structure and the subsoil strata, the length of pile may be about 7.5 to 15 m as the piles are to be socketted in rock.

Pile Foundation-For the prevailing soil conditions and type of structures, bored cast-in-situ piles of 1200 to 1500 mm diameter may be adopted.

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

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

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

Recommended safe vertical load carrying capacity of piles of different lengths below the ground level are as shown in Table 4.10 and the minimum pile lengths (bore hole wise) are indicated in Table 4.11. Piles can be terminated earlier if hard bed rock is encountered at a lower depth during boring.

TABLE 4.10: PILE CAPACITY (IN T)

For 1.00mΦpi	For 1.20mΦ pile	For 1.50mΦpile
350T	475T	750T

TABLE 4.11: BOREHOLE WISE PILE LENGTHS B.G.L (IN M.)

BH No.	Minimum Pile Length Required BGL (in m.)	Pile termination depth BGP (in m.)		
		For 1m. Φ	For 1.2m. Φ	For 1.5m. Φ
BH 1	12.5+1.5D	14M	14.3 M	14.75 M
BH 2	8.75+1.5D	1025M	10.55 M	11 M
BH 3	6.85+1.5D	8.35M	8.65 M	9.1 M
BH 4	9.15+1.5D	10.65M	10.95 M	11.4 M
BH 5	4.35+1.5D	5.85M	6.15 M	6.6 M
BH 6	6.6+1.5D	8.1M	8.4 M	8.85 M
BH 7	6.5+1.5D	8M	8.3 M	8.75 M
BH 8	5.5+1.5D	7M	7.3 M	7.75 M
BH 9	10+1.5D	11.5M	11.8 M	12.25 M

4.5 UTILITY IDENTIFICATION

4.5.1 Introduction

Besides the details of various aspects e.g. transport demand analysis, route alignment, station locations, system design, viaduct structure, geo-technical investigations etc., there are a number of other engineering issues, which are required to be considered in sufficient details before really deciding on taking up any infrastructure project of such magnitude. Accordingly, Existing utilities along/across the alignment have been described here.

Large number of sub-surface, surface and over head 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 working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance. Meticulous planning therefore will have to be taken in tackling the issue of protection/diversion of these utility services. Accordingly, the following engineering item has been studied and described below:

- Existing utilities and planning for their diversion during construction, if necessary.

4.5.2 Utilities and Services

The utility details submitted by M/s CES Consultant Pvt. Ltd. in the combined DPR of line 5 and lines 8 in March'2013 are reviewed by the consultants. Organizations/Departments with concerned utility services in Mumbai are mentioned in **Table 4.12.**

Table 4.12: UTILITY RESPONSIBILITY DEPARTMENTS

S. N.	Utility Service	Area
1	**WATER SUPPLY**	
1.1	Officer of the Hydraulic Engineer, BMC	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
1.2	Office of the Executive Engineer, TMC	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
2	**SEWERAGE**	
2.1	Office of Sewer Operations, Eastern Suburb	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh

S. N.	Utility Service	Area
3	**STORM WATER DRAINAGE**	
	Office of storm water drainage planning section	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
4	**MTNL**	
	Office of DGM, Planning	
5	**ELECTRIC CABLES**	
5.1	Reliance Energy	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
5.2	MSEB	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
5.2.1	MSEDCL (Maharashtra State Electricity Distribution Company Limited)	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
5.2.2	MSETCL (Maharashtra State Electricity Transmission Company Limited)	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
5.3	**TATA POWER**	
5.3.1	Tata underground distribution	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
5.3.2	Tata overhead high tension transmission lines.	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
5.3.3	Tata raw power supply for metro operation (traction & auxiliary load)	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
6	**Mahanagar Gas Limited**	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
7	**Mobile Phone**	
7.1	Vodafone	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
7.2	TTML	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
7.3	TATA Communications	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
7.5	Airtel	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
7.6	Bharti Sanchar Nigam Limited	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh
7.7	Reliance Telecom	Wadala-Ghatkopar-Thane-Kasarvadavali-Gaimukh

4.5.3 Affected Above Ground Utilities

No. of affected various above ground utilities have been identified based on topographical survey maps. The details have been placed in the following table.

Table No. 4.13: Affected Services

S. No	Description	Number
1	Lamp Post	98
2	Electric Pole	10

4.5.4 Underground Utilities

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

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

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

Where permanent diversion of the affected utility is not found feasible, especially at the station locations, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes. During execution, trail pits shall be taken, number & type of exact utilities shall be ascertained. Protection could be taken by having structural piles away from the paver block area (containing all the utilities) & construction done not simultaneously, but in phases for viaduct & station locations respectively.

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 be constructed at the location, where utility is crossing the proposed alignment. The utility service can also be encased within the foundation piles. Also portal way of designing could be also proposed as an alternative option.

Sewer Lines, Strom Water Drains and Water Lines: The sewer/drainage lines generally exist in the service lanes i.e. away from main carriageway. However, in certain stretches, these have come near the central verge or under main carriageway, as a result of subsequent road widening. The major sewer/drainage lines and water mains running across the alignment and likely to be affected due to location of column foundations are proposed to be taken care of by relocating on 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 has been made in the project cost estimate towards diversion of utility services lines.

4.6 LAND ACQUISITION

4.6.1 Land

In order to minimise land acquisitions and to provide good accessibility form either directions, the metro alignments are located mostly along the road, which lie on the corridor. But, at some locations the geometrics of the roads especially at road turnings may not match with geometric parameters required for metro rail systems. In such cases, either the alignment will be off the road or some properties abutting the road would get affected. Further, some land is required for various purposes as detailed below.

Land Requirement for following Major Components

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Radio Towers

- Temporary Construction Depots and work sites.
- Staff quarters, office complex and operation control centre(OCC)

4.6.2 Land Requirement for Elevated Stretches

For elevated section, single pier as well as portal structure supporting the viaduct will be located on road. Accordingly, necessary permission for using such right-of-way will have to be obtained from the concerned authorities. Elevated station is generally proposed with elevated concourse so that land is required only for locating the entry/exit structures. Traffic integration facilities are provided wherever the same are required and, but no land is proposed for acquisition.

The normal viaduct structure of elevated Metro with double U-girder is about 9.9 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 stretches, where the elevated alignment has to be located away from road, a strip of 20-m width is proposed for acquisition.

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 21 m. The staircases giving access to concourse area from ground have been proposed as per site conditions and constraints. Nevertheless it is not possible to find open space at all the locations therefore acquisition of certain private structures is inevitable.

4.6.3 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.

4.6.4 Land for Depot

Depot for complete corridor Wadala - Ghatkopar – Mulund – Thane – Kasarvadavali – Gaimukh has been proposed in land identified by MMRDA at Gaimukh. An area of 23.1 ha govt. land has been earmarked. This area in not considered while preparing the cost estimate, as an area of 30 ha govt. land was already considered in the cost estimate of Mumbai Metro Line-4 DPR.

4.6.5 Land for Traction and Receiving Substation and Radio Towers

No additional RSS is proposed for this extension. RSS already mentioned in DPR of Mumbai Metro Line-4 will serve the whole Corridor (Wadala - Ghatkopar – Mulund – Thane – Kasarvadavali – Gaimukh). Hence, no area is considered for this purpose.

4.6.6 Land Requirement for Stations & Running section

As indicated earlier, the ROW of the roads along which the alignment is planned is sufficiently wide and hence no land is required for acquisition as long as the alignment is straight and in the centre/footpath of the road. However, at curved portions, the alignment could not be kept in the centre of the road and land acquisition at such locations is inevitable in spite of introduction of sharper curves.

In this extension, no land is required for the running section. To the extent possible the Entry and Exit points of stations were planned out of ROW of Road. Details of land permanently required for stations are indicated in Table 4.21.

Table 4.21 LAND REQUIRED FOR STATIONS

S. No.	PLOT NO	AREA PROPOSED TO BE ACQUIRED (Sqm.)	OWNERSHIP
1	GOW-1	182.106	Pvt.
2	GOW -2	97.392	Pvt.
3	GOW -3	154.771	Pvt.
4	GOW -4	154.407	Pvt.
5	GOW -5	426.336	Pvt.
6	GAI-1	182.106	Pvt.
7	GAI-2	218.290	Pvt.
8	GAI-3	77.199	Pvt.
9	GAI-4	54.065	Pvt.
10	GAI-5	379.383	Pvt.
Total Land Area = 1926.055 m^2			
Govt. Land Area = 0 m^2			
Pvt. Land Area= 1926.055 m^2			

4.6.7 Land for Staff Quarters, office complex and operation control centre (OCC)

A large number of officers and staff will be required to be deployed permanently to take care of project implementation and post construction operational activities. Moreover Metro Office Complex and Metro Operation Control Centre (OCC) will also be required. Metro Office Complex will be same for all the proposed metro lines, therefore no separate office complex is proposed for this corridor. Land for staff quarters was already considered in the DPR of Line-4. Being a small extension of Line-4, no land for staff quarters and OCC is proposed for this extension.

4.6.8 Temporary office accommodation

During construction period, huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored and sufficient land is required for storage of these materials. The areas may be identified based on availability as vacant on date nearer to the corridors. At the time of construction, depending up-on the need, the location and size can be reassessed and temporary land acquisitions can be made accordingly.

Since this is a small extension of Mumbai Metro Line-4, thus the land area already considered for this purpose in Line-4 DPR will be sufficient for complete corridor from Wadala to Gaimukh.

4.6.9 Casting Yard

Pre-cast girders are required for construction of elevated structures for which a large open area is required for setting up of casting yard. As far as possible, this area should be close to the site, easily accessible and away from habitation. Since the area for Casting Yard is already considered in DPR of Line-4 and this is just a small extension of Line-4, thus no area for casting yard is proposed for this extension.

4.6.10 Summary of Land Requirements

Abstract of land requirements for different components of this extension is given in **Table 4.22.** No land is proposed for temporary acquisition for this metro extension.

Table 4.22 Summary of Permanent Land Requirement (All figures in Sq. m)

S. No.	Description	Govt.	Pvt.
1	Stations	0	1926.055
2	Running Section	0	0
3	Depot	231000	0
4	Staff Quarter	0	0
5	OCC	0	0
6	RSS	0	0
	Total (Area in sq m)	**231000**	**1926.055**

Total Permanent Land = 23.2926 ha
Permanent Land (Govt.) = 23.1 ha
Permanent Land (Pvt.) = 0.1926 ha

4.7 SAFETY & SECURITY SYSTEMS

4.7.1 General

4.7.1.1 This section 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.

4.7.1.2 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.

4.7.2 Fire Alarm System

4.7.2.1 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.

4.7.2.2 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.

4.7.2.3 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.

4.7.2.4 Addressable Pull Stations (Manual Call Point)

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.

4.7.2.5 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.

4.7.2.6 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.

4.7.2.7 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.

4.7.3 Fire Hydrant System

4.7.3.1 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.

4.7.3.2 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.

4.7.3.3 System Component

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

4.7.3.4 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.

4.7.3.5 Hoses

Hose is a flexible tube used to carry water

4.7.3.6 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.

4.7.3.7 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.

4.7.3.8 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.

4.7.4 Sprinkler System

4.7.4.1 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 maximizing 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.

4.7.5 Fire Extinguishers

4.7.5.1 General

Fire extinguishers form a first aid action against small and incipient fire before it develops into a major hazard.

4.7.5.2 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.

4.7.5.3 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.

4.7.5.4 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.

4.7.5.5 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.

4.7.5.6 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.

4.7.6 Closed Circuit Television

4.7.6.1 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

4.7.6.2 Description

CCTV comprises of the following components:

i. Integrated Port Camera (IP Cameras)

ii. Computer
iii. Software

4.7.6.3 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. PoEtechnology, 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.

4.7.6.4 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.

4.7.6.5 Software

Software installed in computer enables coding & decoding of data for functioning of the system enforced.

4.7.6.6 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)

4.7.6.7 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.

4.7.6.8 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.

Figure 4.1

TYPICAL CROSS SECTION OF THE VIADUCT WITH DOUBLE U GIRDER

SCALE:- NTS

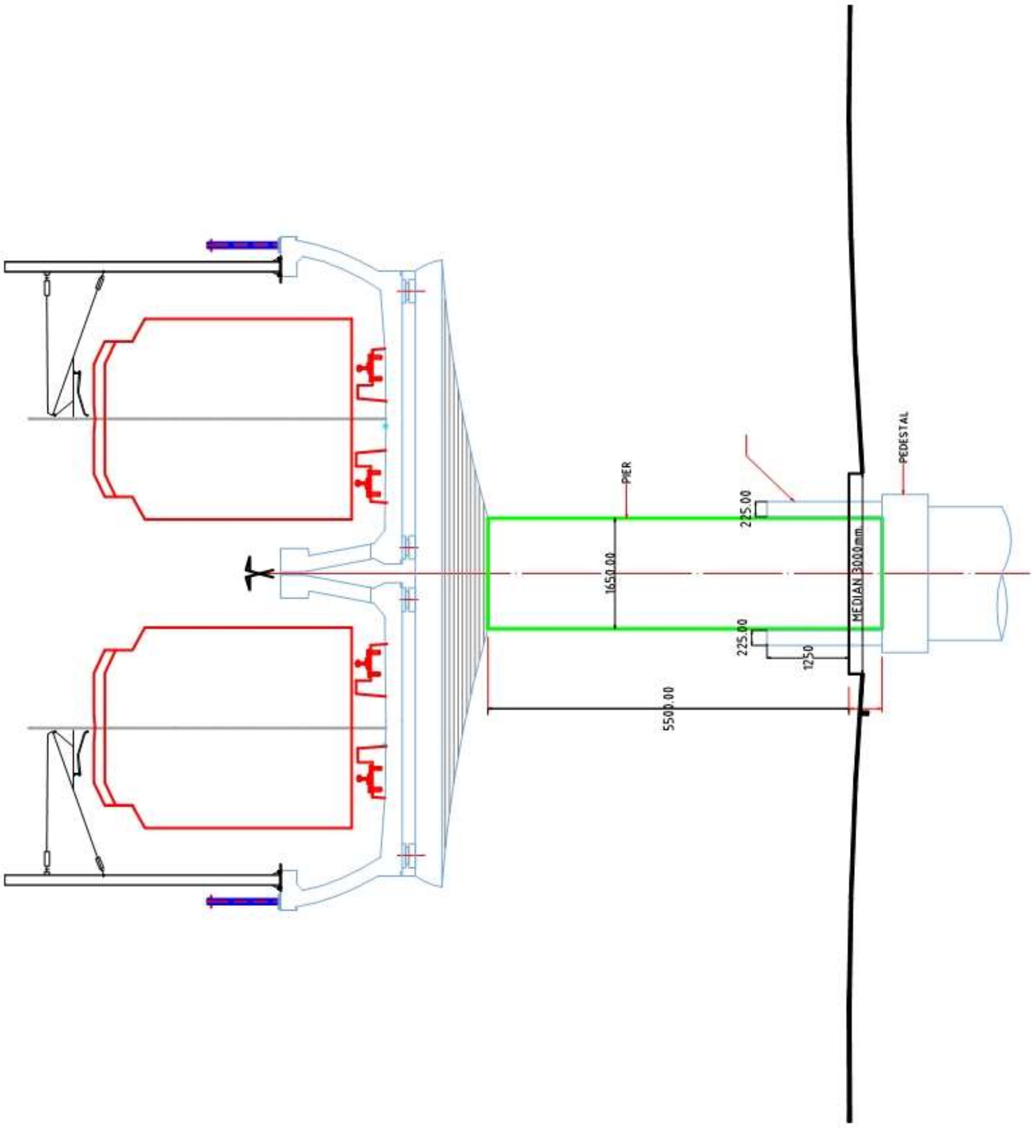
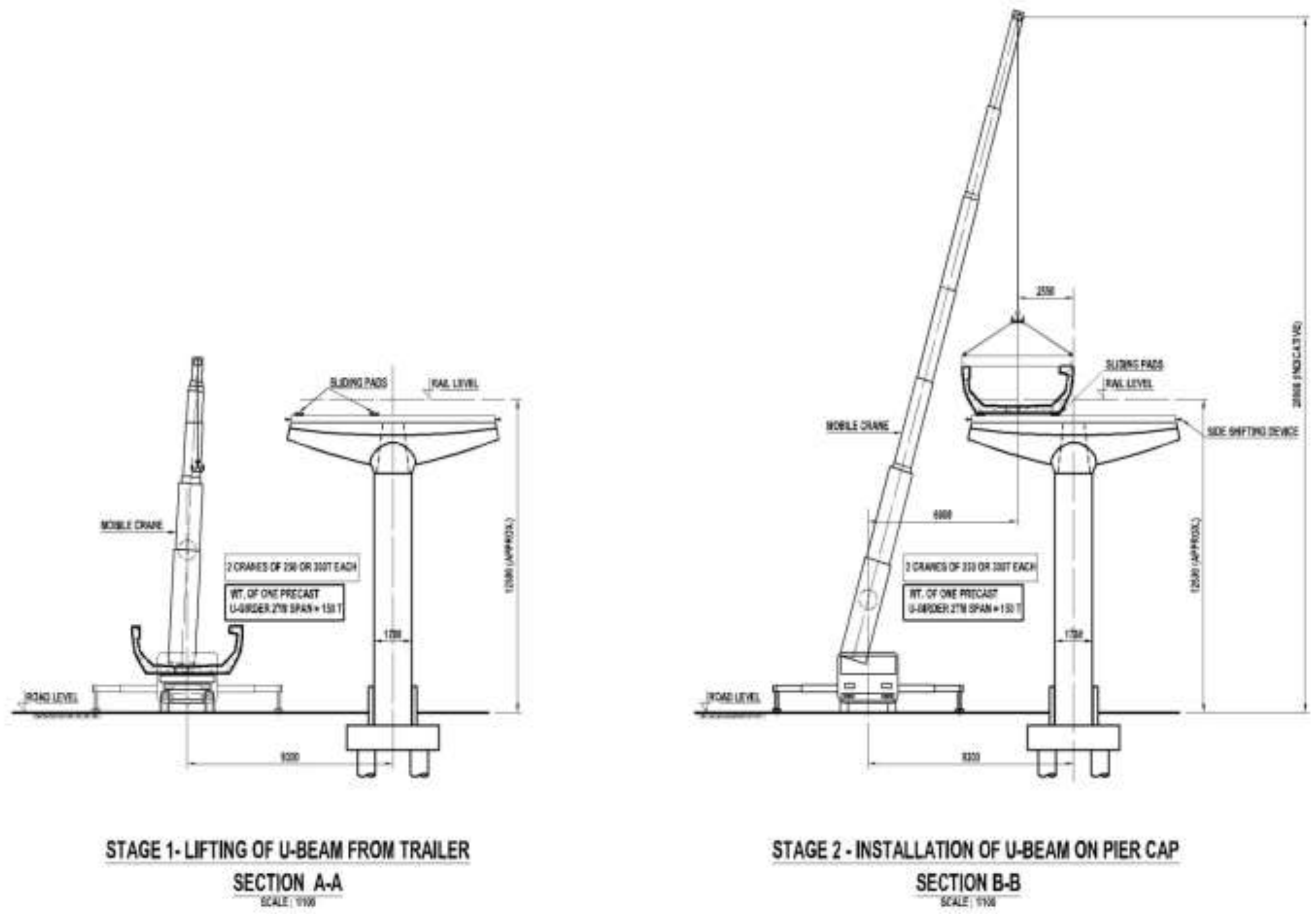


Figure 4.2(a): Erection of Girder using Crane



NOTES:
- METHOD OF ERECTION BY CRANE IS INDICATIVE ONLY AND TO BE DECIDED BY CONTRACTOR. HOWEVER CONTRACTOR MAY PROPOSE ANY OTHER METHOD OF ERECTION.

Figure 4.2(b): Erection of Girder using Crane

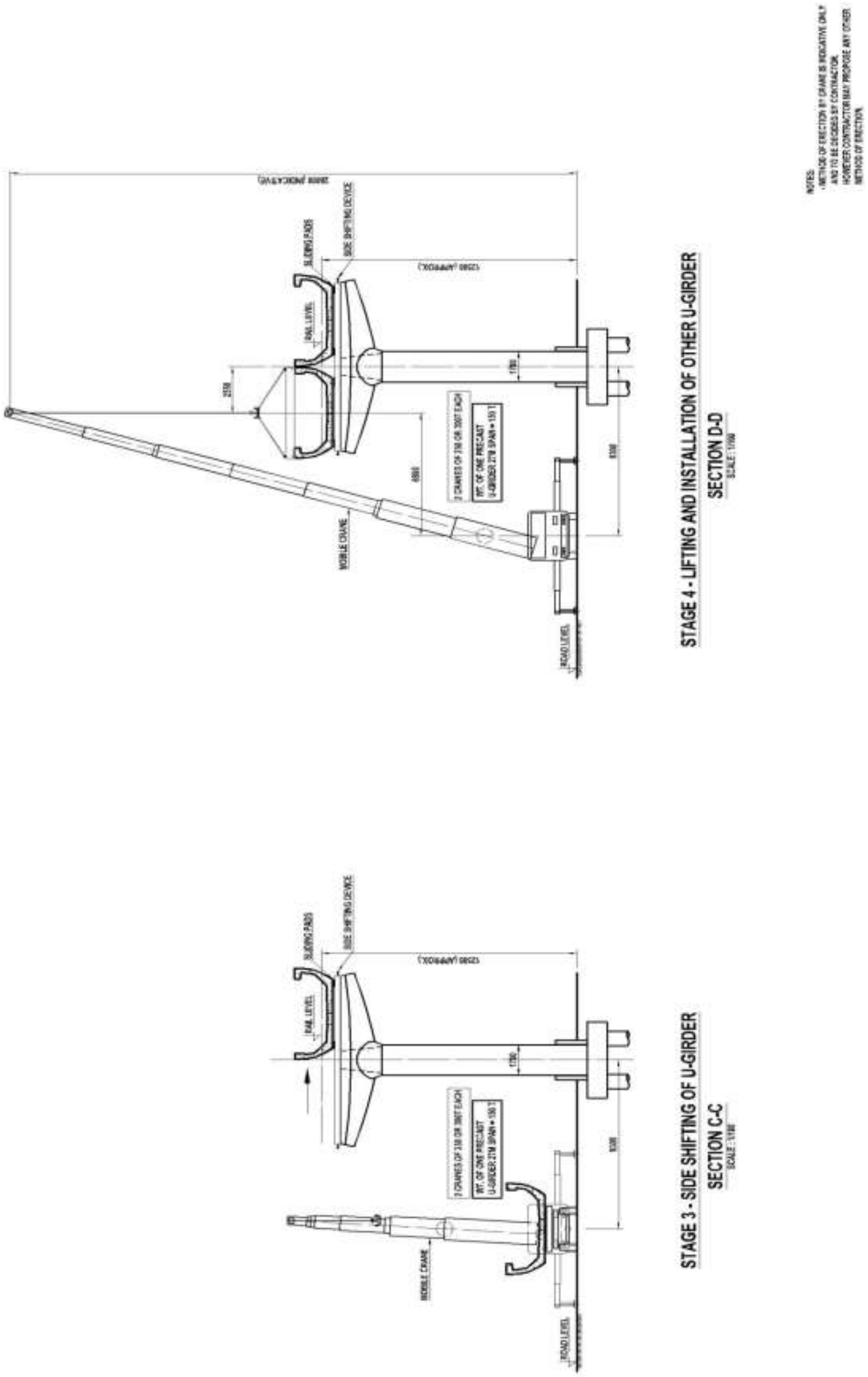


Figure 4.3

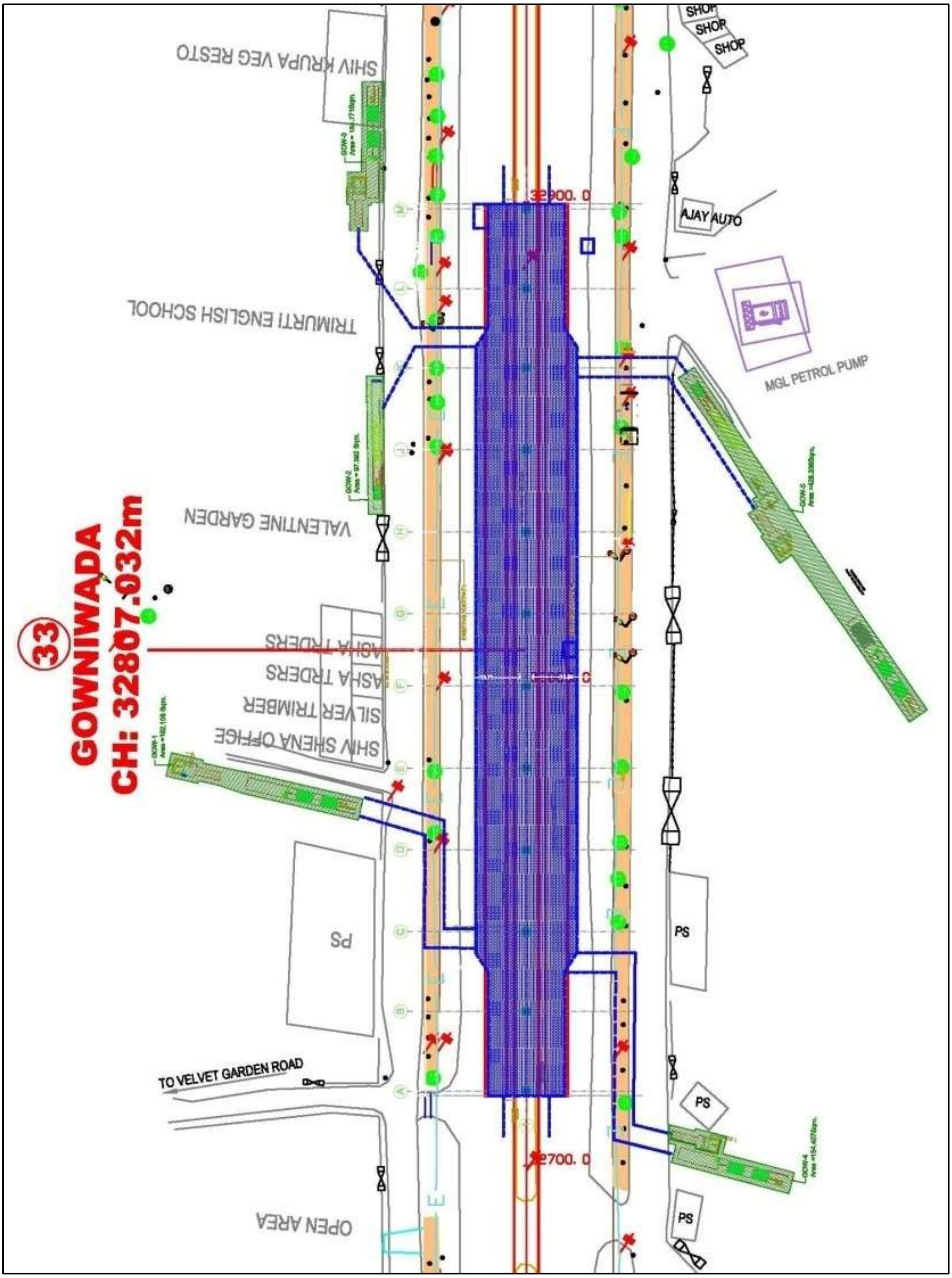
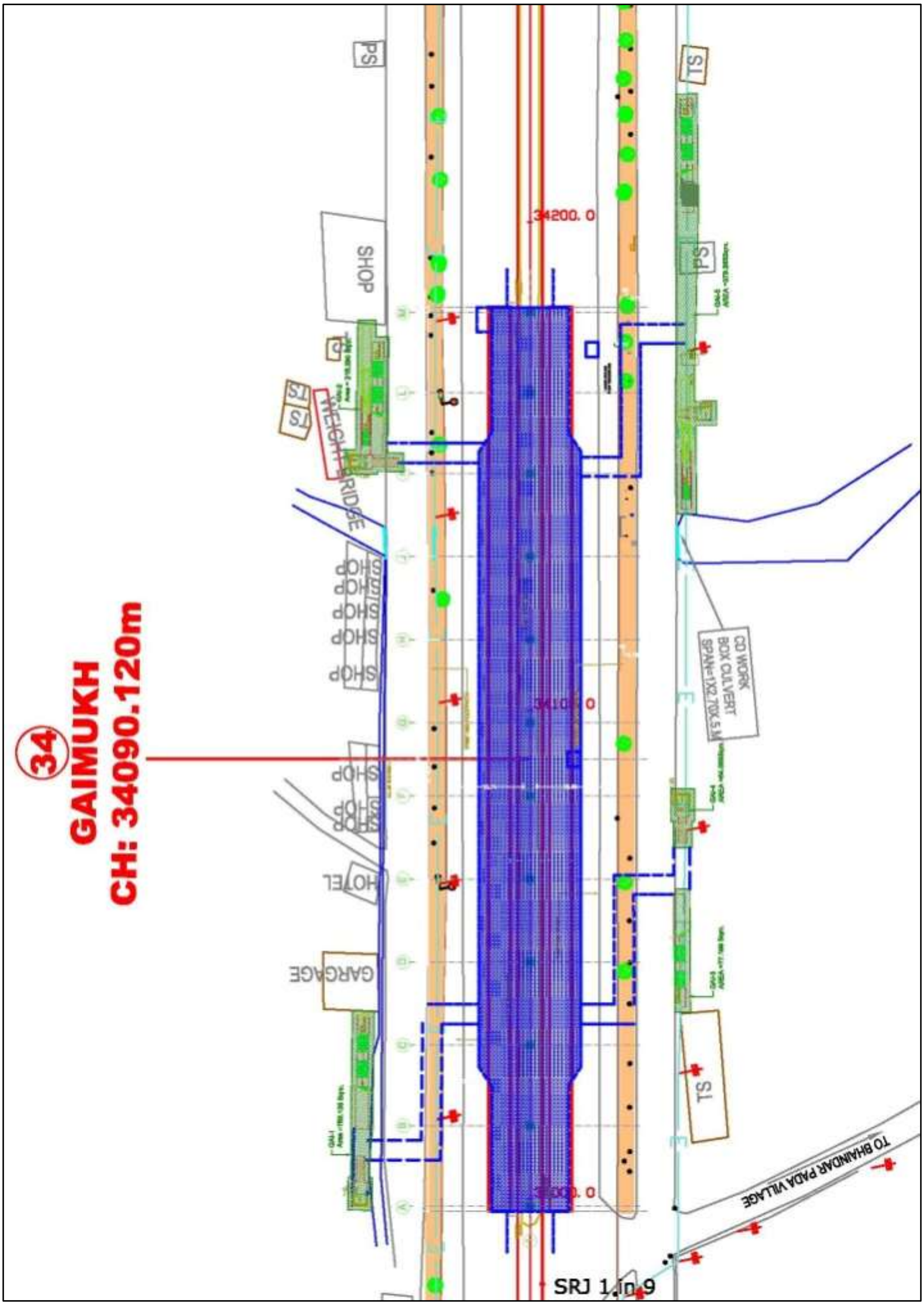

GOWNIWADA
CH: 32807.032m
33
SHIV KRUPA VEG RESTO
TRIMURTI ENGLISH SCHOOL
VALENTINE GARDEN
ASHA TRADERS
SILVER TRIMBER
SHIV SHENA OFFICE
PS
TO VELVET GARDEN ROAD
OPEN AREA
SHOP
SHOP
SHOP
AJAY AUTO
MGL PETROL PUMP
PS
PS
PS
32900. 0
32700. 0

Figure 4.4


GAIMUKH
CH: 34090.120m
34
SRJ 1 in 9
CD WORK
BOX CULVERT
TO BHAINDAR PADA VILLAGE

Annexure-4.1

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.

3. 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-4.5 & Figure-4.6 to this appendix.

Figure-4.5: Typical Elevated Station Layout

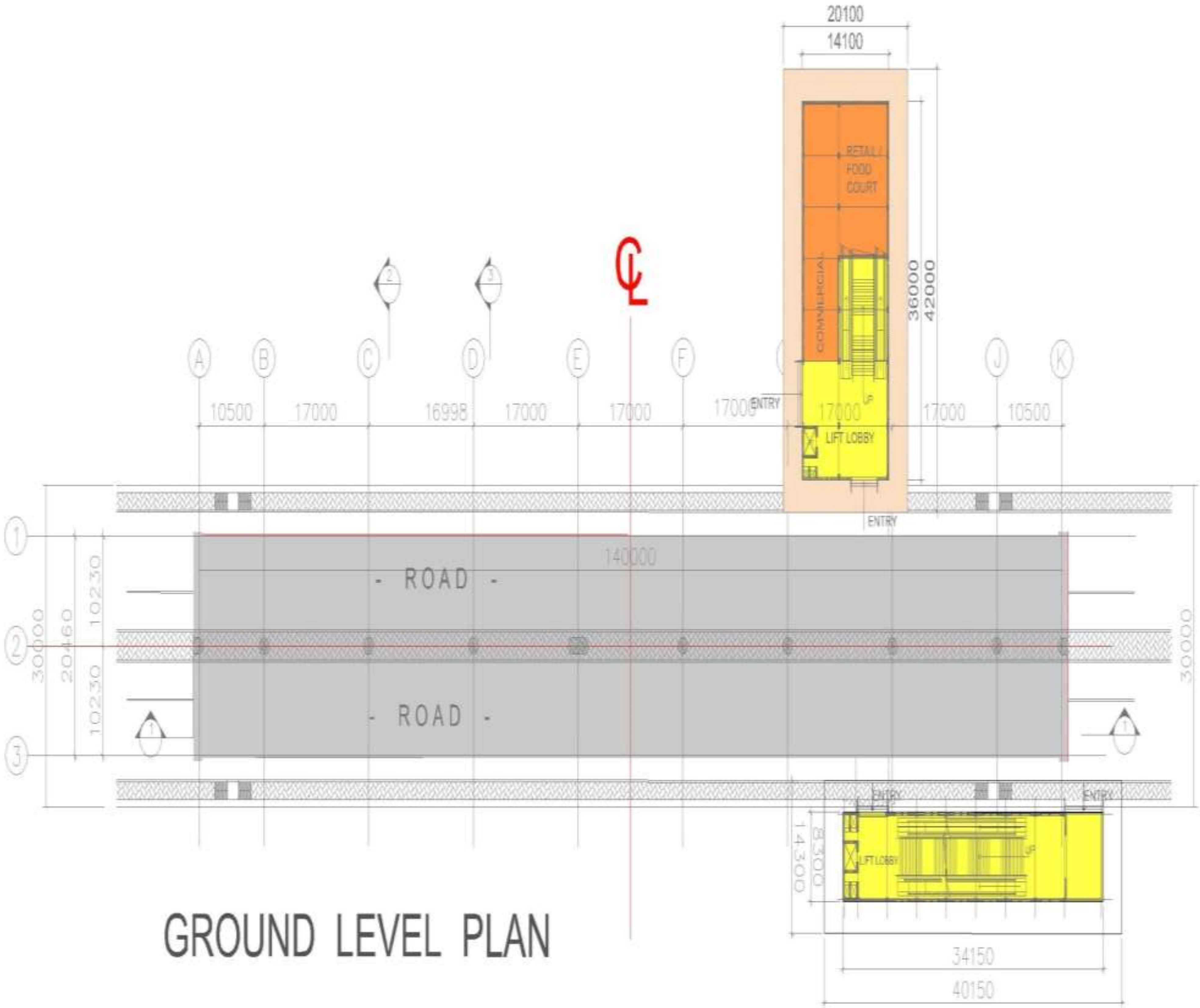


Figure-4.6 Typical Underground Station Layout

Ground Level Plan

Chapter – 5

STATION PLANNING

5.1 STATION PLANNING

General

The Proposed metro rail extension of Mumbai Metro Line-4 runs from Kasarvadavali to Gaimukh. The length of the proposed extension from Kasarvadavali to Gaimukh is approximately 2.668 km. Along this extension of the proposed Line-4, 2 stations have been planned and both are elevated. The locations of the stations have been identified taking into consideration the constraints in land acquisition and congestion issue. Stations are proposed in such a way so as to attract the maximum demand from the traffic nodal points. Location of stations has been shown in the map 5.1.

Map 5.1

5.2 STATION TYPES

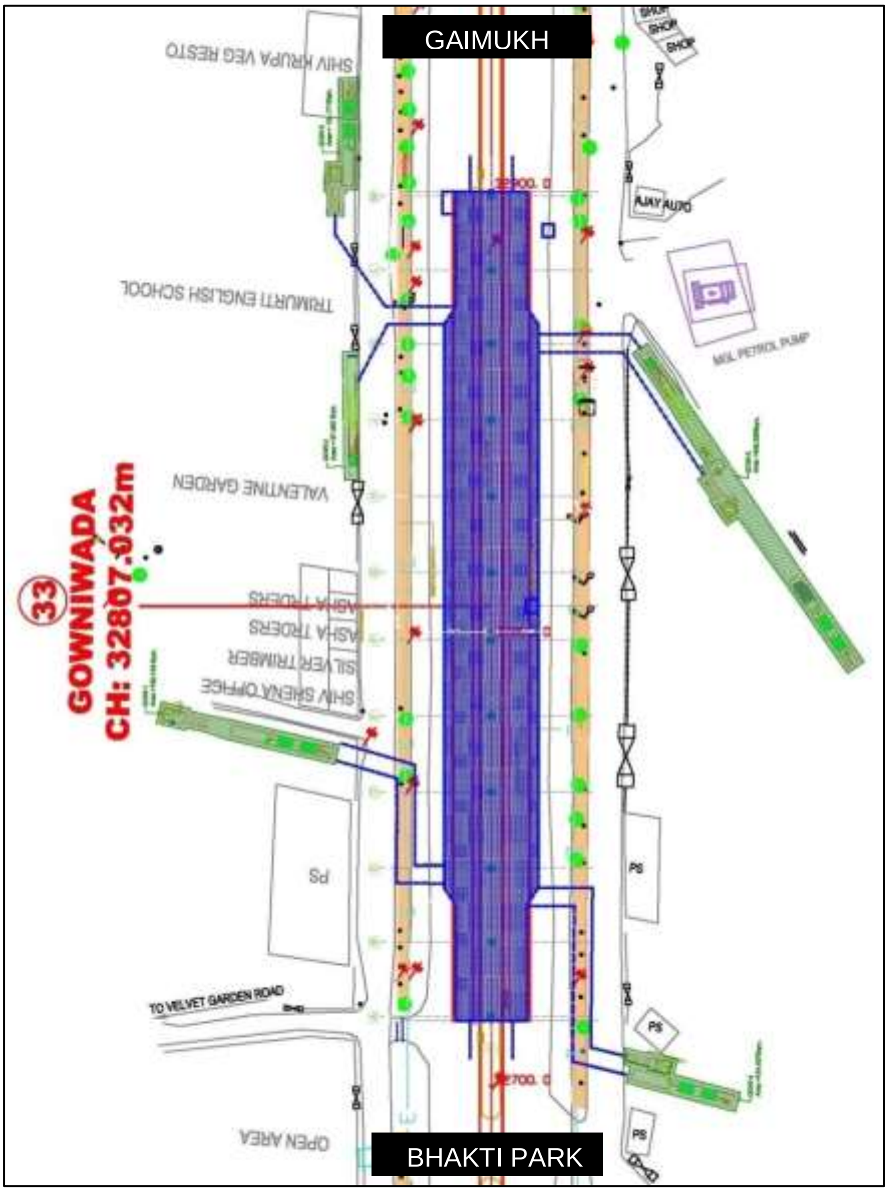
Both stations planned in this extension are elevated and have side platforms. Average inter-station distance is approximately 1.334 km varying from 1283.1 to 1384.9 m depending upon the site, Operational and traffic constrains. The sequence of stations with their respective chainages, Inter station distance and platform characteristics is presented in **Table 5.1**

Table 5.1 List of Stations

S. No.	Station Name	Chainage(m)	Inter Distance Between Two Stations.	Station Type
	KASARVADAVALI	31422.088		Elevated
	START CHAINAGE	31872.088		
1	GOWNIWADA	32807.032	1384.944	Elevated
2	GAIMUKH	34090.120	1283.088	Elevated
	DEAD END	34540.120		

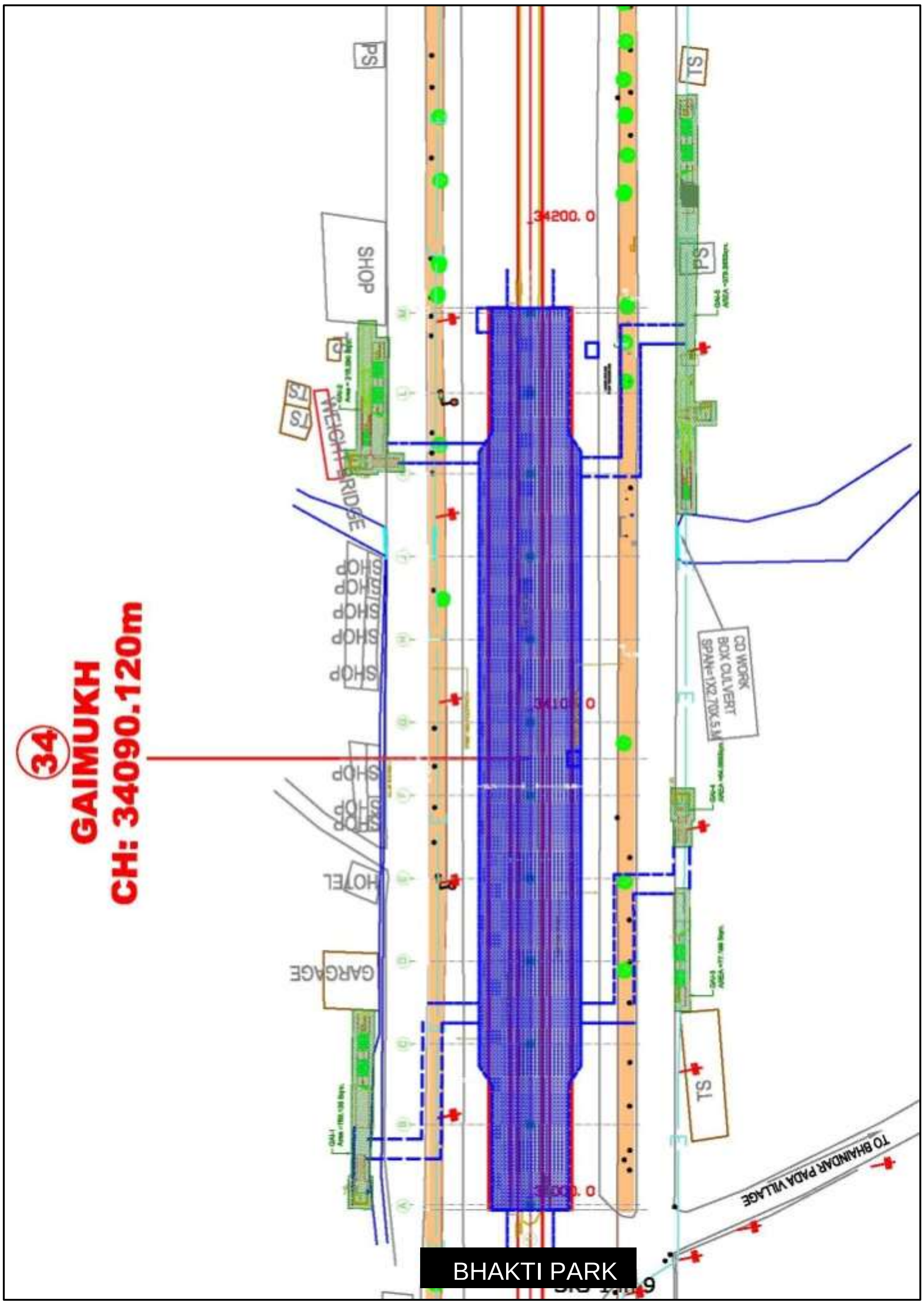
1. GOWNIWADA

Chainage	32807.032m
Inter station Distance	1384.944m
Location	Located on Ghodbunder road, in front of MGL Petrol Pump
Entry / Exit	Four nos. of entry structures have been provided. Two entry structures have been located in front MGL Petrol Pump and the other two in front of Valentine Garden and Trimurti English School.
Catchment Area	Gowniwada, Puranik City, Hawaiian Village.



2. GAIMUKH

Chainage	34090.120m
Inter station Distance	1283.088m
Location	Located on Ghodbunder Road
Entry / Exit	Four nos. of entry structures have been provided.
Catchment Area	Gaimukh, Bhayandarpada and Lodha Splendora.



5.3 PROPOSED STATION CONFIGURATION

5.3.1 In this Metro extension, Proposed Stations are starting from Kasarvadavali and are located on Ghodbunder road. Both stations are of two levels. Each station is 185 m long. 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 both the stations are proposed from both sides.

For both the stations, layout proposed is with two unpaid and one paid area.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5m has been provided under the concourse. Concourse floor level is about 6.5m above the road. Platforms are at a height of about 13.0m from the road level.

The station structure is rested on the central columns which in turn have been placed on the 2.8m wide footpath. Road to concourse staircase and escalator has its independent columns

5.3.2 Drawings

Following drawings are enclosed:

i) Typical Elevated station Type-1
– Floor plans (Road, Concourse and Platform level)

5.3.3 Salient features

Salient features of Metro Rail stations are as follows:

i) Both the stations have two 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 1.100m above the rail level. This would make the platforms in an elevated situation at least 13.5m above ground.

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

ix) 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 5.2 below :

Table 5.2 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**
4	Security Room	9	
5	First Aid Room	10	
6	Female Toilet in paid area	25	**As per National Building Code**
7	Male Toilet in paid area	25	**As per National Building Code**
8	Handicap Toilet	9	**As per National Building Code**
9	Signaling Equipment Room	60	
10	Communication Room	40	
11	UPS Room (SIG/TEL)	60	
12	Mess room	25	
13	Staff Lockers (Gents)	9	
14	Staff Lockers (Ladies)	9	
15	Tank / Pump Room		**At Street level as/requirement**
16	Excess Fare Collection (2 nos.)	6.25	**2.5mx2.5m**
17	Diesel Generator Room	29	**At Street level as/requirement**
18	ASS (Auxiliary Substation)	160	
19	Electrical Switch Room	40	
20	Electrical UPS room	25	
21	F.H.C		**As/requirement**
22	Cleaner Room	10	

Room No.	Description	Minimum Area(m^2)	Remarks
23	Refuse Collection Room	5	**Street level**
24	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.

xii) 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 minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers.

xiii) 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).

5.4 STATION STANDARDS

5.4.1 Queuing Requirements are shown in Table 5.3

Table 5.3 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	4.0m
10	Escalators from working point	8.0m

5.4.2 Table 5.4 shows the Station Planning Requirements

Table 5.4 Station Planning Requirements

Room No.	Description	Minimum Area(m^2)
1	Ticket Issuing Machines per 1 min.	10 passenger
2	AFC Gates per 1 min.	28 passengers
3	Side Platform Station (Normal Condition)	2 persons / sq.m
4	Side Platform Station (Emergency Condition)	5 persons / sq.m
6	Minimum Platform Width	3.0 m
7	Emergency Evacuation Time	5.50 min.

5.4.3 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.

5.5 PASSENGER AMENITIES

Passenger amenities which will be required in the year 2021 and 2031 are shown in table 5.5 and 5.6. Adequate space has been provided for expansion as may be required in 2021 and 2031.

Table 5.5

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

S. No.	Station Name	Hourly Boarding	Hourly Alighting	Ticket ing Gates (Nos.)	Ticket Count ers (Nos.)	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
1	GOWNIWADA	1764	1853	4	2	10	6.07	4	2	4	4
2	GAIMUKH	11864	8558	10	10	10	6.07	4	2	4	4

Table 5.6

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

S. No.	Station Name	Hourly Boarding	Hourly Alighting	Ticket ing Gates (Nos.)	Ticket Count ers (Nos.)	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
1	GOWNIWADA	2416	2463	4	2	10	8.71	4	2	4	4
2	GAIMUKH	16827	15780	13	14	10	8.71	4	2	4	4

5.5.1 Ticketing Gates

Ticketing gates' requirement has been calculated taking the gate capacity as 28 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.

5.5.2 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 40% 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.

5.5.3 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 28 ppm per gate.
- One Excess Fare Collection Office at each exit gate has been provided.

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

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: 28 passengers per minute.
4. Maximum TOM throughput: 10 passengers per minute,
5. Maximum TVM throughput: 5 passengers per minute.
6. 40% of PMT buy tickets/Tokens from BOM/TVM.
7. 60% of PMT use smart cards
8. 10% of smart card users use BOM/TVM for card recharge.

5.6 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.

5.7 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.

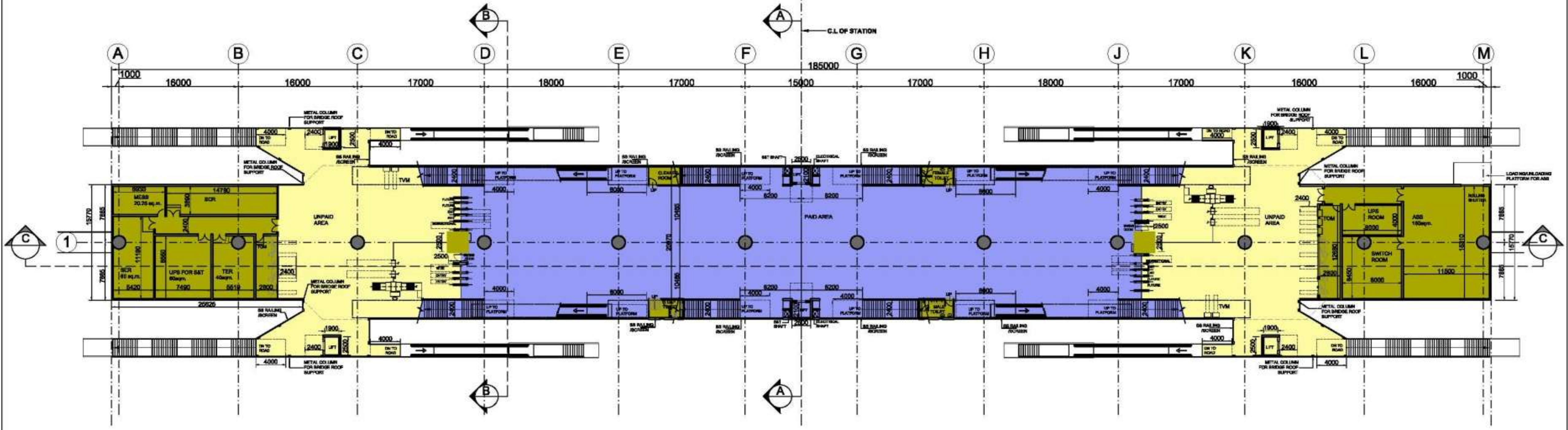
5.8 STATION CONSTRAINTS

At most of the stations the station columns will intrude into current service R.O.W. The space for station portal columns required throughout 185 m station length will be 3.5m wide median, reducing the service road width. Existing carriageway width and balance width after construction of columns are shown in Table 5.6.

Table 5.6

Sr. No.	STATION NAME	Carriage way Width (m)	Location	Carriage way Balance Width (m)	Purpose	Remarks
1	GOWNIWADA	26.52	Located on centre of Ghodbunder Road, 2.8m in width excluding footpath	23.72	Station Columns,	10.5m wide carriage way proposed on both side of median.
2	GAIMUKH	26.52	Located on centre of Ghodbunder Road, 2.8m in width excluding footpath	23.72	Station Columns,	10.5m wide carriage way proposed on both side of median.

TYPE - i



CONCOURSE LEVEL PLAN

STAIRCASE CHART AS/STATION CALCULATION FOR YEAR 2031			
S.NO.	STATION NAME	REQUIRED WIDTH ON EACH PLATFORM (IN METERS)	STAIRCASE WIDTH PROVIDED IN THE DRAWING
1	BHAKTI PARK METRO	7.56	9.60
2	WADALA TT	5.12	9.60
3	ANIK NAGAR BUS DEPOT	4.73	9.60
4	SUMAN NAGAR	8.06	9.60
5	SIDDHARTH COLONY	7.19	9.60
6	AMAR MAHAL JUNCTION	5.05	9.60
7	GARODIA NAGAR	5.81	9.60
8	PANT NAGAR	4.49	9.60
9	LAXMI NAGAR	5.19	9.60
11	GODREJ COMPANY	5.83	9.60
12	VIKHROLI METRO	5.82	9.60
13	SURYA NAGAR	5.15	9.60
14	GANDHI NAGAR	7.36	9.60
15	NAVAL HOUSING	5.57	9.60
16	MANGATRAM PETROL PUMP	4.71	9.60
17	BHANDUP METRO	6.09	9.60
19	SONAPUR	4.47	9.60
20	MULUND FIRE STATION	6.12	9.60
21	MULUND NAKA	4.64	9.60
22	TEEN HAATH NAKA (THANE)	7.00	9.60
23	RTO THANE	7.39	9.60
24	MAHAPALIKA MARG	5.59	9.60
25	CADBURY JUNCTION	8.96	9.60
26	MAJIWADA	6.37	9.60
27	KAPURBAWDI	5.73	9.60
29	TIKUJI-NI-WADI	5.58	9.60
30	DONGARI PADA	6.46	9.60
31	VIJAY GARDEN	5.28	9.60
32	KASARWADAVLI	8.94	9.60

TOM AND AFC AS/STATION CALCULATION FOR YEAR 2031										
S.NO.	STATION NAME	TOM		AFC						
		REQUIRED	PROVIDED	REQUIRED			PROVIDED			
				IN	OUT	R	IN	OUT	R	
1	BHAKTI PARK METRO	13	9	4	4	3	6	4	2	
2	WADALA TT	6	9	2	2	1	6	4	2	
3	ANIK NAGAR BUS DEPOT	2	9	1	1	0	6	4	2	
4	SUMAN NAGAR	4	9	1	1	2	6	4	2	
5	SIDDHARTH COLONY	5	9	2	2	1	6	4	2	
6	AMAR MAHAL JUNCTION	3	9	1	1	1	6	4	2	
7	GARODIA NAGAR	6	9	1	1	3	6	4	2	
8	PANT NAGAR	1	9	0	0	1	6	4	2	
9	LAXMI NAGAR	2	9	1	1	0	6	4	2	
11	GODREJ COMPANY	5	9	1	1	3	6	4	2	
12	VIKHROLI METRO	4	9	1	1	2	6	4	2	
13	SURYA NAGAR	2	9	1	1	0	6	4	2	
14	GANDHI NAGAR	10	9	1	1	6	6	4	2	
15	NAVAL HOUSING	3	9	0	0	3	6	4	2	
16	MANGATRAM PETROL PUMP	2	9	1	1	0	6	4	2	
17	BHANDUP METRO	4	9	1	1	2	6	4	2	
19	SONAPUR	1	9	1	1	0	6	4	2	
20	MULUND FIRE STATION	4	9	0	0	3	6	4	2	
21	MULUND NAKA	1	9	1	1	0	6	4	2	
22	TEEN HAATH NAKA (THANE)	5	9	1	1	3	6	4	2	
23	RTO THANE	7	9	2	2	2	6	4	2	
24	MAHAPALIKA MARG	3	9	1	1	1	6	4	2	
25	CADBURY JUNCTION	5	9	1	1	3	6	4	2	
26	MAJIWADA	5	9	1	1	2	6	4	2	
27	KAPURBAWDI	4	9	1	1	2	6	4	2	
29	TIKUJI-NI-WADI	5	9	1	1	2	6	4	2	
30	DONGARI PADA	6	9	1	1	5	6	4	2	
31	VIJAY GARDEN	4	9	2	2	0	6	4	2	
32	KASARWADAVLI	9	9	1	1	5	6	4	2	

NOTE:-

- AFC GATES ARE PROVIDED AS/THE AVAILABLE SPACE AND CAN BE REDUCE AS/THE CALCULATION
- TICKET COUNTER CAN BE REDUCED AND PROPERTY DEVELOPMENT AREA WILL BE ADDED IN THAT PLACE.
- 7NO OF TVM HAS BEEN PROVIDED IN THE DRAWING

LEGEND

- UNPAID AREA
- PAID AREA
- OPERATIONAL AREA

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
3. ANY DISCREPANCIES MUST BE BROUGHT TO THE NOTICE OF THE CONSULTANT BEFORE EXECUTION OF WORK AT SITE.
4. THIS DRAWING MUST BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTURAL, STRUCTURAL, PLUMBING & FIRE FIGHTING, ELECTRICAL AND TRAFFIC MANAGEMENT DRAWINGS.
5. ALL DOOR/WINDOW CILL & LINTEL LEVELS ARE MEASURED FROM MAIN FLOOR FINISHED LEVELS.

REV. | PARTICULARS | DRN. | CHD. | VER. | DATE | ISSUE DATE | REV. FOR CONSTRUCTION

REFERENCE DRAWINGS: Drg. No. | Description

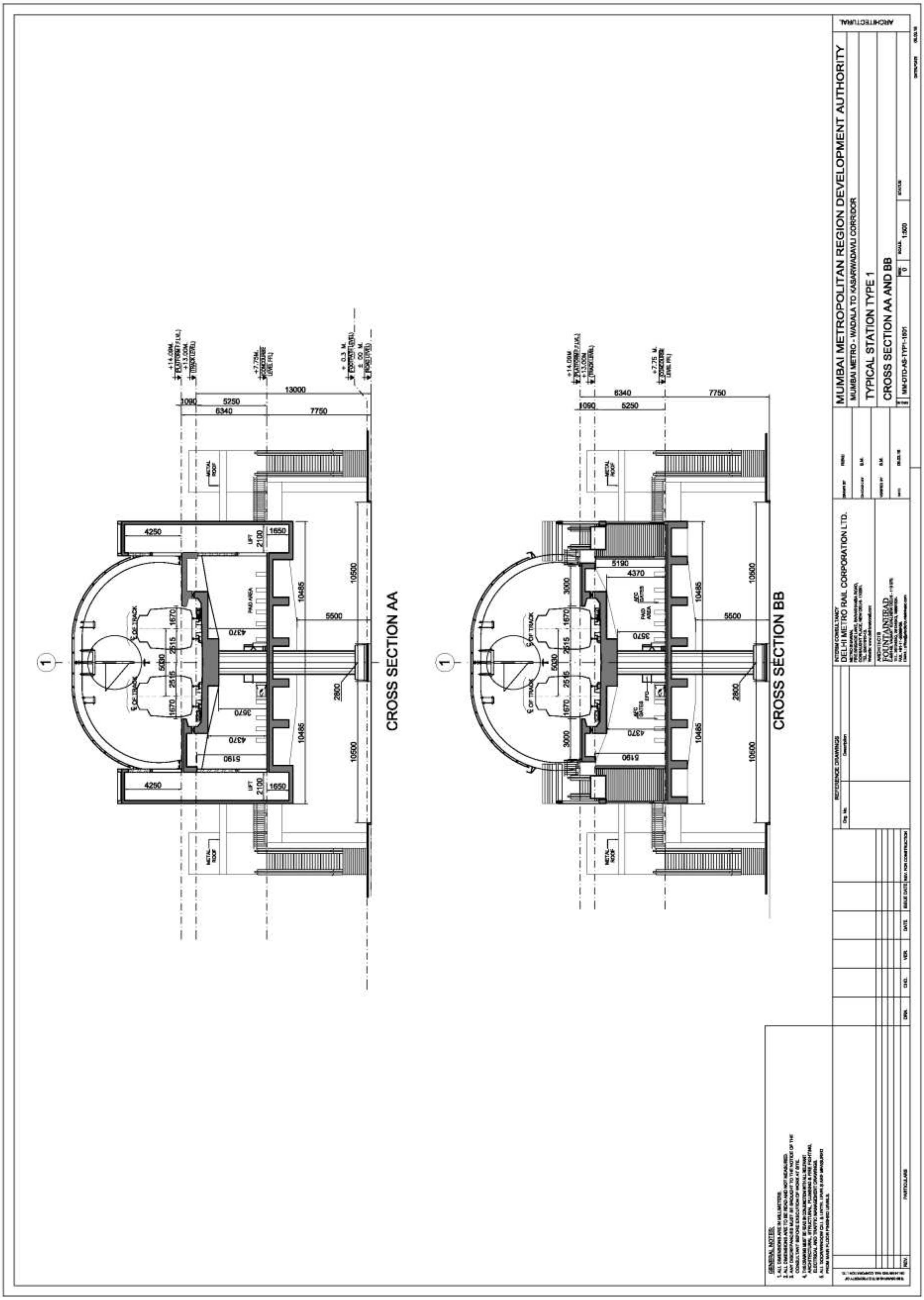
INTERIM CONSULTANCY
DELHI METRO RAIL CORPORATION LTD.

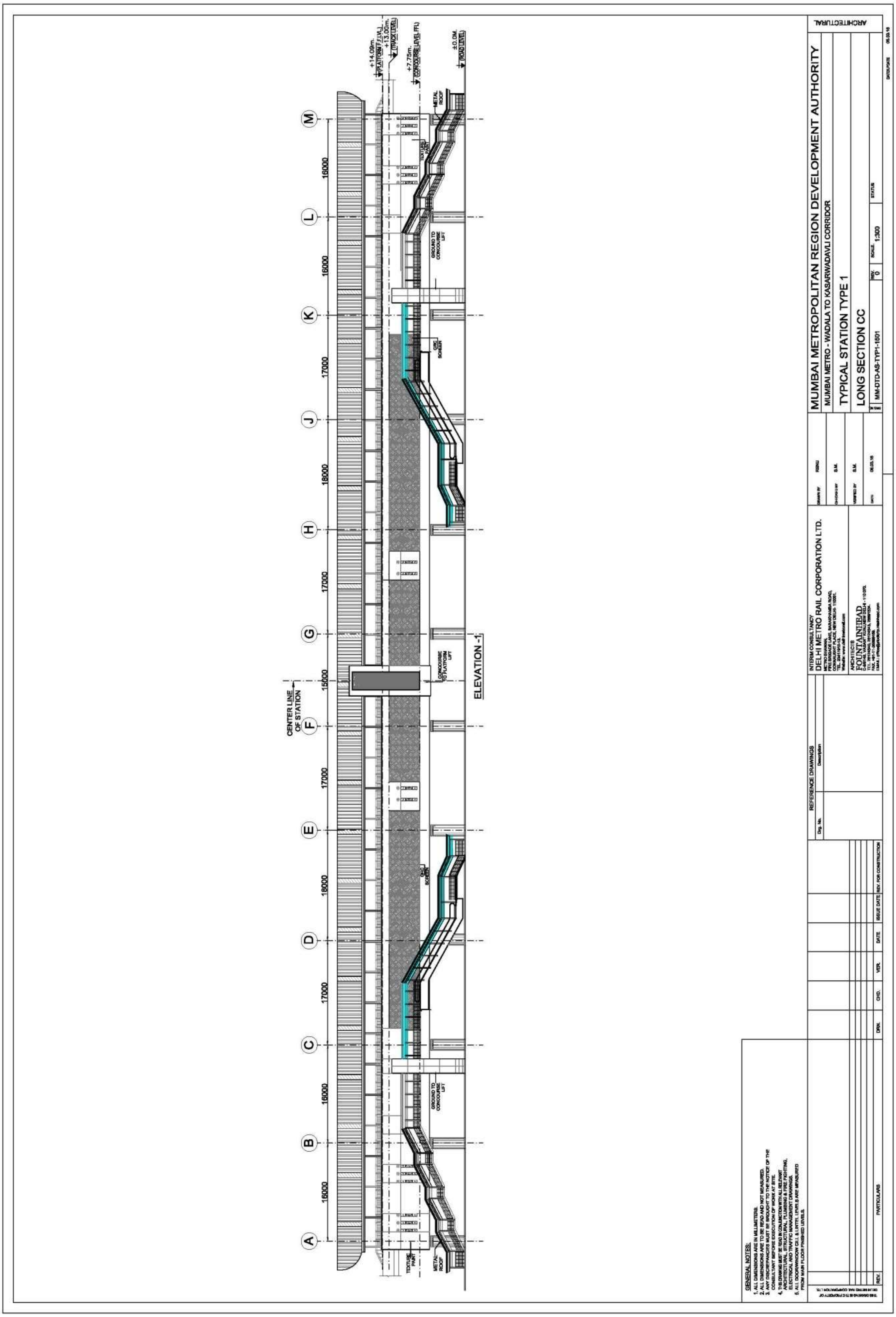
ARCHITECTS
FOUNTAINHEAD

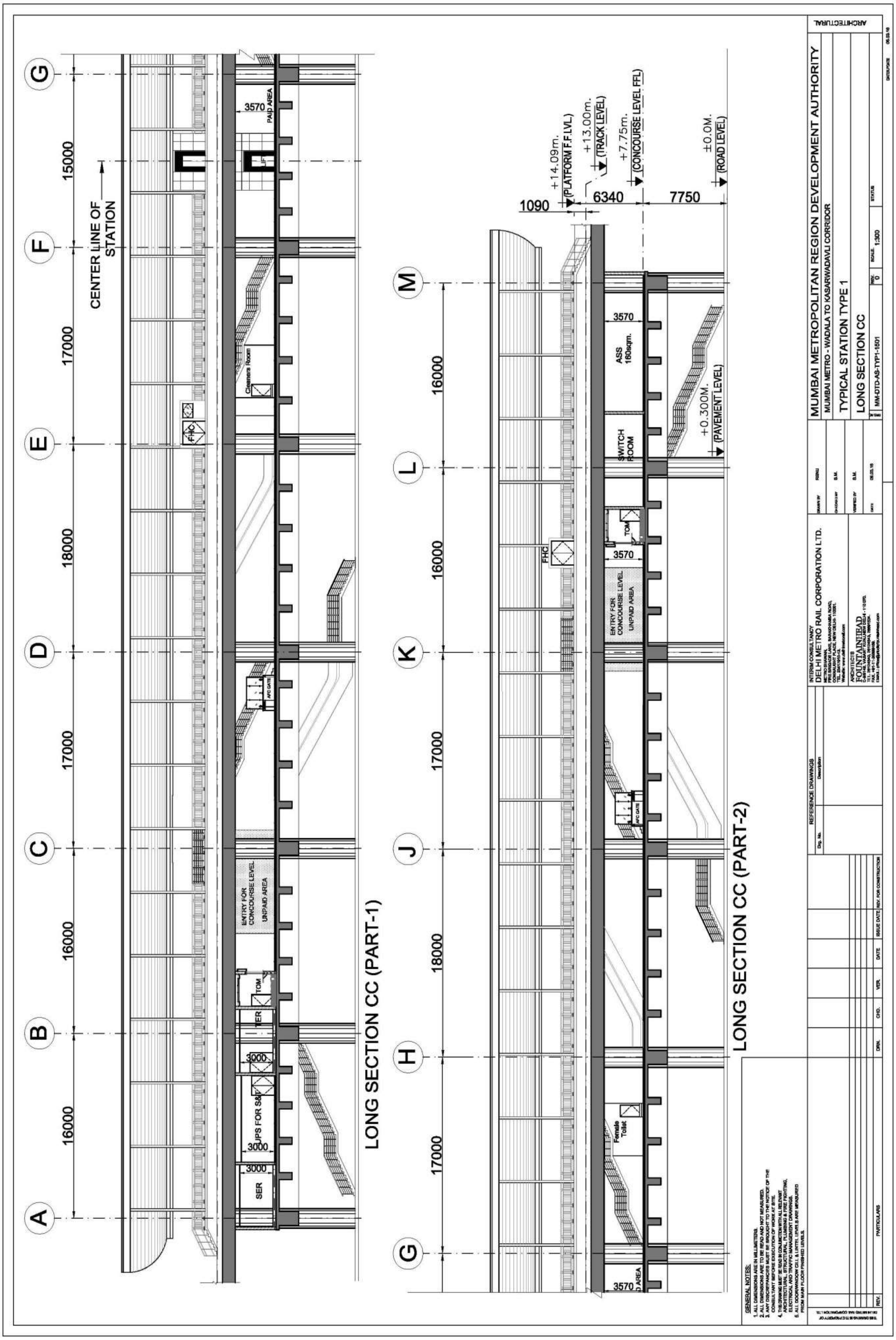
DRAWN BY: RENU
CHECKED BY: S.M.
VERIFIED BY: S.M.
DATE: 06.03.16

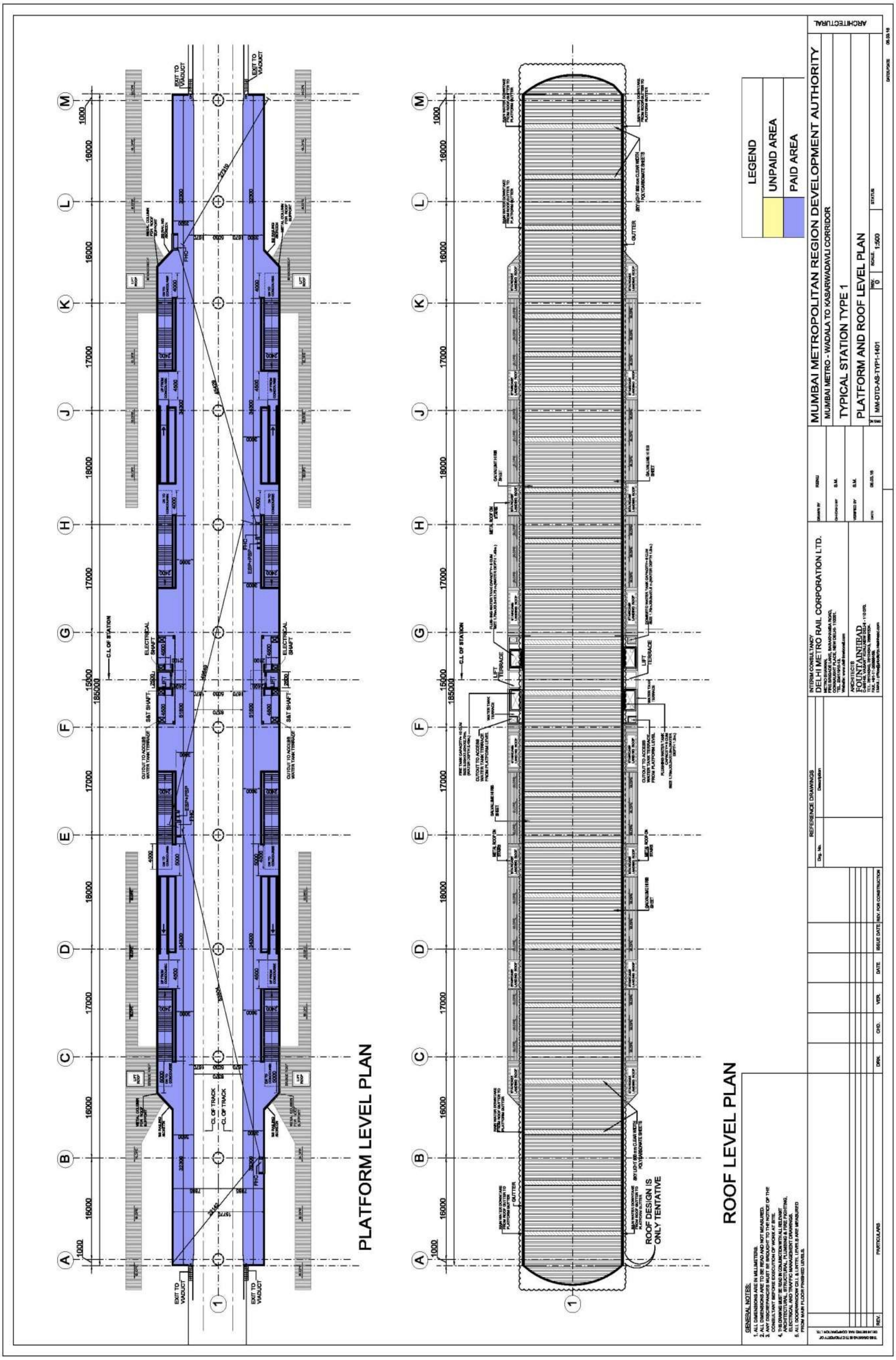
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY
MUMBAI METRO - WADALA TO KASARWADAVLI CORRIDOR
TYPICAL STATION TYPE 1
CONCOURSE LEVEL PLAN
MM-DTD-AS-TYP1-1201 | REV. 0 | SCALE 1:500 | STATUS

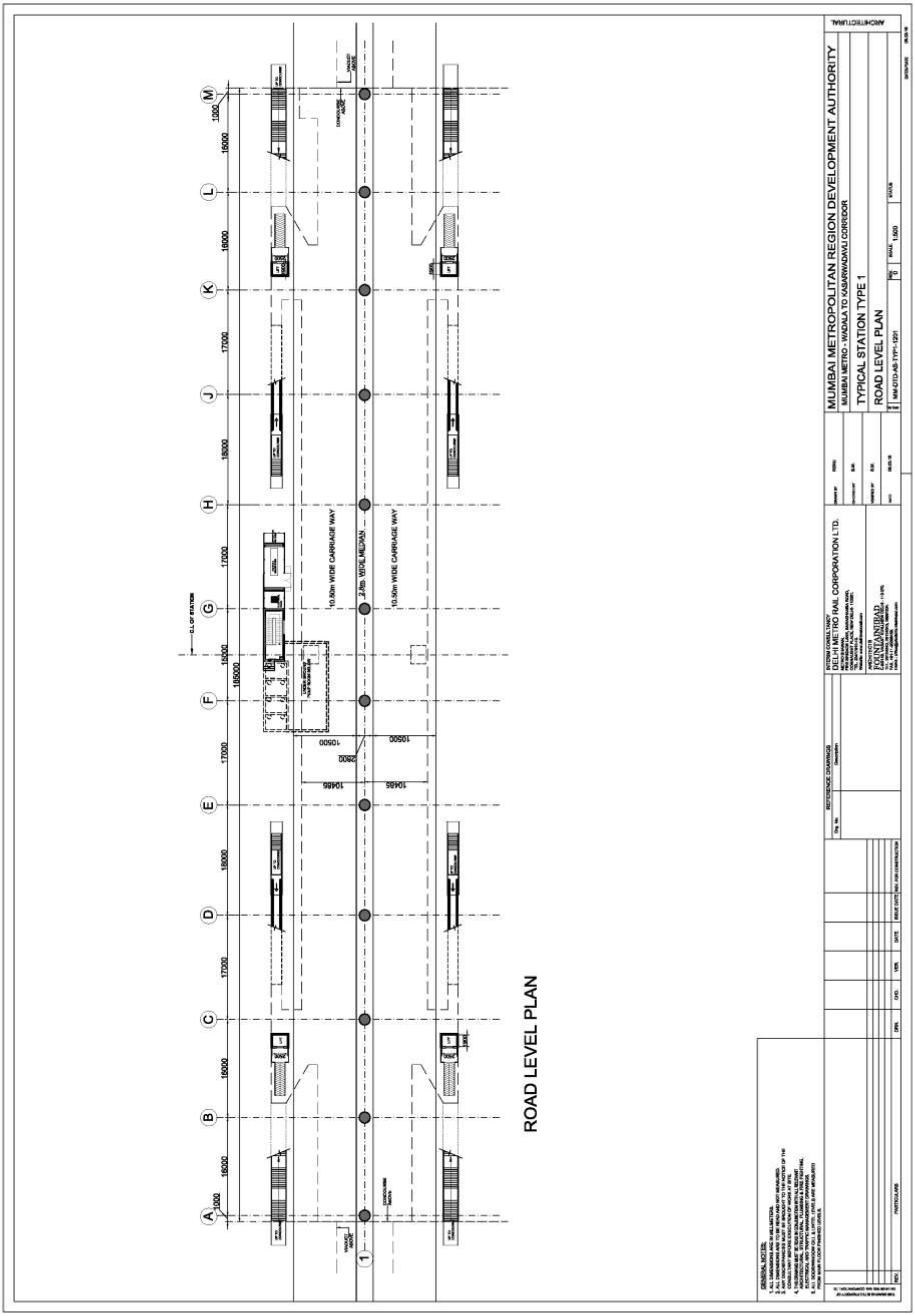
ARCHITECTURAL


MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY
MUMBAI METRO - WADALA TO KASARWADAVLI CORRIDOR
TYPICAL STATION TYPE 1
CROSS SECTION AA AND BB
DELHI METRO RAIL CORPORATION LTD.
ARCHITECTURAL
CROSS SECTION AA
CROSS SECTION BB


MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY
MUMBAI METRO - WADALA TO KASARWADAVLI CORRIDOR
TYPICAL STATION TYPE 1
LONG SECTION CC
MM-DTO-AS-TYP1-1601
ARCHITECTURAL
DELHI METRO RAIL CORPORATION LTD.
REFERENCE DRAWINGS
GENERAL NOTES:
ELEVATION -1
CENTER LINE OF STATION
+14.09m. PLATFORM F.F.LVL.
+13.00m. TRACK LEVEL
+7.75m. CONCOURSE LEVEL (FFL)
±0.0M. ROAD LEVEL
GROUND TO CONCOURSE LIFT
CONCOURSE TO PLATFORM LIFT
METAL ROOF
TEXTURE PAINT
A
B
C
D
E
F
G
H
J
K
L
M
16000
17000
18000
15000
1:300


LONG SECTION CC (PART-1)
LONG SECTION CC (PART-2)
CENTER LINE OF STATION
15000
17000
18000
17000
16000
16000
16000
16000
17000
18000
17000
+14.09m. (PLATFORM F.F.LVL.)
+13.00m. (TRACK LEVEL)
+7.75m. (CONCOURSE LEVEL FFL)
±0.0M. (ROAD LEVEL)
+0.300M. (PAVEMENT LEVEL)
1090
6340
7750
3570
PAID AREA
Cleaners Room
FHC
AFC GATE
ENTRY FOR CONCOURSE LEVEL UNPAID AREA
TOM
SER
3000
UPS FOR S&T
ASS 160sqm.
SWITCH ROOM
Female Toilet
GENERAL NOTES:
REFERENCE DRAWINGS
INTERIM CONSULTANCY
DELHI METRO RAIL CORPORATION LTD.
ARCHITECTS
FOUNTAINHEAD
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY
MUMBAI METRO - WADALA TO KASARWADAVLI CORRIDOR
TYPICAL STATION TYPE 1
LONG SECTION CC
MM-DTD-AS-TYP1-1601
1:300
ARCHITECTURAL


PLATFORM LEVEL PLAN
ROOF LEVEL PLAN
ROOF DESIGN IS ONLY TENTATIVE
LEGEND
UNPAID AREA
PAID AREA
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY
MUMBAI METRO - WADALA TO KASARWADAVLI CORRIDOR
TYPICAL STATION TYPE 1
PLATFORM AND ROOF LEVEL PLAN
DELHI METRO RAIL CORPORATION LTD.
ARCHITECTURAL


ROAD LEVEL PLAN
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY
MUMBAI METRO - WADALA TO KASARWADAVLI CORRIDOR
TYPICAL STATION TYPE 1
ROAD LEVEL PLAN
DELHI METRO RAIL CORPORATION LTD.
10.50m WIDE CARRIAGE WAY
2.8m WIDE MEDIAN
10.50m WIDE CARRIAGE WAY
C.L OF STATION
185000
ARCHITECTURAL

Chapter –6

TRAIN OPERATION PLAN

6.1 OPERATION PHILOSOPHY

The underlying operation philosophy is to make the MRT 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.
- Optimization of train's reliability for achieving best possible availability on line.
- A train consists of 8 coaches.
- Multi-tasking of train operation and maintenance staff.

6.2 STATIONS

List of stations for the Mumbai Metro Line-4 (Wadala to Gaimukh) is given below:

TABLE 6.1: STATIONS

WADALA TO GAIMUKH					
S. No	**Name of Station**	**Chainage (in m)**	**Inter – Station Distance (in m)**	**Station Type**	**Remarks**
0	**Dead End**	-450			
1	BHAKTI PARK METRO	0	450	Elevated	Interchange Station
2	WADALA TT	1000.00	1000.00	Elevated	
3	ANIK NAGAR BUS DEPOT	1861.61	861.61	Elevated	
4	SUMAN NAGAR	2940.00	1078.39	Elevated	
5	SIDDHARTH COLONY	3994.43	1054.43	Elevated	
6	AMAR MAHAL JUNCTION	5338.01	1343.58	Elevated	Interchange Station
7	GARODIA NAGAR	5936.54	598.53	Elevated	
8	PANT NAGAR	7569.22	1632.68	Elevated	
9	LAXMI NAGAR	8646.73	1077.51	Elevated	
10	SHREYES CINEMA	9267.54	620.81	Elevated	
11	GODREJ COMPANY	10430.36	1162.82	Elevated	
12	VIKHROLI METRO	11153.48	723.12	Elevated	

WADALA TO GAIMUKH					
S. No	**Name of Station**	**Chainage (in m)**	**Inter – Station Distance (in m)**	**Station Type**	**Remarks**
13	SURYA NAGAR	12158.25	1004.77	Elevated	
14	GANDHI NAGAR	13160.36	1002.11	Elevated	Interchange Station
15	NAVAL HOUSING	13852.24	691.88	Elevated	
16	BHANDUP MAHAPALIKA	14631.58	779.34	Elevated	
17	BHANDUP METRO	15680.41	1048.83	Elevated	
18	SHANGRILA	16524.06	843.65	Elevated	
19	SONAPUR	17914.82	1390.76	Elevated	
20	MULUND FIRE STATION	19027.80	1112.98	Elevated	
21	MULUND NAKA	20375.90	1348.10	Elevated	
22	TEEN HAATH NAKA (THANE)	21612.24	1236.35	Elevated	
23	RTO THANE	22290.78	678.54	Elevated	
24	MAHAPALIKA MARG	23326.75	1035.97	Elevated	
25	CADBURY JUNCTION	24119.46	792.71	Elevated	
26	MAJIWADA	24943.75	824.29	Elevated	
27	KAPURBAWDI	26333.01	1389.26	Elevated	
28	MANPADA	27198.39	865.38	Elevated	
29	TIKUJI-NI-WADI	27974.04	775.65	Elevated	
30	DONGARI PADA	29439.64	1465.60	Elevated	
31	VIJAY GARDEN	30348.51	908.87	Elevated	
32	KASARVADAVALI	31422.09	1073.57	Elevated	
33	GOWNIWADA	32807.03	1384.94	Elevated	
34	GAIMUKH	34090.12	1283.09	Elevated	
	Dead End	34540.12	450.00		

6.3 TRAIN OPERATION PLAN: 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 these corridors has been considered as: 35 kmph.

6.4 TRAFFIC DEMAND

Peak hour peak direction traffic demands (PHPDT) for the Mumbai Metro ‘Line-4: Wadala-Gaimukh’ in the year 2021 & 2031 for the purpose of planning are indicated in Attachment I/A & I/B respectively.

6.5 TRAIN FORMATION

To meet the above projected traffic demand, the possibility of running trains with composition of 8 cars with different headway has been examined.

Composition

DMC : Driving Motor Car
TC : Trailer Car
MC : Motor Car

Capacity (@ 6 passengers per square meter of standee area)

Driving Motor Car (DMC)	- 282 (42 seated + 240 standing)
Trailer Car (TC)	- 298 (50 seated + 248 standing)
Motor Car (MC)	- 298 (50 seated + 248 standing)
8 Car Train	- 2352 (384 seated + 1968 standing)

6.6 TRAIN OPERATION PLAN

Based on the projected PHPDT demand, Train operation plan with train carrying capacity @ 6 persons per square meter of standee area for the Mumbai Metro ‘Line-4: Wadala-Gaimukh’ for the year 2021 and 2031 is given below:

Line-4: Wadala-Gaimukh

Train Operation Plan for Line-4: Wadala-Gaimukh has been planned in such a way that there is only end to end operation from Wadala to Gaimukh.

i) Year 2021

- 5.00 min Effective Headway with 8-car train.
- Available Peak Hour Peak Direction Capacity of 28224@ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 36000@ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 27570 is in the Section between Laxmi Nagar to Shreyes Cinema and demand in the remaining sections is in the range of 27445 to 11864 only. The planned capacity of 28224 (36000 under dense loading) is more than the PHPDT Demand.

  Traffic demand and train capacity for Line-4 in the year 2021 is tabulated and represented on chart enclosed as Attachment I/A.

ii) Year 2031:

- 4.25 min Effective Headway with 8-car train.
- Available Peak Hour Peak Direction Capacity of 33205@ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 42353@ 8 persons per square meter of standee area under dense loading conditions.

- The maximum PHPDT demand of 30708 is in the Section between Bhandup Metro to Shangrila and demand in the remaining sections is in the range of 30500 to 11571 only. The planned capacity of 33205(42353 under dense loading) is more than the PHPDT demand.

  Traffic demand and train capacity for Line-4 in the year 2031 is tabulated and represented on chart enclosed as Attachment I/B.

  The above Train Operation Plan is based on calculations on the basis of available traffic data. In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by adjusting the Headway.

  The PHPDT capacity provided on the route in different years of operation is tabulated below:

TABLE 6.2 Capacity Provided for Line-4: Wadala - Gaimukh

Sections	Year	Head -way (min)	Total No. of Rakes	Rake Consist	Total No. of Cars**	Provision for No. of cars in DPR of May'16	Additional No. of cars for Extens-ion of Line-4#	Max. PHPDT Demand	PHPDT Capacity Available
Wadala to Gaimukh	2021	5.00	29	8-car	232	216	16	27570	28224 (36000*)
Wadala to Gaimukh	2031	4.25	33	8-car	264	264	0	30708	33205 (42353*)

***** *@ 8 persons per square meter of standee area*
*** Total No. of cars shown above are the total cars calculated as per PHPDT data.*
 # Additional cars requirement for Line-4 extension has been calculated after subtracting provision for no. of cars in previous Line-4 (Wadala-Kasarvadavali) DPR (May 2016) from the total car requirements.

6.7 TRAIN FREQUENCY

TABLE 7.3Train Frequency Line-4: Wadala-Gaimukh

Section	2021		2031	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
Wadala to Gaimukh	5.00 min	8 to 16 min	4.25 min	6 to 16 min

No services are proposed between 00:00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

6.8 HOURLY TRAIN OPERATION PLAN

The hourly distribution of daily transport capacity is presented in **Table 1.1 & 1.2** for 'Wadala to Gaimukh' Section (Line-4) for the years 2021 and 2031 enclosed as **Attachment II.**

Number of train trips per direction per day for 'Wadala to Gaimukh' Section (Line-4) is worked out as 139 in the year 2021 and 164 in the year 2031.

The directional split for Line-4: Wadala to Gaimukh is presented in **Table 2** enclosed as **Attachment III**.

6.9 VEHICLE KILOMETER

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Mumbai Metro Rail Network, Line-4: Wadala-Gaimukh is given in **Table 3** enclosed as **Attachment IV**.

6.10 YEAR WISE 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.**

Requirements of coaches is calculated based on following assumptions-
Assumptions –

(i) Train Composition planned as under:

8 car Train Composition (with 75% Powering)	: DMC +TC +MC+MC+MC+MC+TC+DMC
Train Carrying Capacity of 8 Car Train	: 2352 passengers (@6 passengers per square meter of standee area)

(ii) Coach requirement has been calculated based on headway during peak hours.

(iii) Traffic reserve is taken as one train to cater to failure of train on line and to make up for operational time list.

(iv) Repair and maintenance reserve has been estimated as 10 % of total requirement (Bare).

(v) The calculated number of rakes in fraction is rounded off to next higher number.

(vi) Schedule speed is taken as: 35kmph

(vii) Total Turn round time is taken as 6 min at terminal stations.

6.11 COST ESTIMATE

The estimated cost per coach at Jan 2017 Price level exclusive of taxes and duties may be assumed as INR 10.2 Crores per Coach. Total 232 coaches are required in year 2021 for the Line-4 (including extension) in Mumbai Metro Rail Network. Provision of 216 cars for Line-4 (Wadala-Kasarvadavali) in year 2021 is already available in DPR of May 2016. Additional 16 cars are required due to extension of Line-4. Hence budget provision of Rs. 163.2 Crores is to be kept in the estimate for Rolling stock owing to extension of Line-4.

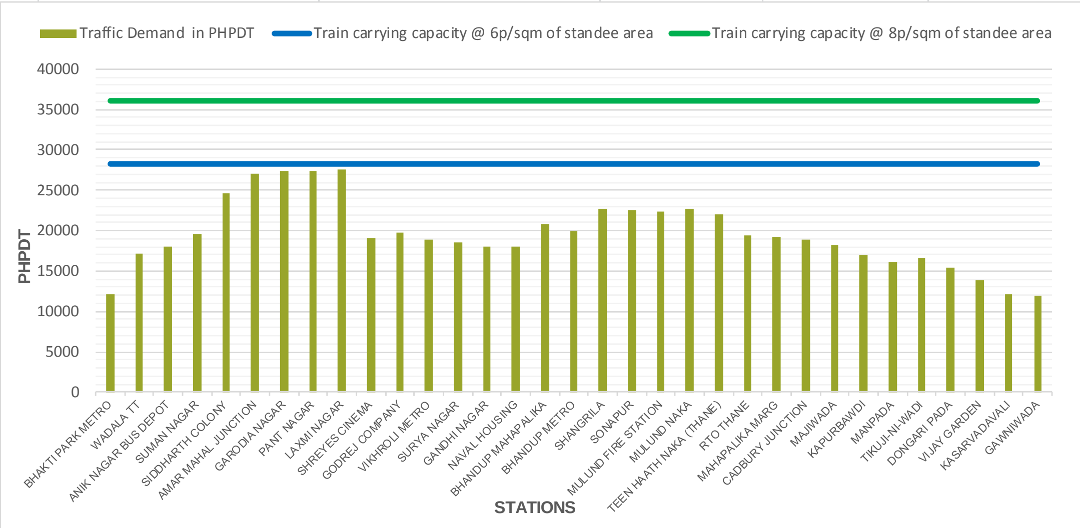
Attachment - I/A

PHPDT Demand and Capacity Chart

Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor

Year:	**2021**
No. of cars per train	**8**
Passenger Capacity @ 6 persons/sqm of a 8-Car Train:	**2352**
Passenger Capacity @ 8 persons/sqm of a 8-Car Train:	**3000**
Headway (min)	**5.00**

S.No.	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	BHAKTI PARK METRO	WADALA TT	12158	28,224	36,000
2	WADALA TT	ANIK NAGAR BUS DEPOT	17188	28,224	36,000
3	ANIK NAGAR BUS DEPOT	SUMAN NAGAR	17945	28,224	36,000
4	SUMAN NAGAR	SIDDHARTH COLONY	19508	28,224	36,000
5	SIDDHARTH COLONY	AMAR MAHAL JUNCTION	24698	28,224	36,000
6	AMAR MAHAL JUNCTION	GARODIA NAGAR	27087	28,224	36,000
7	GARODIA NAGAR	PANT NAGAR	27439	28,224	36,000
8	PANT NAGAR	LAXMI NAGAR	27445	28,224	36,000
9	LAXMI NAGAR	SHREYES CINEMA	**27570**	28,224	36,000
10	SHREYES CINEMA	GODREJ COMPANY	19061	28,224	36,000
11	GODREJ COMPANY	VIKHROLI METRO	19731	28,224	36,000
12	VIKHROLI METRO	SURYA NAGAR	18860	28,224	36,000
13	SURYA NAGAR	GANDHI NAGAR	18586	28,224	36,000
14	GANDHI NAGAR	NAVAL HOUSING	18099	28,224	36,000
15	NAVAL HOUSING	BHANDUP MAHAPALIKA	17954	28,224	36,000
16	BHANDUP MAHAPALIKA	BHANDUP METRO	20738	28,224	36,000
17	BHANDUP METRO	SHANGRILA	19956	28,224	36,000
18	SHANGRILA	SONAPUR	22738	28,224	36,000
19	SONAPUR	MULUND FIRE STATION	22489	28,224	36,000
20	MULUND FIRE STATION	MULUND NAKA	22338	28,224	36,000
21	MULUND NAKA	TEEN HAATH NAKA (THANE)	22786	28,224	36,000
22	TEEN HAATH NAKA (THANE)	RTO THANE	22012	28,224	36,000
23	RTO THANE	MAHAPALIKA MARG	19443	28,224	36,000
24	MAHAPALIKA MARG	CADBURY JUNCTION	19161	28,224	36,000
25	CADBURY JUNCTION	MAJIWADA	18854	28,224	36,000
26	MAJIWADA	KAPURBAWDI	18144	28,224	36,000
27	KAPURBAWDI	MANPADA	17062	28,224	36,000
28	MANPADA	TIKUJI-NI-WADI	16023	28,224	36,000
29	TIKUJI-NI-WADI	DONGARI PADA	16714	28,224	36,000
30	DONGARI PADA	VIJAY GARDEN	15390	28,224	36,000
31	VIJAY GARDEN	KASARVADAVALI	13823	28,224	36,000
32	KASARVADAVALI	GAWNIWADA	12179	28,224	36,000
33	GAWNIWADA	GAIMUKH	11864	28,224	36,000



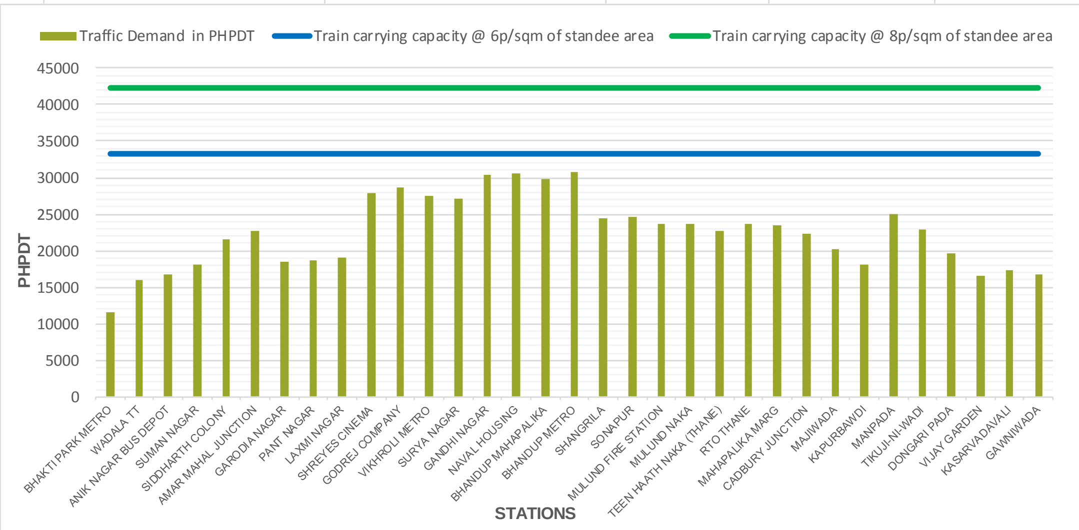
Attachment - I/B

PHPDT Demand and Capacity Chart

Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor

Year:	2031
No. of cars per train	8
Passenger Capacity @ 6 persons/sqm of a 8-Car Train:	2352
Passenger Capacity @ 8 persons/sqm of a 8-Car Train:	3000
Headway (min)	4.25

S.No.	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	BHAKTI PARK METRO	WADALA TT	11571	33,205	42,353
2	WADALA TT	ANIK NAGAR BUS DEPOT	15910	33,205	42,353
3	ANIK NAGAR BUS DEPOT	SUMAN NAGAR	16736	33,205	42,353
4	SUMAN NAGAR	SIDDHARTH COLONY	18154	33,205	42,353
5	SIDDHARTH COLONY	AMAR MAHAL JUNCTION	21629	33,205	42,353
6	AMAR MAHAL JUNCTION	GARODIA NAGAR	22731	33,205	42,353
7	GARODIA NAGAR	PANT NAGAR	18439	33,205	42,353
8	PANT NAGAR	LAXMI NAGAR	18704	33,205	42,353
9	LAXMI NAGAR	SHREYES CINEMA	19038	33,205	42,353
10	SHREYES CINEMA	GODREJ COMPANY	27910	33,205	42,353
11	GODREJ COMPANY	VIKHROLI METRO	28755	33,205	42,353
12	VIKHROLI METRO	SURYA NAGAR	27514	33,205	42,353
13	SURYA NAGAR	GANDHI NAGAR	27055	33,205	42,353
14	GANDHI NAGAR	NAVAL HOUSING	30432	33,205	42,353
15	NAVAL HOUSING	BHANDUP MAHAPALIKA	30500	33,205	42,353
16	BHANDUP MAHAPALIKA	BHANDUP METRO	29825	33,205	42,353
17	BHANDUP METRO	SHANGRILA	**30708**	33,205	42,353
18	SHANGRILA	SONAPUR	24394	33,205	42,353
19	SONAPUR	MULUND FIRE STATION	24697	33,205	42,353
20	MULUND FIRE STATION	MULUND NAKA	23636	33,205	42,353
21	MULUND NAKA	TEEN HAATH NAKA (THANE)	23743	33,205	42,353
22	TEEN HAATH NAKA (THANE)	RTO THANE	22793	33,205	42,353
23	RTO THANE	MAHAPALIKA MARG	23614	33,205	42,353
24	MAHAPALIKA MARG	CADBURY JUNCTION	23525	33,205	42,353
25	CADBURY JUNCTION	MAJIWADA	22240	33,205	42,353
26	MAJIWADA	KAPURBAWDI	20189	33,205	42,353
27	KAPURBAWDI	MANPADA	18121	33,205	42,353
28	MANPADA	TIKUJI-NI-WADI	25022	33,205	42,353
29	TIKUJI-NI-WADI	DONGARI PADA	22861	33,205	42,353
30	DONGARI PADA	VIJAY GARDEN	19658	33,205	42,353
31	VIJAY GARDEN	KASARVADAVALI	16580	33,205	42,353
32	KASARVADAVALI	GAWNIWADA	17328	33,205	42,353
33	GAWNIWADA	GAIMUKH	16827	33,205	42,353



Attachment- II

TABLE 1.1

Hourly Train Operation Plan

Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor

Year- 2021

5 - Headway (min)

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	3
6 to 7	12	5	5
7 to 8	8	8	7
8 to 9	**5.00**	**12**	**12**
9 to 10	**5.00**	**12**	**12**
10 to 11	**5.00**	**12**	**12**
11 to12	8	8	7
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	8	7	8
17 to 18	**5.00**	**12**	**12**
18 to 19	**5.00**	**12**	**12**
19 to 20	**5.00**	**12**	**12**
20 to 21	8	7	8
21 to 22	12	5	5
22 to 23	16	3	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**139**	**139**

TABLE 1.2
Hourly Train Operation Plan
Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor
Year- 2031

4.25 - Headway (min)

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	3
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.25**	**15**	**14**
9 to 10	**4.25**	**15**	**14**
10 to 11	**4.25**	**15**	**14**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4.25**	**14**	**15**
18 to 19	**4.25**	**14**	**15**
19 to 20	**4.25**	**14**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	3	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**164**	**164**

Attachment III

TABLE 2
Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor
PHPDT for the year 2021

S.No	From Station	To Station	Peak hour Load	Directional Split to Bhakti park	Directional Split to Gaimukh
1	BHAKTI PARK METRO	WADALA TT	12158	50%	50%
2	WADALA TT	ANIK NAGAR BUS DEPOT	17188	50%	50%
3	ANIK NAGAR BUS DEPOT	SUMAN NAGAR	17945	50%	50%
4	SUMAN NAGAR	SIDDHARTH COLONY	19508	50%	50%
5	SIDDHARTH COLONY	AMAR MAHAL JUNCTION	24698	50%	50%
6	AMAR MAHAL JUNCTION	GARODIA NAGAR	27087	50%	50%
7	GARODIA NAGAR	PANT NAGAR	27439	50%	50%
8	PANT NAGAR	LAXMI NAGAR	27445	50%	50%
9	LAXMI NAGAR	SHREYES CINEMA	**27570**	50%	50%
10	SHREYES CINEMA	GODREJ COMPANY	19061	50%	50%
11	GODREJ COMPANY	VIKHROLI METRO	19731	50%	50%
12	VIKHROLI METRO	SURYA NAGAR	18860	50%	50%
13	SURYA NAGAR	GANDHI NAGAR	18586	50%	50%
14	GANDHI NAGAR	NAVAL HOUSING	18099	50%	50%
15	NAVAL HOUSING	BHANDUP MAHAPALIKA	17954	50%	50%
16	BHANDUP MAHAPALIKA	BHANDUP METRO	20738	50%	50%
17	BHANDUP METRO	SHANGRILA	19956	50%	50%
18	SHANGRILA	SONAPUR	22738	50%	50%
19	SONAPUR	MULUND FIRE STATION	22489	50%	50%
20	MULUND FIRE STATION	MULUND NAKA	22338	50%	50%
21	MULUND NAKA	TEEN HAATH NAKA (THANE)	22786	50%	50%
22	TEEN HAATH NAKA (THANE)	RTO THANE	22012	50%	50%
23	RTO THANE	MAHAPALIKA MARG	19443	50%	50%
24	MAHAPALIKA MARG	CADBURY JUNCTION	19161	50%	50%
25	CADBURY JUNCTION	MAJIWADA	18854	50%	50%
26	MAJIWADA	KAPURBAWDI	18144	50%	50%
27	KAPURBAWDI	MANPADA	17062	50%	50%
28	MANPADA	TIKUJI-NI-WADI	16023	50%	50%
29	TIKUJI-NI-WADI	DONGARI PADA	16714	50%	50%
30	DONGARI PADA	VIJAY GARDEN	15390	50%	50%
31	VIJAY GARDEN	KASARVADAVALI	13823	50%	50%
32	KASARVADAVALI	GAWNIWADA	12179	50%	50%
33	GAWNIWADA	GAIMUKH	11864	50%	50%

Attachment IV

TABLE 3

Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor
Vehicle Kilometer

Year	2021	2031
Section Length	34.09	34.09
No of cars per train	8	8
No of working Days in a year	340	340
Number of Trains per day each Way	139	164
Daily Train -KM	9478	11182
Annual Train - KM (10^5)	32.23	38.02
Annual Vehicle - KM (10^5)	257.80	304.15

Attachment-V

RAKE REQUIREMENT-Mumbai Metro, Line-4: (Wadala to Gaimukh) Corridor

Year-2021

S. No.	Section: From	Section: To	Length (km)	Gauge	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: Bare	Bare (round-up)	Traffic Reserve	R&M	Total No. Of Rakes (8-car configuration)	Total no. of cars	Cars required as per previous DPR**	Additional cars required for extension of Line-4
1	Wadala	Gaimukh	34.09	SG	35	2021	5.00	58.44	3	0	6	122.88	24.58	25	1	3	29	232	216	16
																TOTAL	29	232	216	16

Year-2031

S. No.	Section: From	Section: To	Length (km)	Gauge	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: Bare	Bare (round-up)	Traffic Reserve	R&M	Total No. Of Rakes (8-car configuration)	Total no. of cars	Cars required as per previous DPR**	Additional cars required for extension of Line-4
1	Wadala	Gaimukh	34.09	SG	35	2031	4.25	58.44	3	0	6	122.88	28.91	29	1	3	33	264	264	0
																TOTAL	33	264	264	0

* Passenger capacity @ 6p/sqm for a train of 8 car configuration 2352

** Previuos provision of car requiremnet has been taken from DPR of Line-4: Wadala to Kasarvadavali corridor of Mumbai Metro dtd. May 2016

NOTE: Repair & Maintenance Reserve as a percentage of total requirement (Bare + Traffic Reserve) 10%

Attachment – VI

SALIENT FEATURES OF STANDARD GAUGE WITH 3.2 M WIDE ROLLING STOCK

S. No.	Parameter	Standard Gauge 3.2m wide stock
1	**Gauge (Nominal)**	1435mm Standard Gauge
2	**Traction system**	
2.1	Voltage	25KV AC
2.2	Method of current collection	Overhead Current Collection System
3	**Train composition**	
3.1	For 8 car train	DMC+TC+MC+MC+MC+ MC+TC+DMC
4	**Coach Body**	Stainless Steel/Aluminium
5	**Coach Dimensions**	
5.1	Height	3.9m
5.2	Width	3.2m
5.3	Length over body (approx.)	
	- Driving Motor Car (DMC)	21.84m
	- Trailer Car (TC)	21.74m
	- Motor Car (MC)	21.74m
	Maximum length of coach over couplers/buffers:	*22 to 23 m (depending upon Kinematic Envelop and SOD)*
5.4	Locked down Panto height	4048mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity- @ 6 standees/sqm**	
7.1	Coach carrying capacity	
	DMC	282 (seating - 42; standing - 240)
	TC	298 (seating - 50; standing - 248)
	MC	298 (seating - 50; standing - 248)
7.2	Train Carrying capacity (8-car train)	2352 (seating - 384; standing - 1968)
8	**Weight (Tonnes)**	

S. No.	Parameter	Standard Gauge 3.2m wide stock
8.1	Tare weight (maximum)	* The maximum tare weight for 8-car unit shall be 338 T, with weight of any car not exceeding 43 T.
	DMC	42
	TC	43
	MC	42
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DMC	18.33 (@ 6 persons per sqm of standee area)
	TC	19.37 (@ 6 persons per sqm of standee area)
	MC	19.37 (@ 6 persons per sqm of standee area)
8.3	Gross weight in tons (@ 6 persons per sqm of standee area)	
	DMC	60.3
	TC	62.4
	MC	61.4
9	**Axle load(T)(@ 8 persons per sqm of standee area)**	**17**
		System should be designed for 17T axle load
10	**Maximum Train Length (approx.) (8-car configuration)**	184m
11	**Speed**	
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Traction Motors Ventilation**	Self
14	**Acceleration on level tangent track**	1.0 m/sec^2 @ AW3 1.2 m/sec^2 @ AW2
15	**Deacceleration on level tangent track**	1.1 m/sec^2 @ AW3 1.1 m/sec^2 @ AW2 (>1.35 m/sec^2 during emergency)
16	**Type of Bogie**	Fabricated
17	**Secondary Suspension springs**	Air

S. No.	Parameter	Standard Gauge 3.2m wide stock
18	**Brakes**	- An electro-pneumatic (EP) service friction brake - An electric regenerative service brake - Provision of smooth and continuous blending of EP and regenerative braking - A fail safe, pneumatic friction emergency brake - A spring applied air-release parking brake - Tread brakes
19	**Coupler**	
	Driving Cab end of cars (DMC)	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
	Between two units of a train	Automatic coupler with mechanical, pneumatic and electrical coupling head
20	**Detrainment Door**	Front
21	**Type of Doors**	Sliding
22	**Lighting**	LED based with dimmer control
23	**Cooling**	
23.1	Transformer	Forced
23.2	CI & SIV	Self/Forced
23.3	TM	Self-ventilated
24	**Control System**	Train Control and Monitoring System (TCMS)
25	**Traction Motors**	3 phase VVVF controlled
26	**Temperature Rise Limits**	
26.1	Traction Motor	Temperature Index **minus** 70° C
26.2	CI & SIV	10° C temperature margin for Junction temperature
26.3	Transformer	IEC specified limit **minus** 20° C
27	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load.
28	**PA/PIS**	Required
29	**Passenger Surveillance (CCTV)**	Required
30	**Battery**	Ni-Cd
31	**Headlight type**	LED
32	**Train Operation**	UTO(GoA4) with CBTC signaling

Chapter – 07

MAINTENANCE DEPOT

7.1 **CORRIDOR:** Line-4 (Wadala – Gaimukh) corridor of Mumbai Metro Rail Network, comprises as below:

Corridor	Route length(Km)
Wadala to Gaimukh	34.09

7.2 DEPOT- CUM- WORKSHOP

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 8- Car each and space earmarked for future provision.
(iii) All Stabling lines are designed to accommodate one train of 8- 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 (preferably as close to depot as possible) to cater to the required stability facilities.
(v) In case of space constraint for depot two storeyed Stabling lines can also be planned.

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 all key Rolling Stock equipment by suitable advanced condition monitoring techniques available. 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.
- Increase in the periodic maintenance intervals with predictive maintenance based on condition monitoring.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Periodic review of maintenance practices to update replacement cycle of critical components based on experience.
- 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. 383 kms running per train per day, taking in consideration the passenger load of 2021, 2031 respectively.

TABLE- 7.1

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, wheelsets/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:

TABLE- 7.2

S. No.	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 & intensive cleaning 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:

Traffic data are available up to year 2031 only; hence space to be earmarked for future expansion beyond 2031 year for stabling, inspection and workshop line.

(i) Planned rakes as per TOP:

TABLE- 7.3

Year	No. of Rakes of 8-car each	Total No. of coaches
2021	29	232
2031	33	264

(ii) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum -Workshop.

TABLE- 7.4: Stabling and Inspection Lines

Year	No. of Rakes	SBLs	IBLs
2021	29	27 lines x one train of 8-car	Two bays of 2 lines each with one train of 8-Cars, required from year 2021 and additional one bay of 2 lines each with one train of 8-Cars required from year 2031.
2031	33	29 lines x one train of 8-car	

TABLE- 7.5 Workshop Lines

Year	No. of Rakes	WSLs
2021	29	Two bays of 2 lines each with one train of 8- Cars is to be required for the year 2021 and catering up to year 2031.
2031	33	

7.6 REQUIREMENT OF MAINTENANCE/INSPECTION LINES FOR DEPOT-CUM-WORKSHOP:

TABLE- 7.6

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2021 - Maximum no. of rake holding is (29 TS x 8 = 232 Cars)		
'A' Checks (5000 km) approx. 15 days	(29X8) Cars = 232 Cars	2 Line x one train of 8- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(29X8) Cars = 232 Cars	1 Line x one train of 8- Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 8- Cars (with sunken Floor)
Requirement		2 bays of 2 lines.
ii) Year 2031 -Maximum no. of rake holding is (33 TS x 8 = 264 Cars)		
'A' Checks (5000 km) approx. 15 days	(33 X 8) Cars = 264 Cars	3 Line x one train of 8- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(33 X 8) Cars = 264 Cars	2 Line x one train of 8- Cars (with sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 8- Cars (with sunken Floor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
Requirement		Additional one bay of 2 lines each with one train of 8-Cars required from year 2031 to cater future requirements.

7.7 INSPECTION REQUIREMENTS AT DEPOT

Facilities for carrying out inspection activities 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 and other pneumatic systems.
- 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 8- Car train would be Approx. 184 meters. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximate dimensions have been taken in consideration, however final dimensions shall be decided based on actual site conditions/ area available at the time of design finalization of depot:

(i) Length of one 8- Car rake= 184 m
(ii) Pathway in the entry side=10m
(iii) Free length at outer ends of two trains of 8- Car rakes (for cross pathway, Signal and Friction buffers) = 10m
(iv) Total length of Stabling lines = (ii) + (i) + (iii) = 10+184+10= 204 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 8- Car rake = 184 m
(ii) Embedded track in the entry side =10 m
(iii) Pit length of IBL = 188 m
(iv) Embedded track length at outer ends of IBL = 12 m
(v) Total length of Inspection lines = (ii) + (iii) + (iv) = 10+188+12= 210 m (approx.)

The width of the Inspection bay in computed as below:

(i) Centre – to- Centre spacing between the lines= 6.5 m
(ii) Centre line of outer lines to column of Shed= 4.5 m
(iii) Width of a 2 line Inspection Bay= (ii)+(i)+(ii) = 4.5+6.5+4.5 = 15.5 m approx. 16 m.

a) There shall be one inspection bay of 210 m X 16 m size each with provision of accommodating two inspection lines each having sunken floor and overhead roof inspection platforms in two lines adjacent to I-Girder. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 6.5 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 1:10 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. Both lines of inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment on retractable OHE.

c) 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 the 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- 7.7

Year	IOH & POH	Major Overhauling	Unscheduled repairs /lifting	Total	Remarks
2021	1	2 line 8- Car train and free space of 8-car length for storage of other equipment.	1 line x 2 train of 3 Car train length.	Two bays of 2 lines each with one train of 8-Cars is to be required for the year 2021 and catering up to year 2031.	The size of workshop shall be 210 m X 21 m for one working bay comprising of two lines capable of accommodating one 8-Car rake with Bogie turn
2031					table facility, one line of 8- Car rake length with free space of 8- Car rake length for storage of wheel/ bogie/ equipment etc.

(i) Each bay shall be comprising of two lines (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 210m x 21m. The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 8- 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.

(ii) 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.

(iii) 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.

(iv) 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.

(v) 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.

(vi) 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.

(vii) Workshop will have service building with array of rooms along its length. Total size is proposed to be 210 m 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.

(viii) 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 50 m long. The unloading bay should be of 50 m X 30 m and the bearing capacity of the floor should be 15-20 MT/m^2. 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 and minimum turning radius for the trailer movement should be 20-23 m. in case of space limitation a point lifting jack system can be installed.

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 main line train operation 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 Table 8.8.

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 mtrs. 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 8- 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, Inspection and intensive cleaning sheds. Thus, the pneumatic pipeline shall run within the workshop, inspection and intensive cleaning 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 cum rail vehicle equipped with re-railing and rescue item: 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 road cum rail vehicle equipped with re-railing and rescue item 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.

XIV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL) of 50 m X 16 m 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 rigid/ retractable OHE in such a way that, the cranes become operational only when the rigid/ retractable 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, workshop and inspection shed 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 and List of Plants & Equipments at Depot-cum-workshop:

7.12.1 List of Buildings at Depot-cum-workshop

TABLE- 7.8

S. No.	Name of Building	Size	Remarks
1.	Inspection Shed	210m x 16m for each bay.	Servicing of Cars for 15 days & 45 days inspection.
	Workshop Shed	210 x 21m for each bay.	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs. Space for future provision to be kept beyond year 2031
	Associated Sections	210m x 8m	Rooms for carrying out the inspection &
	Stabling line shed	204m x 144m (for initial provision of 27 SBL lines)	Provisional for total area as per requirement of stabling of 33 rakes during year 2031 is to be made (with initial provision for 29 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.
	Auto coach washing platform	20m X 10m	
7.	Washing apron for Interior Cleaning	184m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	Blowdown plant	30m X 5m (additional to intensive cleaning)	Heavy cleaning of under frame and roof through compressed air at 30 days interval.
9.	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.
10.	ETU Building	30m X 15m	For parking of CMV and OHE machinery.
11.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
12.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
13.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
14.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.

S. No.	Name of Building	Size	Remarks
15.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
16.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
17.	a) Traction 25kV/33kV /66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
18.	Waste Collection Bin	10m x 10m	Garbage dumping
19.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
20.	Work shop Manager Office	30m x 20m	Office of Depot in charge
21.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
22.	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.
23.	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.
24.	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*:

Table – 7.9

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-Depot IBL-4 Lines WSL-4 Lines	
			Qty. (set)	Approx. Cost Provision (INR Lakh)
1	Under floor Pit Wheel lather	621.00	1	**621.00**
2	Syn. Pit Jacks-for 8 cars unit	1700.00	1	**1700.00**
3	Automatic Train Washing Plant	268.00	1	**268.00**
4	Battery Shunting Loco	349.89	1	**349.89**
5	Electric Tractors (RRM)	199.00	1	**199.00**
6	Electric Tractors (RRM) for UFWL	184.00	1	**184.00**
7	Syn. Mobile Jacks for 4 cars unit	136.40	1	**136.40**
8	Bogie Turn Table	27.86	4	**111.44**

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-Depot IBL-4 Lines WSL-4 Lines	
			Qty. (set)	Approx. Cost Provision (INR Lakh)
9	Re-railing & Rescue equipment (set)	81.99	1	**81.99**
10	Rail cum Road Vehicle (RRV)	42.26	1	**42.26**
11	Blow Down Plant	196.00	**1**	**196.00**
12	Mobile jib Cranes (1T Manual)	1.53	**1**	**1.53**
13	Under track Mobile Lifting Table (1T for IBL)	2.75	**3**	**8.25**
14	CI/SIV Mobile Lifting Table (3T for WS)	3.62	**1**	**3.62**
15	Arial Work Lift Platform	19.61	**1**	**19.61**
16	High Pressure Wash Pumps	5.37	**2**	**10.74**
17	AC Filter cleaning machine	23.50	**1**	**23.50**
18	Mobile compressor-10bar	4.20	**1**	**4.20**
19	HP compressor-17bar	3.36	**1**	**3.36**
20	EMU Battery Charger	5.56	**2**	**11.12**
21	Box Container for re-railing equipment	5.12	**1**	**5.12**
22	wooden blocks	0.77	**1**	**0.77**
23	Auxiliary truck	1.82	**1**	**1.82**
24	Road Truck	10.56	**1**	**10.56**
25	Battery operated Platform Truck for WS and DCOS	6.33	**2**	**12.66**
26	Welding & Cutting Equipments	2.24	**1**	**2.24**
27	Work Benches	0.54	**10**	**5.40**
28	Vertical Carousal storage system	35.00	**1**	**35.00**

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-Depot IBL-4 Lines WSL-4 Lines	
			Qty. (set)	Approx. Cost Provision (INR Lakh)
29	Weighing scales	2.65	**1**	**2.65**
30	Storage Bins	7.59	**1**	**7.59**
31	Pallet Trucks	0.39	**5**	**1.95**
32	Fork Lift Truck-3T(Elect)	10.35	**1**	**10.35**
33	Stackers (1T for DCOS)	9.50	**1**	**9.50**
34	Mobile Safety Steps & Ladders	5.12	**LS**	**5.12**
35	Set of Pallets	15.00	**LS**	**15.00**
36	Storage racks for DCOS stores	62.50	**LS**	**62.50**
37	Storage racks for workshop, tool room	31.50	**LS**	**31.50**
38	Electric and Pneumatic Tools	33.50	**LS**	**33.50**
39	Measuring & calibration Instruments	62.51	**LS**	**62.51**
40	Special Jigs and Fixtures	60.29	**LS**	**60.29**
41	Industrial Furniture	90.00	**LS**	**90.00**
42	Miscellaneous/other machinery	93.71	**LS**	**93.71**
43	Display boards inside depot	7.50	**1**	**7.50**
44	Industrial vacuum Cleaners (heavy duty + dry/wet)	4.83	**1**	**4.83**
45	Small Part Cleaner	1.00	**1**	**1.00**
46	Polyester Web Sling+B51+B51:B70:BB51:B70	1.00	**LS**	**1.00**
47	25KV OHE Live Indicators	2.60	**3**	**7.80**
48	Wheel Gauges/Templates	3.80	**LS**	**3.80**

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-Depot IBL-4 Lines WSL-4 Lines	
			Qty. (set)	Approx. Cost Provision (INR Lakh)
49	Ultrasonic Flaw Detector	2.18	**1**	**2.18**
50	Memory Recorder/Chart recorder etc.	10.00	**1**	**10.00**
51	Induction heater	8.40	**1**	**8.40**
52	Hyd. Axle Bearing puller	9.60	**1**	**9.60**
53	Training equipment/ diagnostic software/Camera, Projector, computer equipment/laptop etc.	16.79	**LS**	**16.79**
54	Industrial Videoscope	10.13	**2**	**20.26**
55	Lifting jacks for Aircon (two post lift)	4.37	**1**	**4.37**
56	Auto wheel profile meters and attachments for dia. and back to back measurement.	19.18	**1**	**19.18**
57	Coupler backlog Gauge	8.15	**1**	**8.15**
58	25 Ton Hydraulic C Frame Press	7.44	**1**	**7.44**
59	Hydraulic work bench for Gear Box	16.00	**1**	**16.00**
60	Hydraulic work bench for couplers	7.60	**1**	**7.60**
61	Special tools for coupler	17.50	**LS**	**17.50**
62	Other tools/equipment as per RS contractor	50.00	**LS**	**50.00**
63	Bogie Test Stand	388.00	**1**	**388.00**
64	Wheel Press (300T)	467.50	**1**	**467.50**
65	Vertical turret lathe	131.00	**1**	**131.00**
66	Damper testing machine	52.98	**1**	**52.98**
67	Spring testing machine	201.10	**1**	**201.10**

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-Depot IBL-4 Lines WSL-4 Lines	
			Qty. (set)	Approx. Cost Provision (INR Lakh)
68	Rail fed Bogie wash plant	188.10	**0**	**0.00**
69	Heating oven for TM	5.88	**1**	**5.88**
70	High Voltage test set	2.00	**1**	**2.00**
71	SS cage for HV Test Set	3.20	**1**	**3.20**
72	Impulse Tester for TMs	11.05	**1**	**11.05**
	OVER ALL TOTAL			**6,021.76**

7.13 COST ESTIMATE

The total estimated cost at Jan'17 price level may be assumed as Rs. 60.21 Crores. This would be required for Rolling Stock M&P equipment for one depot at Gaimukh for line-4.

7.14 UN-ATTENDED TRAIN OPERATION (UTO)

(i) Proper segregation for UTO and non-UTO zone shall be earmarked while finalizing of depot layout.

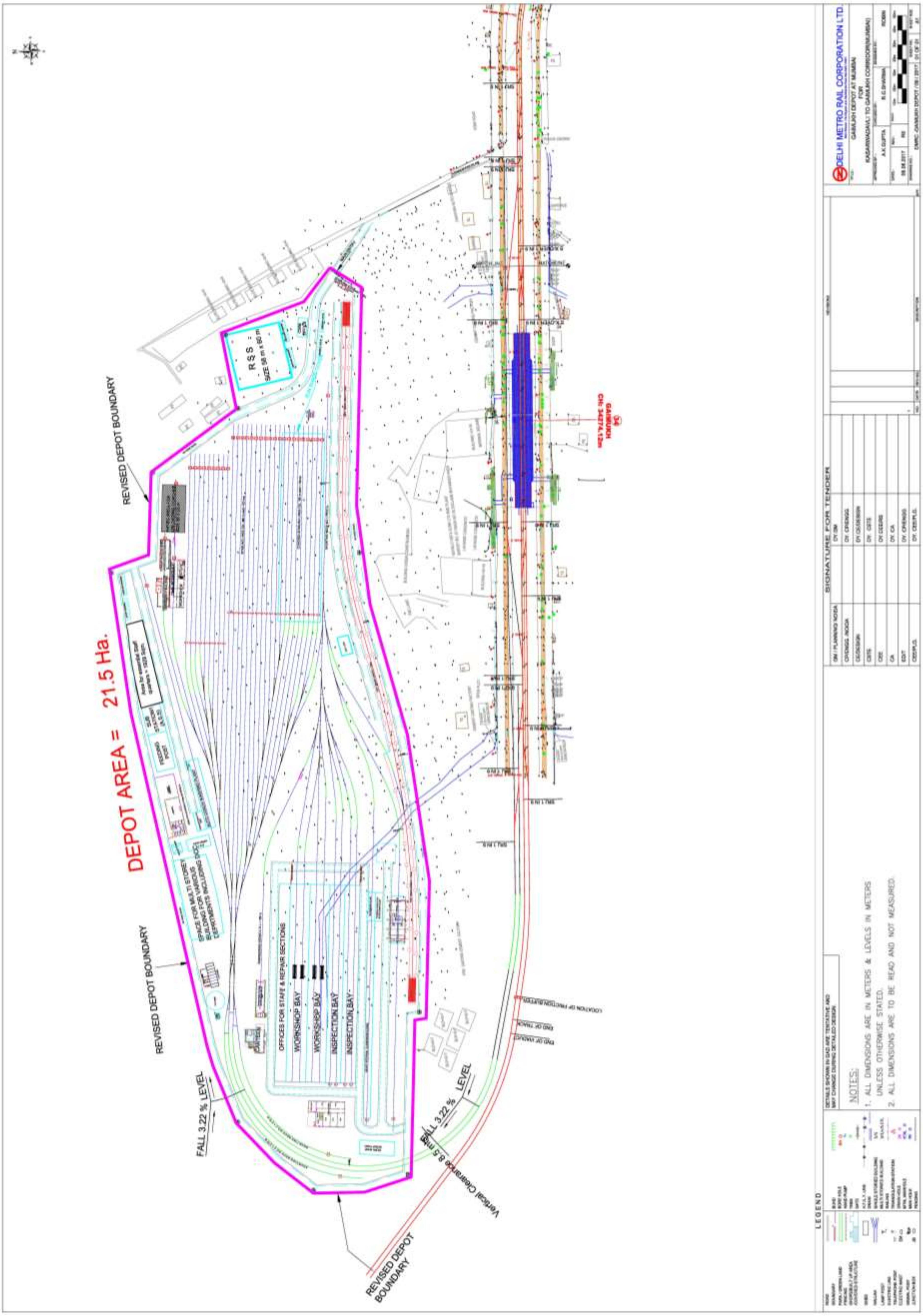
(ii) Train Operator (TO) platform of 10m X 12m (L X B) shall be provided in each overlap zone of UTO and non-UTO.

(iii) Bulb fencing of depot tracks shall be done up to 1.5 m height from T.O.R. (Top of the Rail) level.

(iv) Gates should be provided in some interval with locking facility.

(v) All crossing roads which crosses the track should have gates with locking facilities.

(vi) All stabling lines should have SPK (Staff Protection Key) to avoid unauthorized entry.


DEPOT AREA = 21.5 Ha.
REVISED DEPOT BOUNDARY
REVISED DEPOT BOUNDARY
REVISED DEPOT BOUNDARY
RSS
GAIMUKH
FALL 3.22 % LEVEL
FALL 3.22 % LEVEL
Vertical Clearance 8.5 m
OFFICES FOR STAFF & REPAIR SECTIONS
WORKSHOP BAY
WORKSHOP BAY
INSPECTION BAY
INSPECTION BAY
SPACE FOR MULTI STOREY BUILDING FOR VARIOUS DEPARTMENTS INCLUDING OCC
NOTES:
1. ALL DIMENSIONS ARE IN METERS & LEVELS IN METERS UNLESS OTHERWISE STATED.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
SIGNATURE FOR TENDER
LEGEND
DELHI METRO RAIL CORPORATION LTD.

Chapter – 08

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, signaling & telecom, fire fighting & air-conditioning 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 at Pantograph/ Current Collector – 50 kWh/1000 GTKM for 25 kV ac system and 60 kWh/GTKM for 750 V dc system as per MOUD guideline.
(ii) Elevated/at –grade station load – initially 250 kW, which will increase to 300 kW in the year 2031.
(iii) Depot auxiliary load - initially 2000 kW, which will increase to 2200 kW in the year 2031.

Keeping in view of the train operation plan and demand of traction and auxiliary power, power requirements projected for the year 2021 and 2031 are summarized in table 8.1 below:

Table 8.1 Power Demand Estimation (MVA)

Corridor	Load	Year	
		2021	**2031**
Extension of Line-4 from Kasarvadavali to Gaimukh (2 Elevated Station, 2.668 km)	Traction	2.21 MVA	2.59 MVA
	Auxiliary	0.62 MVA	0.74 MVA
	Total	**2.82 MVA**	**3.34 MVA**

The detailed calculations of power demand estimation are attached at Annexure 8.1.

8.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed extension of Line – 4 Mumbai metro is being designed to handle about 30,708 passengers per direction during peak hours when trains are expected to run at **4.25** 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 there must be two sources of supply and both the sources of Supply & their 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 100 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 100 kV network to cater to various types of demand in vicinity of this extension of Line-4. Keeping in view the shifting of Depot from Kasarvadavali Depot to Gaimukh, Receiving Sub-stations proposed to be set up at Kasarvadavali Depot earlier is proposed to be shifted to Gaimukh Depot. Power supply for this section from Kasarvadavali to Gaimukh Station will be taken care by Gaimukh Depot RSS. In the event of failure of RSS located at Gaimukh depot, the power supply will be extended from the RSS of Line-4 (Wadala to Kasarvadavali) and vice versa. 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 M/s MSETCL at 220, 110 & 100 kV voltage through cable feeders:

Table 8.2 Sources of Power Supply

S. No.	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length b/w GSS & RSS
1	Extension of Line-4(Wadala to Kasarvadavali) from Kasarvadavali to Gaimukh	220/100kV GSS of M/s MSETCL at Kolshet	RSS at Gaimukh depot.	4 km

DMRC has done a joint survey/ meeting with M/s MMRDA, M/s Reliance Infrastructure Ltd, M/s TATA Power Company Ltd and M/s MSETCL on 07.08.2016 to 09.02.2016 for this corridor for feasibility of Power Supply (Annexure – 8.2).

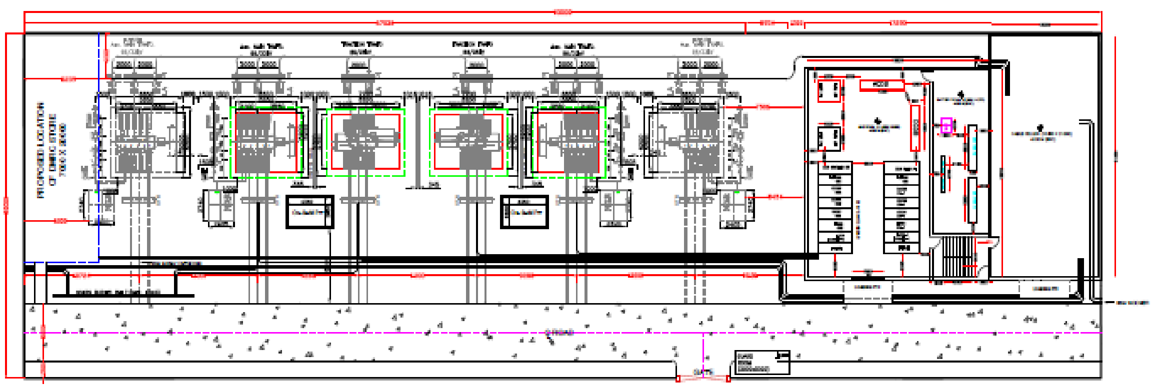
The 100 kV power supply will be stepped down to 3 Φ 33 kV and 1 Φ 25 kV level at the RSS located at Gaimukh depot of metro authority. The 1 Φ 25 kV will be fed to the OHE to cater to traction load and the 33 kV power will be distributed along the alignment through 33 kV Ring main cable network for feeding auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of this RSS of the line on fault or input supply failure, train services can be maintained from RSS of Line-4 (Wadala to Kasarvadavali). 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

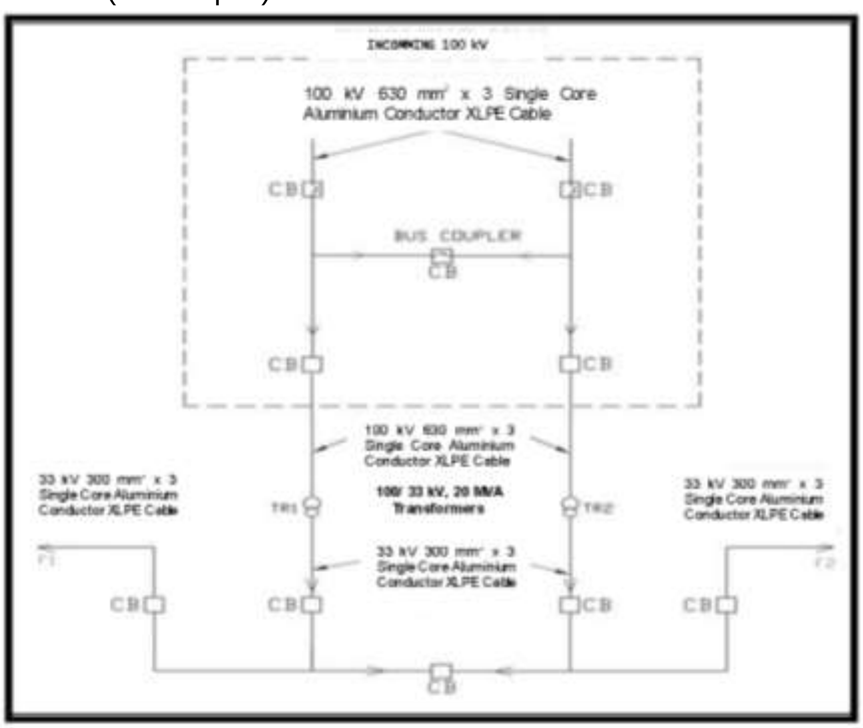
Typical High Voltage Gas Insulated Sub-Station (GIS)

The 110 kV cables will be laid through public pathways from the Sub-stations of Supply Authority to RSS of Metro Authority. RSS at Gaimukh depot shall be provided with 2 Nos. (One as standby) 100/25 kV 21.6/30 MVA (ONAN/ ONAF) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 100/33 kV 20 MVA (ONAN) three phase Transformers for feeding auxiliary loads. The same capacity Traction Transformer and Auxiliary Transformers are proposed for Line – 4 from Wadala to Kasarvadavali corridor. The capacity of transformers may be reviewed considering the load requirement/distribution of extension of Line-4 at the time of detailed design.



Typical Layout of GIS RSS

Gas Insulated Switchgear (GIS) type Switchgear will be planned due to less space in Mumbai and reduced maintenance. 100 kV GIS substation land requirement will be approx. 60 X 40 m (2400 sq. m).



TYPICAL 100/33kV RSS LAYOUT

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 15% less as compared to 750V DC 3rd rail traction system for the estimated level of traffic.

- **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** – In future, 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. In DC traction system it is mostly imported.

- Though in underground section higher side tunnel diameter is required.

b) **750-850 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-** The regeneration is 18%, because 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.

- **Higher Consumption of Specific Energy:** As per MOUD guideline specific energy consumption in 750 V dc system is 60 kWh/GTKM and in 25 KV ac system is 50 kWh/GTKM. The specific energy consumption in 750 V dc system is higher as compared to 25 kV ac system. Hence operating cost will increase in 750 V dc system (copy enclosed).

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 consideration 25 kV ac Traction System is recommended for extension of Line-4. This is 95% available indigenously.

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

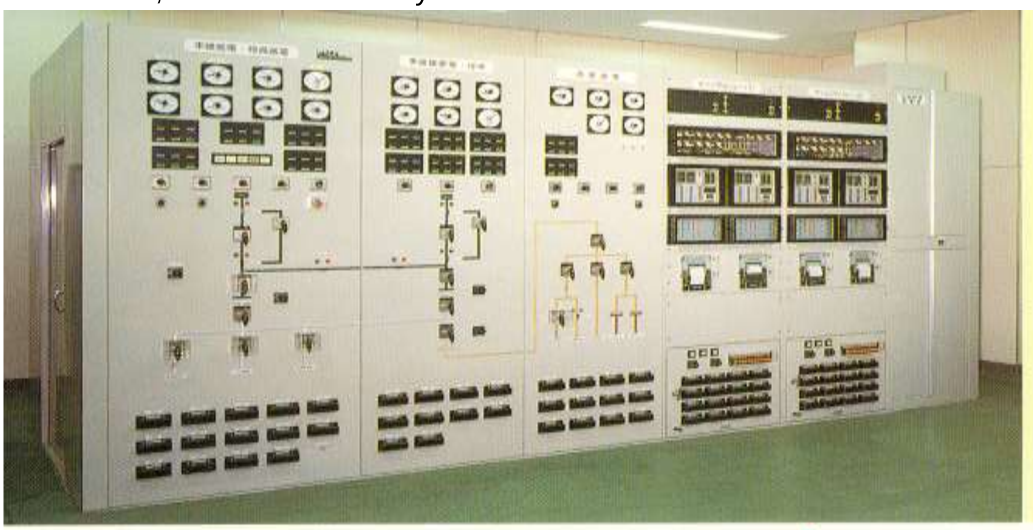
Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 300 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415 kV) of 315 kVA capacity are proposed to be installed at the elevated/ at grade 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, 33kV/415V 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/ 150 sq.mm 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, RSS of Gaimukh depot shall be provided with 2 Nos. (One as standby) 220/25 kV 21.6/30 MVA (ONAN/ ONAF) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 100/33 kV 20 MVA (ONAN) three phase Transformers for feeding auxiliary loads. The same capacity Traction Transformer and Auxiliary Transformers are proposed for Line – 4 from Wadala to Kasarvadavali corridor. 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 100 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 300 mm^2 FRLSH Aluminium 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 160 kVA capacity at the elevated station to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system
(vi) Air-conditioning system etc.

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 DMRC Stations and Depots 17.1 MWp 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 50 kWp to 150 kWp 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 20 kWp to 50 kWp capacity Solar PV systems are generally provided. In DMRC Depot area, approx.1000 kWp to 1500 kWp of solar capacity has been provided. Solar PV system in station parking area can also be planned as per availability of area.

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-potable 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 re-generative braking 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 30-38% 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 9.89 million units in initial years 2021, which will be about 11.70 million Units in the year 2031, for the extension of Line – 4 from Kasarvadavali to Gaimukh. 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 100 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 M/s MSETCL for FY 2017 – 18 demand charges **Rs 250/ kVA** per month and energy charges Rs **9.16/ kWh**. 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	
Extension of Line-4 from Kasarvadavali to Gaimukh				
POWER (Traction & Auxiliary)			Kasarvadavali to Gaimukh	
S.No.	**Particulars**	**Unit**	**2021**	**2031**
A	**Traction Power Requirement**	1	4	5
1	No. of cars	(2DMC+2 TC+4MC)	8	8
2	Passenger Weight	T	195.0	195.0
3	Train Tare Weight	T	338.0	338.0
4	Total Train Weight	T	533.0	533.0
5	Section Length	km	3.12	3.12
6	Headway	mts	5.00	4.25
7	SEC at Pantograph/ current Collector (As per MOUD guideline)	KWhr/ 1000 GTKM	50	50
8	No. of Trains/hr in both directions	Nos.	24	28
9	Peak Traction Power Requirement	MW	2.00	2.35
11	Depot Power Requirements	MW	1.00	1.30
12	No. of Depot	No	0	0
13	Total Traction Power Requirement	MW	2.00	2.35
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**2.21**	**2.59**
B	**Aux. Power Requirement**			
1	Elevated/at-grade Station Power Consumption	MW	0.25	0.30
2	Underground station Power Consumption	MW	2.20	2.50
3	Mid Shaft	MW	0.30	0.30
4	No. of Elevated/at-grade Stations	Nos.	2	2
5	No. of Underground stations	Nos.	0	0
6	No. of Mid Shaft	Nos.	0	0
7	Total Station Aux Power Requirement	MW	0.5	0.6
8	Depot Aux Power Requirement	MW	2.0	2.2
9	No. of Depot	No.	0	0
10	Total Aux Power Requirement	MW	0.50	0.60
	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for aux loads	**MVA**	**0.62**	**0.74**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**2.82**	**3.34**

Note:
1. The Depot Power requirement has already been considered in DPR for Line - 4 (Bhakti Park to Kasarvadavali). Hence Depot power not considered in above calculation.
2. The requirement of PD load is not considered in Power calculation.

MUMBAI METRO			Annexure 8.2	
Extension of Line-4 from Kasarvadavali to Gaimukh				
ENERGY CONSUMPTION			Kasarvadavali to Gaimukh	
S.No.	**Particulars**	**Unit**	**2021**	**2031**
A	**Traction Energy**	1	1	2
1	Section Length	KM	3.12	3.12
2	No. of Trains per direction in a day	Nos.	139	164
3	Weight of Train & Passenger	T	533.0	533.0
4	SEC at Pantograph/ current Collector (As per MOUD guideline)	KWH/ 1000 GTKM	50	50
	Yearly Traction Energy consumption with 365 days working	**million units**	**8.44**	**9.95**
B	**Auxiliary Energy**			
1	Elevated/at-grade Station	MW	0.25	0.30
2	Underground Station	MW	2.20	2.50
3	Mid Shaft	MW	0.30	0.30
4	No. of Elevated/at-grade Stations	Nos.	2	2
5	No. of Underground Stations	Nos.	0	0
6	No. of Mid Shaft	Nos.	0	0
7	Total Station Aux. Power Requirement	MW	0.50	0.60
8	Depot Aux power requirement	MW	2.00	2.20
9	No. of Depot	No	0	0
10	Total Aux. Power Requirement	MW	0.50	0.60
11	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	**MVA**	**0.62**	**0.74**
12	Diversity Factor of Aux. loads		0.40	0.40
	Yearly Aux. Energy Consumption 19 hrs/day and 365 days working (million units)	**million units**	**1.46**	**1.75**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**9.89**	**11.70**

Note:
1. The Depot Power requirement has already been considered in DPR for Line - 4 (Bhakti Park to Kasarvadavali). Hence Depot power not considered in above calculation.
2. The requirement of PD load is not considered in energy calculation.

MUMBAI METRO								Annexure 8.3
Extension of Line-4 from Kasarvadavali to Gaimukh								(25 kV AC TRACTION SYSTEM)
S.No.	Description	Unit	Rate at per awarded	LOA date	Rate with Escalation @ 5% per annum- March 2017	Qty	Amount (Rs in Crores)	Remarks
1.0	**Station Buliding**							
1.1	Elevated Stations							
a	E&M work	Each	2.85	22.04.13	3.47	2	6.93	Cost taken from Phase-III Contract CE-1 Lot-2.
b	DG sets	Each	0.17	15.02.13	0.21	2	0.42	Cost taken from Phase-III Contract CE-2 Lot-1.
c	Lifts	Each	1.42	27.12.12	1.72	2	3.45	Cost taken from Phase-III Contract CE-3 Lot-1. Considered 4 Elevators per station.
d	Escalator	Each	2.61	16.04.13	3.18	2	6.35	Cost taken from Phase-III Contract CE-4 Lot-2. Considered 4 Escalators per station.
	Sub-total (a ot d)	**Each**			**8.58**		**17.16**	
2.0	**Depot**							
2.1	Depot							
a	EM Works	Each	21.41	05.06.13	24.19	0	0.00	Cost taken from Phase-III Contract CE-5 Lot-2 (Kalindikunj Depot). Cost of Depot already considered in Bhakti Park to Kasarvadavali Corridor, Line - 4. Hence Depot cost not considered in this Extension Corridor.
	Sub-Total						**0.00**	
3.0	**Traction & Power Supply including OHE, ASS etc.**							
3.1	Elevated & Underground Section							
a1	25 kV AC Traction (OHE) with ASS & Cabling.	R.km	5.73	29.10.15	6.17	3.1	19.24	Cost taken from Contract NE - 01 Cost is lower as compare to cost of CE-7 Lot-1
a2	25 kV AC Traction (OHE) for depot	LS	20.90	03.07.13	24.80	0.00	0.00	Cost is taken from Phase-III Contract CE-7 Lot-2 (Kalindikunj Depot).Cost of Depot already considered in Bhakti Park to Kasarvadavali Corridor, Line - 4.Hence Depot cost not considered in this Extension Corridor.
a3	RSS (GIS)	Eash	49.79	20.10.15	53.59	0.00	0.00	Cost taken from Noida Greater Noida Contract (NE - 02). Cost of Depot already considered in Bhakti Park to Kasarvadavali Corridor, Line - 4. Hence Depot cost not considered in this Extension Corridor.
	Total cost of 25 kV Traction (a1+a2+a3)						**19.24**	
4.0	**Misc. Utilities**							
a	EM Works Utility diversion	R.km	4.00		4.0	3.12	12.48	Due to higher no. of utility work
Grand Total (1.0+2.0+3.0+4.0)							**48.88**	

Chapter – 9

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

9.1 LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

The available national and state level legal Acts and Legislation referred during the study are:

- The Water (Prevention and Control of Pollution) Act, 1974 (Amendment 1988).
- The Water (Prevention and Control of Pollution) Cess Act 1977, (Amendment), 2003.
- The Water (Prevention and Control of Pollution) Cess Rules, 1978, 1991.
- The Air (Prevention and Control of Pollution) Act 1981, amended 1987.
- The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1982, 1983
- Noise Pollution (Regulation and Control) Rules, 2000 amendment 2002, 2006.
- Municipal Solid Waste Rules, 2000
- The Environment (Protection) Act, 1986, amended 1991.
- The Environment (Protection) Rules,1986.
- The Indian Forest Act, 1927.
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules, 2003.
- Maharashtra (Urban Area) Protection of Trees Act 1975
- The Wild Life (Protection) Act 1972, Amendment, 2002

9.1.1 Environmental Categorization

The proposed project do not passes through any Wildlife Sanctuary, National Park, or any other environmentally sensitive or protected areas. The proposed extension is between Kasarvadavali and Gaimukh (2.668 km) on the centre of the road. The Rapid Environmental Assessment (REA) checklist has screened the project proposed for ADB funding considering the aspects of project siting, potential environmental impacts including climate change and disaster risk. Although, the proposed project will bring in many benefits to the area, there is potential for environmental impacts on the above ground structures due to vibration construction and operation of the metro. Therefore, the project has been classified as category 'A' and requires Environmental Impact Assessment (EIA) Report.

Requirement of Environmental Clearance

As per provisions of the EIA Notification, 14 September 2006 as amended up to 1 December 2009, any person who desires to undertake any new project in any part of India or the expansion or modernization of any existing industry or project listed in Schedule-I of the said notification shall submit an application to the Ministry of Environment and Forests, Government of India in accordance with the guidelines issued by the Central Government in the Ministry of Environment and Forests from time to time. Metro Rail project is not included in the Schedule-I of the EIA

Notification, 2006. Thus, the project does not require an environmental clearance certificate from the Ministry of Environment and Forests, Government of India.

Requirement of Forest Clearance

As per Indian "Forests Conservation Act (1980), every project requiring diversion of forest land for non-forestry purposes require forest clearance from MoEF. The forestry clearance is granted through two-stage process: Stage 1 refers, in principle agreement, to the project proposal in which usually the conditions relating to transfer, mutation and declaration as RF/ PF under the Indian Forest Act, 1972, of equivalent non-forest land for compensatory afforestation and funds for raising compensatory afforestation thereof are stipulated. Stage II involves formal approval under the Act after receipt of compliance report from the State Government in respect of the stipulated conditions. Since alignment is not passing through any forest land and no diversion of forest land is involved in the proposed project, no forest clearance is required for this project.

Required Clearances/Permissions

For the proposed project, required clearances/ permissions related to environment have been summarized below.

Table 9.1: Permissions/Clearances Required for the Project

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980) Procedural Guidelines developed by the Department of Environment, GoM; Tree removal will be guided as per state government rules.	MCGM / District Collector	MMRDA
	CRZ clearance	The Ministry of Environment and Forests had issued the Coastal Regulation Zone (**CRZ**) Notification on 19.2.1991 under the Environment (Protection) Act, 1986, with the aim to provide comprehensive measures for the	MCZMA	MMRDA
B. Implementation Stage				
3	Consent to operate hot mix plant, crushers, batching plant	Air (Prevention and Control of Pollution) Act 1981	Maharashtra State Pollution Control Board	Contractor
4	Permission for withdrawal of groundwater	Environment (Protection) Act, 1986	Central Ground Water Authority	Contractor
5	Permission for sand mining from river bed	Environment (Protection) Act, 1986	Mining Department/ MoEF	Contractor

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
6	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 1989	Maharashtra State Pollution Control Board	Contractor
7	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 1989	Local civic body to use local solid waste disposal site	Contractor
8	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	Maharashtra State Pollution Control Board	Contractor
9	Pollution Under Control Certificate	Central Motor and Vehicle Act 1988	Department of Transport, Govt. of Maharashtra authorised testing centres	Contractor
10	Roof Top Rain Water Harvesting (RWH)	Central Groundwater Authority (CGWA) Guidelines	Central Ground Water Authority/ MCGM	Contractor
11	Permission for groundwater extraction for drinking purpoes	Environment (Protection) Act, 1986	CGWA	Contractor
12	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	District Labour Commissioner	Contractor

9.1.2 Objective and Scope Of The Study

The objective of the Environment and Social Impact Assessment study is to facilitate the Mumbai Metropolitan Region Development Authority (MMRDA) evaluate the environmental impacts of its proposed activity. MMRDA proposes to apply for loan to seek financial support from ADB. Thus, the objective of the study is to conduct Environmental Impact Assessment as per requirement of ADB. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of Kasarvadavali to Gaimukh Metro corridor at Mumbai. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles.

9.1.3 Approach and Methodology

The MMRDA has considered different alternative corridors. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are minimum private land acquisition, least disturbance to properties, minimum disturbance to ecology/biodiversity. In the analysis of alternatives, a comparison of scenario with and without the project has also been made. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the alignment proposed by MMRDA. The approach is to follow the sequence of steps adopted in an EIA study. The basic concept is to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The identification of parameters for data generation and impact assessment are important. The analysis of assessment depends upon the reliable data generated/ available on environmental attributed. This study has documented the baseline data for various parameters of physical, ecological and environmental pollution (air, water and noise). The impacts are assessed for various phases of project cycle namely:

- Impacts due to project location,
- Impacts due to project design,
- Impacts due to project construction, and
- Impacts due to project operation.

The impacts are categorized as negative and positive. The cost of management and monitoring programs were estimated and budgeted for.

9.2 PROJECT AREA

The metro project in Mumbai is proposed between Kasarvadavali and Gaimukh (2.668 Km) as an extension of Wadala (Bhakti Park) and Kasarvadavali (32.193 Km). This corridor is also named as Line IV. The proposed alignment would serve the city by providing connectivity between Wadala (Bhakti Park) and Kasarvadavali via Ghatkopar, Lalbahadur Shastri Marg, Thane, Manpada etc along with the intermediate eastern suburban areas of Mumbai. The project area also includes the maintenance depot and construction depots in addition to viaduct and station areas. This metro extension is proposed in Mumbai to cater the requirement of the city for a length of about 2.668 km. Entire corridor will be elevated. The Metro corridor will have Standard Gauge alignment.

9.3 ENVIRONMENTAL SCOPING

Baseline environmental status in and around the proposed project depicts the existing environmental conditions of the location. Baseline data was collected for various/environmental attributes so as to compute the impacts that are likely to arise due to proposed project.

The scope of the present study includes detailed characterization of following environmental components, which are most likely to be influenced by the proposed project:

❖ Land Environment
❖ Water Quality (Surface + Ground water)

- ❖ Meteorological conditions
- ❖ Ambient Air Quality
- ❖ Noise Levels
- ❖ Biodiversity
- ❖ Socio Economic studies.

The information presented in this chapter has been acquired from various sources. Data on land environment has been collected and compiled from various reports and field surveys. The data on water, air, noise quality, and biodiversity were collected through field studies, sampling in December 2015. Climatological data was collected from India meteorological Department. Efforts have been made to compile the available data from literature, books, maps and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental Attributes and Frequency of Baseline Survey is presented in **Table 9.2**.

Table 9.2 Environmental Attributes and Frequency of Monitoring

S. No	Attribute	Parameter	No. of Samples	Source
LAND ENVIRONMENT				
1	Geology	Geological Status	---	Literature review
2	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
3	Ground Water	Physical, Chemical and Biological parameters	One	Sampling/ Monitoring locations
AIR, NOISE AND METEOROLOGY				
4	Ambient Air Quality	PM_{10}, SO_2, NO_x	2	Sampling/ Monitoring locations
5	Noise	Noise levels in dB (A) Leq, Lmax, Lmin, L_{10}, L_{50}, L_{90}	2	Sampling/ Monitoring locations
6	Soil Quality	Physico-chemical parameters	1	Sampling/ Monitoring locations
SOCIO-ECONOMIC				
6	Socio-economic aspects	Socio-economic profile	Once	Field Studies, Literature review.
Ecology				
7	Trees	Number	Once	Filed Studies

Table 9.3 Sampling / Monitoring Locations:

S. No	Monitoring Requirement	No of samples/ Locations	Location
1.	AA Q Monitoring – Pm10, Pm2.5, So2, Nox	02	1. Manpada 2 Kasarvadavali
2.	Ground Water Sampling for Analysis – General Chemical & Micro Parameters	1	1. manpada
3.	Noise Level Monitoring – 24 Hourly	02	1. Manpada 2. Kasarvadavali
4.	Soil Sampling for Analysis – General Physical, Chemical, Havy Metal Parameters	01	1. Nr. Kasarvadavali

9.3.1 Land Environment

The Project area is situated in Mumbai. The elevation of the project area is ranging between 3 to 5 m above the mean sea level (a-MSL). Parameters involved in land environment are, physiography, geology and soils, and seismicity. These are discussed in the following paragraphs.

9.3.1.1 Geography, Geology and Soil

The total area of Mumbai is 437.71 km^2. Of this, the island city spans 67.71 km^2 while the suburban area spans 370 km^2 together accounting for 437.71 km^2 under the administration of Municipal Corporation of Greater Mumbai (MCGM).

Mumbai lies at the mouth of the Ulhas River on the western coast of India, in the coastal region known as the Konkan. It sits on Salsette Island (Sashti Island), which it partially shares with the Thane district. Mumbai is bounded by the Arabian Sea to the west. Many parts of the city lie just above sea level, with elevations ranging from 1m to 15; the city has an average elevation of 14 m. Northern Mumbai (Salsette) is hilly, and the highest point in the city is 450 m at Salsette in the Powai–Kanheri ranges. The Sanjay Gandhi National Park (Borivali National Park) is located partly in the Mumbai suburban district, and partly in the Thane district, and it extends over an area of 103.09 km^2.

Apart from the Bhatsa Dam, there are six major lakes that supply water to the city: Bhatsa supply about 50% of city water requirement. Vihar, Lower Vaitarna, Upper Vaitarna, Tulsi, Tansa and Powai. Tulsi Lake and Vihar Lake are located in Borivili National Park, within the city's limits. The supply from Powai lake, also within the city limits, is used only for agricultural and industrial purposes. Three small rivers, the Dahisar River, Poinsar (or Poisar) and Ohiwara (or Oshiwara) originate within the park, while the polluted Mithi River originates from Tulsi Lake and gathers water overflowing from Vihar and Powai Lakes. The coastline of the city is indented with numerous creeks and bays, stretching from the Thane creek on the eastern to Madh Marve on the western front. The eastern coast of Salsette Island is covered with large mangrove swamps, rich in biodiversity, while the western coast is mostly sandy and rocky.

Soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy. The underlying rock of the region is composed of black Deccan basalt flows, and their acidic and basic variants dating back to the late Cretaceousand early Eocene eras.

9.3.1.2 Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. Mumbai sits on a seismically active zone owing to the presence of 23 fault lines in the vicinity. Mumbai falls in zone III according to IS 1893: 2002 which means an earthquake upto magnitude 6.5 on Richer scale may be expected. (**Figure 9.1).**

Project Area

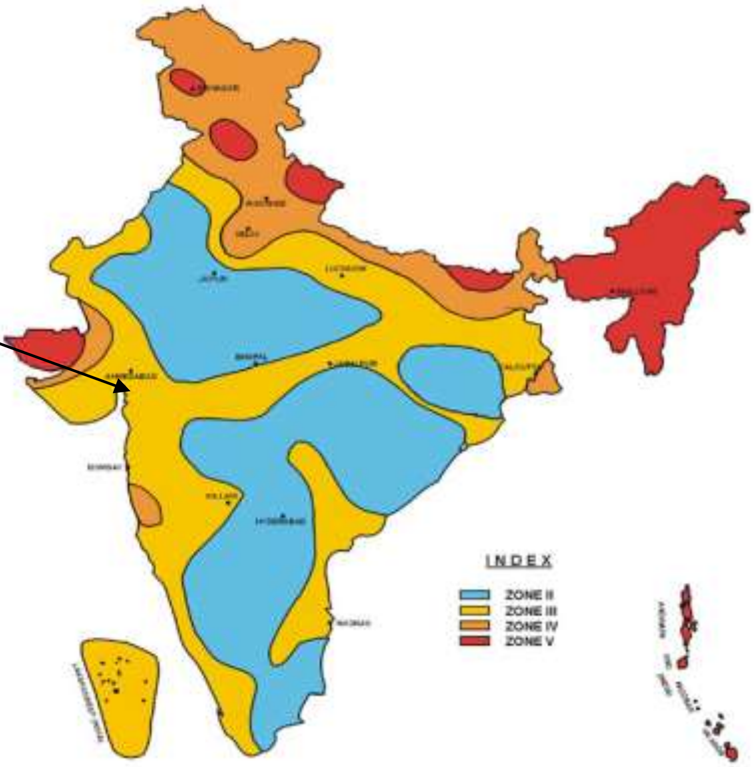


Figure 9.1 Seismic Zoning Map of India

9.4 WATER ENVIRONMENT

Water environment consists of water resources and its quality. Its study is important from the point of view of assessing the sufficiency of water resources for the needs of the project in its various stages of the project cycle and also to assess the impact of the project on water environment. In the proposed project, ground water is proposed to be used during operations to meet out domestic water requirements of the project in case water is not made available by Municipal Corporation of Greater Mumbai(MCGM). Hence its quality has been tested to evaluate its suitability for the intended purpose. Anticipated impacts of the proposed project on water environment have also been addressed.

9.4.1 Water Resources

Under colonial rule, tanks were the only source of water in Mumbai, with many localities having been named after them. The MCGM supplies potable water to the city from six lakes, most of which comes from the Tulsi and Vihar lakes. The Tansa lake supplies water to the western suburbs and parts of the island city along the Western Railway. The water is filtered at Bhandup, which is Asia's largest water filtration plant. India's first underground water tunnel was completed in Mumbai to supply water to the Bhandup filtration plant.

About 700 million litres of water, out of a daily supply of 3500 million litres, is lost by way of water thefts, illegal connections and leakages, per day in Mumbai. Almost all of Mumbai's daily refuse of 7,800 metric tonnes, of which 40 metric tonnes is plastic waste, is transported to dumping grounds in Gorai in the northwest, Mulund in the northeast, and to the Deonar dumping ground in the east. Sewage treatment is carried out at Worli and Bandra, and disposed of by two independent marine outfalls of 3.4 km and 3.7 km at Bandra and Worli respectively.

9.4.2 Hydrogeology and Ground Water

The entire Mumbai district is underlain by basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow Alluvium formation of Recent age also occur as narrow stretch along the major river flowing in the area. Hydrogeological map of Mumbai is given in **Fig.9.2**.

Hard Rock Areas: Deccan Trap Basalt

The 'Pahoehoe' flows in the district consists of highly vesicular bottom layer having closely spaced horizontal joints but the thickness is generally less. The vesicles are generally filled with secondary minerals and green earths. In such cases, they do not serve as aquifer. However, such vesicular zones are weathered in most part of the area, thus, making them moderately permeable. But if, vesicles are not filled, they act as highly permeable aquifers. The simple and compound "Pahoehoe" flow comprises a basal vesicular zone, middle relatively massive portion followed by a vesicular top. The vesicles of "Pahoehoe" flows are generally not interconnected and thus there is a variation in water holding capacity from the base to the top of the flow.

The ground water exists in fractures, joints, vesicles and in weathered zone of Basalt. The occurrence and circulation of ground water is controlled by vesicular unit of lava flows and through secondary porosity and permeability developed due to weathering, jointing, fracturing etc., of Basalt. The ground water occurs under phreatic, semi confined and confined conditions. The leaky confined conditions are also observed in deeper aquifers. Generally, the phreatic aquifer ranges down to depth of 15 m bgl. The water bearing zone down to depth of 35 m bgl forms the semi confined aquifer and below this deeper aquifer down to depth of 60 m bgl is observed. The yield of the dugwells varies from 10 to 1000 m^3/day, whereas that of borewells ranges between 50 and 1000 m^3/day. It is expected that the potential of deeper aquifers would be much more limited as compared to the unconfined/phreatic aquifer.

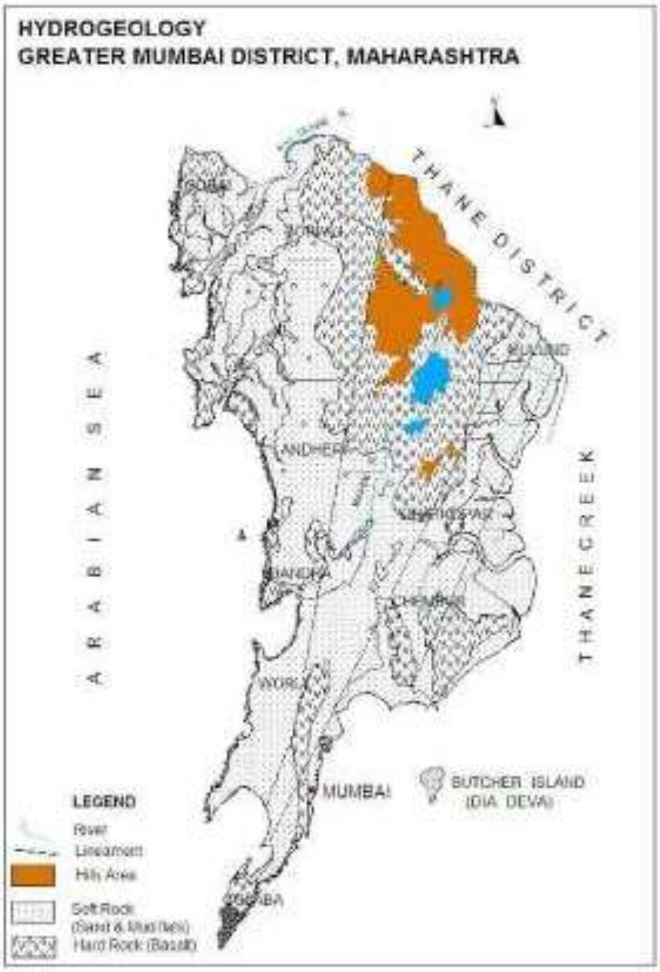


Fig. 9.2 Hydrogeological map of Greater Mumbai.

Soft Rock Areas: Alluvium

River Alluvium patches along the course of rivers and Marine Alluvium in the coastal area, are highly potential aquifer but with limited areal extent. The ground water occurs under water table condition in sandy / gritty layers. The alluvial fill of low lying areas underlain by weathered basalt has relatively better ground water potential.

Yields of Wells

The yields of the wells are the functions of the permeability and transmissivity of aquifer encountered. This varies with location, diameter and depth of wells. There are mainly two types of ground water structures i.e. dugwells and borewells in the area. The yields of the dugwells varies form 10 to 1000 m^3/day, whereas that of borewells ranges between 50 and 1000 m^3/day tapping the promising aquifer in the depth range of 60 to 80 m bgl, however, majority of the borewells are low yielding. The variation in yield between pre-monsoon and post-monsoon is quite high.

9.4.3 Water Quality

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality are related to drinking water, safety of human contact, and for health of ecosystems. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for our use. Water sampling Sites have been shown in **Table 9.3.** Water quality has been given in **Table 9.4.**

Groundwater quality is quite good. However total dissolved solids are a little higher than the desirable limits, but within the permissible limits. All other parameters are well within the desirable limits.

Table 9.4 Ground Water Quality at Project Site

Physical Parameters	Results	*Limits*
Sample	**Manpada**	
Date of Sampling	**12-02-2016**	
Colour, Hazen	Colourless	5 (15) Max
Odour	Unobjectionable	Unobjectionable
Taste	Agreeable	Agreeable
Turbidity, NTU	3.4	1 (5) Max
PH	7.87	6.5-8.5 Max
Total Hardness as $CaCO_3$, mg/l	243	200 (600) Max
Chloride as Cl, mg/l	136	250 (1000) Max
Total Iron as Fe, mg/l	0.08	0.3 Max
Total Dissolved Solids, mg/l	1478	500 (2000) Max
Sulphates as SO_4, mg/l	168	200 (400) Max
Nitrates as NO_3, mg/l	64.2	45 Max
Fluorides as F, mg/l	3.17	1.0 (1.5) Max
Lead as Pb, mg/l	BDL	0.01 Max
Copper as Cu, mg/l	BDL	0.05 (1.5) Max
Manganese as Mn, mg/l	BDL	0.1 (0.3) Max
Phenolic Compound as C_6H_5OH, mg/l	BDL	0.001 (0.002) Max
Mercury as Hg, mg/l	BDL	0.001 Max
Cadmium as Cd, mg/l	BDL	0.01 Max
Selenium as Se, mg/l	BDL	0.01 Max
Arsenic as As, mg/l	BDL	0.05 Max
Cyanide as Cn, mg/l	BDL	0.05 Max
Zinc as Zn, mg/l	1.21	5 (15) Max
Detergent as MBAS, mg/l	BDL	0.2 (1.0) Max
Chromium as Cr+6 , mg/l	BDL	0.05 Max
Total Alkalinity as $CaCO_3$, mg/l	185.2	200 (600) Max
Aluminum as Al, mg/l	BDL	0.03(2) Max
Boron as B, mg/l	BDL	0.5(1) Max
Bacteriological Analysis		
Coliform, MPN/100Ml	Nil	10 Max
E-Coli/Ml	Negative	Negative

9.5 METEOROLOGY

9.5.1 General

Mumbai has a tropical climate, specifically a tropical wet and dry climate (Aw) under the Köppen climate classification, with seven months of dryness and peak of rains in July. The cooler season from December to February is followed by the summer season from March to June. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season. Between June and September, the south west monsoon rains lash the city. Pre-monsoon showers are received in May. Occasionally, north-east monsoon showers occur in October and November. The maximum annual rainfall ever recorded was 3,452 mm for 1954. The highest rainfall recorded in a single day was 944 mm on 26 July 2005. The average total annual rainfall is 2,146.6 mm for the Island City, and 2,457 mm for the suburbs.

The average annual temperature is 27.2 °C, and the average annual precipitation is 2,167 mm. In the Island City, the average maximum temperature is 31.2 °C, while the average minimum temperature is 23.7 °C. In the suburbs, the daily mean maximum temperature range from 29.1 °C to 33.3 °C, while the daily mean minimum temperature ranges from 16.3 °C to 26.2 °C. The record high is 42.2 °C set on 14 April 1952, and the record low is 7.4 °C set on 27 January 1962.

9.5.2 Temperature

The temperature data for Mumbai has been taken. The month-wise minimum & maximum temperatures have been given in **Table 9.5.**

Table 9.5 Normal Temperature at Mumbai

Month	Mean Daily Maximum Temperature, °C	Mean Daily Minimum Temperature, °C
January	30.7	16.8
February	31.2	17.8
March	32.5	21.0
April	33.0	23.9
May	33.3	26.3
June	32.1	26.0
July	30.0	24.9
August	29.6	24.7
September	30.4	24.3
October	33.2	23.4
November	33.5	20.9
December	32.0	18.6
Annual	31.8	22.4

Source: India Meteorological Department, Govt. of India.

9.5.3 Rainfall

The detail of rainfall at the Mumbai (Santacruz) is given in **Table** 9**.6.**

Table 9.6 Month wise Rainfall at Mumbai

S. No.	Month	Rainfall	Peak Rainfall
1	January	0.6	
2	February	1.3	
3	March	0.2	
4	April	0.7	
5	May	12.5	
6	June	523.1	2220.6
7	July	799.7	
8	August	529.7	
9	September	312.3	
10	October	55.8	
11	November	16.8	
12	December	5.3	
Annual	Annual	2258.0	

Source: India Meteorological Department, Govt. of India.

9.5.4 Air Environment

The atmospheric concentrations of air pollutants were monitored at 2 locations near the proposed alignment during the month of February 2016. Air Monitoring was carried out for PM_{10}, NOx, SO_2 and CO. Results of the air quality monitoring are presented in **Table 9.7.**

Table 9.7 Ambient Air Quality Results µg/m^3

S. No.	Parameter	Manpada	Kasarwadavli	Regulatory Standards (NAAQS) Residential/ Sensitive 24 hourly
Date of Monitoring February 2016		11/12	12/13	
1	RSPM PM-10	184	191	100
2	Oxides of Sulphur - SO_2	41.3	53.5	80
3	Oxides of Nitrogen – NOx	51.2	69.1	80
4	Carbon Monoxide CO	1860	1740	2000

RSPM= Respirable Suspended Particulate Matter.

The results show that the concentration of RSPM(PM_{10}) is higher at all the locations whereas all other parameters are within permissible limits.

9.5.5 Noise Environment

Noise is responsible for adverse impacts on physical and mental health of the people. The other impacts are:

- Physiological effects,
- Hearing impairment,
- Communication interference, and
- Sleep disruption

Noise level survey was conducted along the alignment with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise levels were measured at four locations on 12-13 February 2016 for 24 hours. The noise levels so obtained are summarized in **Table 9.8.**

Table 9.8 Noise Levels

Location		L Max	L Min	Leq	L_{10}	L_{50}	L_{90}
Manpada	Day	84.4	58.3	69.1	74.5	63.9	61.6
	Night	73.9	51.6	62.5	71.2	56.2	53.9
Kasarvadavali	Day	87.9	62.6	72.8	84.0	68.6	65.1
	Night	83.9	51.3	60.6	79.6	57.3	53.8

Allowable Noise Levels dB (A) :

Category of Area/Zone	Day Time	Night Time	
Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition .
Commercial Area	65	55	
Residential Area	55	45	
Silence Area	50	40	

Day Time (6.00 Am-10.00 Pm); Night Time (10.00 Pm-6.00Am)

The observed noise level is higher than the permissible limits at all locations which may be due to heavy traffic movement and other activities on the roads.

9.5.6 Trees

Tree survey has been carried out along the proposed alignment. Tree with Girth at Breast Height (GBH) 30 cm have been counted. The alignment does not pass through any forest area. About 49 trees are located in the Depot area. Thus, there is likelihood of felling of 49 trees. No endangered species of trees have been noticed during field survey. Trees have been found of indigenous and common species like Pipal, Mango, Jamun, Neem, Coconut, Palm, Babool, Ber, Gulmohar, Tadi and Badam etc.

9.5.7 Flora and Fauna

Sanjay Gandhi National Park earlier known as Borivali National Park is the nearest reserve area which is about 2.5 Km on western direction of the alignment. This is the miraculously preserved green oasis in the center of urban sprawl. This national park is "one of the very few" that is surrounded by a metropolis like Mumbai, yet sustaining sizable population of big cats like panthers. It is hard to believe that with in just less then an hour and half from Gateway of India, one is transported from hectic and fast life of Mumbai city to a serene and tranquil atmosphere of pleasing verdant wilderness. The rich and diverse forest holds more than one thousand species of plants, 40 species of mammals, 251 of birds, covering migratory, land and water birds, 38 species of reptiles, 9 species of amphibians besides a large variety of fishes.

Flora: The park is a tree lovers delight in all seasons with the great amount of bio-diversity, ranging from Adina cardifolia (kadamb), Albizzia lebbek (Shirish), Pongamia pinnata (Karanj), Tectona grandis (Teak) Dalbergia latifolia (Sishum) to Acacia, Zizyphus and evergreen patches of Euphorbial in the dry month of February to May, spectacular flowering of Butea monosperma (Flame of Forests) is a real feast to eye. Flowering of Bombax malabaricum (Semal) and Erythrina indica (Indian coral tree) add colour. There are large patches of Bamboo, which make the feel of the jungle even better. The forest has a lot of Liana (woody climbers), a remnant from wetter evergreen past, many species of orchids and a large variety of shrubs. Every monsoon is a riot of colors from violet of Zingiberaceae species to the stark white of costus species. Among the many spectacular sights one that is definitely is mostworthy, is seven yearly mass flowering of Strobilanthus species (Karvi). Thousands and thousands of these flowers cover the hill slopes giving purple touch to this beautiful landscape.

Fauna: The national Park is a bird watcher paradise. From the tiny Tickell's flower pecker (small bird in India), many species of sun bird (humming birds) to the majestic white bellied sea eagle, it is virtual visual feast with birds like paradise flycatcher, the elusive Trogon, many species of Kingfishers, Woodpeckers, and Drongos. The continuous calling of large large green barbet, the wildly screeching parakeets, the metallic calls of the Racket-trailed Drongo, the musical call of the Blue flycatcher or the extremely melodious some of the Malabar whistling thrush or the familiar refrain of the Spotted babbler are just a few facets of nature's symphony in this forest.The Reptilian world is well represented from Crocodiles in Tulsi lake to Monitor lizards to Pythons, Cobras, Russess' viper, Bamboo pit viper. Smaller reptiles add to the wonder of this part. The invertebrate world from Crabs to Spiders to insects, Giant wood spiders, Signature spiders, Black wood spider with their large webs in monsoon are a real treat. The insect world from Silk cotton bugs to Beetles to various kinds of Mantis. The Butterfly world is represented in such a fascinating range of sizes and colours, from the spectacular Blue Mormon to the phenomenal artist of camouflage the Blue Oak leaf, the bright jezebels and Large Yellow and White Orange tips, Monarchs, Egg flies, Sailers are some of the many attractive butterflies one can find here.

9.6 SOCIO- ECONOMIC CONDITIONS

Socially and culturally this area is cosmopolitan in nature. According to the 2011 census, the population of Mumbai was 12,479,608. The population density is estimated to be about 20,482 persons per square kilometre. The living space is 4.5 sq metre per person. As Per 2011 census, Greater Mumbai, the area under the administration of the MCGM, has a literacy rate of 94.7%, higher than the national average of 86.7%. The sex ratio was 838 (females per 1,000 males) in the island city, 857 in the suburbs, and 848 as a whole in Greater Mumbai, all numbers lower than the national average of 914 females per 1,000 males. The low sex ratio is partly because of the large number of male migrants who come to the city to work.

Residents of Mumbai call themselves Mumbaikar, Mumbaiite, Bombayite or Bombaiite. Mumbai has a large polyglot population like any other metropolitan city of India. Sixteen major languages of India are also spoken in Mumbai, most common being Marathi, Hindi, Gujarati and English. English is extensively spoken and is the principal language of the city's white collar workforce. A colloquial form of Hindi, known as Bambaiya – a blend of Marathi, Hidi, Gujarati, Konkani, Urdu, Indian English and some invented words – is spoken on the streets.

Mumbai suffers from the same major urbanisation problems seen in many fast growing cities in developing countries: widespread poverty and unemployment, poor public health and poor civic and educational standards for a large section of the population. With available land at a premium, Mumbai residents often reside in cramped, relatively expensive housing, usually far from workplaces, and therefore requiring long commutes on crowded mass transit, or clogged roadways. Many of them live in close proximity to bus or train stations although suburban residents spend significant time travelling southward to the main commercial district. With a literacy rate of 69%, the slums in Mumbai are the most literate in India.

9.7 SOCIO-ECONOMIC SURVEY

A socio-economic survey was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed metro alignment on their conditions. There can be two types of impacts on the PAPs. One is the displacement of residential house and another is displacement of commercial establishments. It has been found that no residential or commercial establishment on the corridor or station area. The Depot is also carved out in an ope area without habitation.

Land is mainly required for viaduct, construction of stations and allied services, construction of Depot including laying of stabling lines, workshops, washing lines, administrative buildings and Water, Sewage and Effluent treatment systems in addition to storage facilities. Additionally, land is also required for RSS.

9.8 ARCHAEOLOGICAL SITES

The proposed alignment of Mumbai Metro corridor does not pass through or near any of the Archaeological monuments or heritage sites.

9.9 ENVIRONMENTAL IMPACTS ASSESSMENT

9.9.1 Environmental Impacts

This section identifies and appraises the negative impacts on various aspects of the environment likely to result from the proposed development. It is pertinent to mention that the negative environmental impacts listed below are based on the assumption that no negative impact mitigation measure or benefit enhancements are adopted.

- Land Environment
- Water Environment
- Air Environment
- Noise Environment

- Biological Environment
- Socio-Economic Environment

The impacts on the above environmental components have been further assessed during various phases of project cycle namely project location, project design, construction and operation.

9.9.2 Impacts Due To Project Location

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems,
- Socio-economic impacts;
- Impact on Historical and Cultural Monuments;

9.9.2.1 Project Affected People (PAPs)

There will be acquisition of private land and property in this project hence there are many PAPs as a result of the project activity. Detailed socio-economic assessment has been made for PAPs in Social Impact Assessment.

9.9.2.2 Change of Land Use

The details of land required (permanent and temporary) and change in land use are presented in **Table 9.9.** The required land (permanent & temporary) for the construction of the proposed alignment is both government as well as private land which shall be allotted by Mumbai Metropolitan Regional Development Authority. Private land will be acquired as per the provisions of The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013 (Act 30 of 2013) and Resettlement and Rehabilitation Policy for Mumbai Urban Transport Project (MUTP) notified in March 1997 and amended in December 2000.

Table 9.9 Change in Land Use (m^2)

S.No.	Corridor	Land Requirement (m^2)		Temporary casting yard/ site office	Total
		Govt.	Private	Govt.	
1.	Station & facilities	0	1926	-	1926
2.	Running Sections	-	-	-	61350
3.	Depot	231000	-	-	231000
4.	Staff Quarters	-	-	-	-
5.	OCC	-	-	-	-
6.	Receiving Sub Station	-	-	-	-
7.	Temporary Office/ Site Office	-	-	-	-
8.	Segment Casting Yards	-	-	-	-
	Total	231000	1926	-	232926

Source: DPR

9.9.2.3 Loss of Forests/ Trees

The proposed metro lines are in urban/ city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. However, trees do exist in patches in the corridor selected for the project. There are about 85 trees which are likely to be felled during construction.

Trees are assets in purification of urban air, which by utilizing CO_2 from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO_2 conversion will get effected and the losses are reported below:

i) Total number of Trees	:	49
ii) Decrease in CO_2 absorption @ 21.8 Kg/ year tree for 8 years	:	8545.6 kg
iii) Oxygen production @ 49 kg/ year tree For 8 years	:	19208 kg

The average consumption of oxygen for a person is about 182 kg/ year. It means these trees will meet the requirement of about 105 people round the year. Trees help carbon sequestration acting as a carbon sink. By removing the carbon and storing it as cellulose, trees release oxygen back into the air.

9.9.2.4 Utility/ Drainage Problems

Metro lines are mostly planned to run through the urban area. The alignment will cross many properties, drains/ nalas, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, roads, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance.

9.9.2.5 Socio-Economic Impact on PAPs

It is found that no residential or commercial structure is getting affected. Land is mainly required for viaduct, construction of stations and allied services, construction of Depot including laying of stabling lines, workshops, washing lines, administrative buildings and Water, Sewage and Effluent treatment systems in addition to storage facilities.

9.9.2.6 Impact on Archaeological Sites

There is no historical monument having any archeological value in the vicinity of the proposed alignment. Thus on this aspect there would be no impact.

9.9.2.7 Impact on Sensitive Receptors

There are many sensitive receptors along the alignment like residential areas and religious places but care has been taken to keep safe distance between the alignment and sensitive receptors. However, during operation stage care would be taken to provide noise barriers of suitable design wherever required to minimize the impact.

9.9.3 Impacts Due To Project Design

Considered impacts, due to project designs are:

- Lighting,
- Risk Due to Earthquake.

9.9.3.1 Lighting

The platforms, concourse, staircase and escalator areas for the elevated stations will have adequate and uniform fluorescent lighting to provide pleasant and cheerful environment. It is proposed to adopt the norms prevailing in Metro for illumination. It is pertinent to note that care has been taken at design stage itself to avoid too much illuminating the stations. Maximum illumination level proposed is 200 Lux which provides normal lighting.

9.9.3.2 Risk Due to Earthquake

The project area lies in Zone III of Bureau of Indian Standards (BIS) Seismic Zoning Map **(Fig. 3.1)**. Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures.

9.9.4 Impacts Due To Project Construction

Although environmental hazards related to construction works are mostly of temporary nature. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are:

- Top Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk to existing building,
- Excavated soil disposal problems,
- Dust Generation,
- Increased water demand,
- Impact due to Supply of Construction Material,
- Disposal of Construction and Demolition Waste,
- Impacts due to batching plant and casting yard,
- Noise Pollution,

9.9.4.1 Soil Erosion, Pollution and Health Risk at Construction Site

Every care has to be taken to avoid damage to the top soil. It has to be preserved and utilized. Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have mix concrete directly from batching plant for use at site. Health risks include disease hazards due to lack of sanitation facilities in labour camps (water supply and human waste disposal) and insect vector disease hazards of local workers and disease hazards to the local population. Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities. In addition to these, efforts need to be made to avoid water spills, adopt disease control measures and employment of local labour. Problems could arise due to difference in customs of workers from outside and local residents. These risks could be reduced by providing adequate facilities in worker's camps, raising awareness amongst workers and by employment of preferably local labour.

9.9.4.2 Traffic Diversions and Risk to Existing Buildings

During construction period, complete/ partial traffic diversions on road will be required, as most of the construction activities are on the central verge of road. Traffic would get affected on the roads. Rather than completely blocking the roads it will be advisable to make the narrow portion of roads as one way to allow for operation of traffic together with construction activities. Advance traffic updates/ information on communication systems will be an advantage to users of affected roads. The rail corridor does not pose any serious risk to existing buildings since there is safe distance between buildings and proposed corridor.

9.9.4.3 Problems of Excavated Soil and Bentonite Disposal

The proposed alignment is elevated and thus the excavation would be limited to piers and their piling. The soil would be used for refilling at station site. If there would be some residual soil, it would be utilized by MMRDA for internal use for refilling Depot sites and, if surplus, it would be disposed off at designated locations as per Mumbai Authority directions. Some Bentonite muck would also be generated in the project. Disposal of Bentonite would be at designated land fill site.

9.9.4.4 Dust Generation

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be only short-term. Protective measures shall be undertaken during construction phase. Movement of trucks and other heavy equipments at construction site would generate dust during construction phase.

9.9.4.5 Increased Water Demand

The water demand will increase during construction phase for meeting out drinking and domestic water requirement of workers. Sufficient water for construction purpose would be made available by TMC/ MCGM as it is responsible for water supply in Mumbai. Water requirement for construction of Metro will be met through the public supply. It is suggested to use treated STP water for the purpose of Construction. Proper care shall be taken while drawing water from public facilities to avoid any negative impact on the residents living in the vicinity of project whose water demand is, in any case, met by Municipal Corporation of Greater Mumbai supplied water.

9.9.4.6 Impact due to Supply of Construction Material

Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of metro corridor. These shall be sourced from the nearest source. Quarry operations are independently regulated activities and outside the purview of the project proponent. It is nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources.

Although quarry operation is out of purview of the metro construction but, the construction material shall be sourced only from legalized and approved quarries.

9.9.4.7 Generation of Construction and Demolition Waste

Construction and demolition (C&D) debris is defined as that part of the solid waste stream that results from land clearing and excavation, and the construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste includes concrete, stones and dirt generated during excavation (sometimes collectively referred to as "fill material" or rubble). C& D Waste may be generated from Pile caps, residual cement bags, residual steel scrap, excess construction material stacked at site etc. It is a waste stream that is separate and distinct from residential and commercial waste, commonly called municipal solid waste (MSW).

About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/ spoils. Dumping of construction waste/spoil in haphazard manner may cause surface and ground water pollution near the construction sites. The C& D waste would be handled and disposed off to C&D waste processing facility or for back filling of low lying areas, leaving no significant impact on environment.

9.9.4.8 Impacts due to Casting Yard and Batching Plant

During construction phase there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by MMRDA away from habitation. There would be requirement to get NOC (Consent to establish) and Consent to operate under water and air Acts from Maharashtra Pollution Control Board at the time of establishing the facilities. Simultaneously, there would be requirement to get the authorization for storage and handling of hazardous chemicals to store and handle used oils and other such materials. The Application forms for seeking Consent to Establish, Consent to Operate and Authorization for storage of Hazardous chemicals are available from the Regional office of Maharashtra Pollution Control Board at Mumbai. There would be significant movement of men, material and machinery in batching plant and casting yard. It is expected that both batching and casting yard would be located at same complex. Huge quantity of Cement, aggregates and other construction materials would be used in batching plant and casting yard. There would be generation of dust, noise, flue gases and other contaminants from the working of heavy machinery for handling and transporting the construction materials. The mitigation measures have been elaborated in EMP.

9.9.4.9 Noise Pollution

The major sources of noise pollution during construction are movement of vehicles for transportation of construction material to the construction site and the noise generating activity at the construction site itself. The Metro construction is equipment intensive.

9.9.4.10 Loss of Historical and Cultural Monuments

No historical/ cultural monuments will be lost as a result of the proposed development.

9.9.5 Impacts Due To Project Operation

Along with many positive impacts, the project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise pollution,
- Water supply and sanitation at Stations,
- Station refuse disposal and sanitation,
- Pedestrianization and visual issues

9.9.5.1 Noise Pollution

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures. The noise level at 2 m distance from the rail alignment is about 73 dB(A) as per the experience in operating metro system. The noise level reduces with distance logarithmically. At places, the alignment is likely to be passing close to the buildings which may affect the residents. At such places noise barriers would be used to minimize the noise impact in the vicinity of the alignment.

9.9.5.2 Water Supply and Sanitation at Stations

Public facilities such as water supply, sanitation and wash rooms are very much needed at the stations. The water requirement for stations would be for drinking, toilets, cleaning and also for other purpose like AC. Water Demand as per existing Metro corridors is calculated and presented in **Table 9.10**. It is assumed that there would be similar water requirements in Mumbai Metro as well. Raw water should be treated and brought to national drinking water standards, before used for consumption. In addition, water will be required for contractor's camps during construction. The water requirement for the stations will be met through the public water supply system or purpose built tube wells after taking necessary approvals from CGWA. However, as an environmental conservation measure, rainwater harvesting structure will also be constructed at stations and along the via-duct.

Table 9.10 Water Requirement at Stations

S. No.	Particular	Water Demand for each station KLD
1	At Stations for Drinking Purpose	6
2	At Elevated stations for AC, cleaning, chiller and other purposes	17
	Total	**23**

Thus there would be total water requirement of 736 KLD in 32 stations. However, arrangement of water will have to be made at each station separately.

9.9.5.3 Station Refuse

The collection and removal of refuse from stations in a sanitary manner is of great importance for effective vector control, nuisance abatement, aesthetic improvement and fire protection. The refuse from station includes;

- Garbage,
- Rubbish, and
- Floor Sweepings.

As per the available data from Delhi Metro Phase I and II and other operational metros, the solid waste generation is about 0.8 – 1.2 cum/day at elevated stations. At elevated stations, the solid waste generation is more due to airborne dust. Thus about 26 to 29 cum of solid waste will be generated from the thirtytwo stations of this corridor of Mumbai metro. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authorities. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals

9.9.5.4 Visual Impacts

The introduction of MRTS implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recent MRTS projects have attempted to incorporate this objective in their designs. Since a low profile would cause the least intrusion, the basic elevated section has been optimised at this stage itself.

9.9.5.5 Vibrations

This corridor is elevated throughout the alignment. As per the experience from working metros particularly Delhi Metro it is found that the problem of ground vibration is felt in case of Underground sections only. In elevated corridors there has been no complaint of vibration in the vicinity of alignments. Therefore the vibration impact is not considered significant. However preventive measures to reduce the vibration at source would be applied in the rail design itself.

9.9.6 Impacts Due To Depot

One Depot is proposed at Kasarvadavali. The depot will have following facilities:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop, and
- Offices.

These facilities could generate water and noise issues. The depot area may have to be filled up. Problems anticipated at depot sites are:

- Water supply,
- Oil Pollution,
- Cutting of trees
- Sanitation,
- Effluent Pollution,
- Noise Pollution,

- Loss of livelihood,
- Impact due to filling of area, and
- Surface drainage.

- **Water Supply**

  Water supply will be required for different purposes in the depot. The water requirement for drinking will be 500 litre per day and 1,00,000 litre per day for other requirements (Departments and Contractors office). The water after conventional treatment can be processed through Reverse Osmosis (RO) technology for specific use such as final washing of equipment/ trains.

- **Oil Pollution**

  Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. The spilled oil should be trapped in oil and grease trap. The collected oil would be disposed off to authorised collectors, so as to avoid any underground/ surface water contamination.

- **Noise Pollution**

  The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheels and train speed are the factors which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. Due to less activity, no impact on the ambient noise is anticipated.

- **Solid Waste**

  At per available data, it is estimated that about 2 Ton per month of solid waste will be generated from the Depot site which will be taken by the cleaning contractor weekly and disposed to the Municipal waste disposal sites.

  Sludge of the order of 250 kg/year is expected to be generated from the ETP/STP that will be stored in leak proof containers and disposed off as per State Pollution Control Board site.

  According to experience and observation at operational DMRC depots, Oil and grease of the order of 2652 litres/ year will be produced in the Depot which will be disposed off through approved re-cyclers.

  About 2.5 ton/month of iron turning of the PWL for the wheel profiling is likely to be generated from the Depot.

9.10 POSITIVE ENVIRONMENTAL IMPACTS

Based on project particulars and existing environmental conditions, potential impacts that are likely to result from the proposed Mumbai metro corridors development have been identified and wherever possible these have been quantified. This chapter deals with the positive impacts of the project. The introduction of the corridor will also yield benefits from non-tangible parameters such as saving due to equivalent reduction in road construction and maintenance, vehicle operating costs, less atmospheric air pollution and socio-economic benefits of travel time, better accessibility, better comfort and quality of life. However, all benefits cannot be evaluated in financial terms due to non-availability of universally accepted norms. The parameters such as economic growth, improvement in quality of life, reduction in public health problems due to reduction in pollution, etc have not been quantified.

Various positive impacts have been listed under the following headings:

- Employment Opportunities;
- Enhancement of Economy;
- Mobility, Safety and reduced accidents;
- Traffic Congestion Reduction;
- Reduced Fuel Consumption;
- Reduced Air Pollution;
- Reduction in Number of Buses/ Auto rickshaws, and

- **Employment Opportunities**

  The project is likely to be completed in a period of about 4 years. During this period manpower will be needed to take part in various activities. About 1500 persons are likely to work during peak period of activity. In operation phase of the project about 35 persons per kilo meter length of the corridor, ie (approx. 105 persons) will be employed for operation and maintenance of the proposed system in shifts. Thus the project would provide substantial direct employment. Besides, more people would be indirectly employed in allied activities and trades.

- **Enhancement of Economy**

  The proposed transport facility of MMRDA will facilitate sub-urban population to move quickly. With the development of Wadala (Bhakti Park) – Ghatkopar-Mulund- Thane-Kasarvadavali – Gaimukh corridor, it is likely that more people will be involved in trade, commerce and allied services. MMRDA will, however, make it convenient for more people to move in the present suburban areas. This will reduce population pressure on transport facilities in the urban area.

- **Mobility Safety and Reduced Accidents**

  The metro network increases the mobility of people at faster rate. The proposed corridor will provide more people connectivity to other parts of the city. Metro journey is safe and result in reduced accidents on roads.

- **Traffic Congestion Reduction**

  To meet the forecast transport demand in the year 2031, it is estimated that the number of buses will have to be more. During this period personalised vehicles may also grow. Together, they will compound the existing problems of congestion and delay. The proposed development will reduce journey time and hence congestion and delay.

- **Reduced Fuel Consumption**
  On implementation of the project, it is estimated that both petrol and diesel consumption will get reduced. The saving will be due to two factors namely Reduction in vehicles and decongestion on roads.

- **Reduced Air Pollution**
  There will be reduction in air pollution due to reduction of emissions from the vehicles substituted by Metro.

- **Carbon Credits**
  Due to savings in fuel and reduction in air pollution etc. carbon credit would be generated during operation of the metro rail similar to the experience with Delhi Metro Rail Corporation Ltd. However, at this stage calculation of carbon credits is not feasible which would be worked out after the system become operational.

- **Improvement of Quality of Life**
  Development of Metro rail in the city would lead to overall improvement of quality of life of local populace by virtue of availability of better transport facility at competitive rates, better road safety, reduced pollution, improved general health etc.

9.11 CHECKLIST OF IMPACTS

The impact evaluation determines whether a project development alternative is in compliance with existing standards and regulations. It uses acceptable procedures and attempts to develop a numeric value for total environmental impact. A transformation of the review of multiple environmental objectives into a single value or a ranking or projects is the final step in impact assessment. There are about hundred methods for carrying out impact assessment, which can be grouped into the following categories:

- Ad-hoc method,
- Checklist,
- Matrix,
- Network,
- Overlays,
- Environmental Index and
- Cost Benefit analysis.

Each of the methods is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented. Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. A typical checklist identifying anticipated environmental impacts is shown in **Table 9.11**.

Table 9.11 Checklist of Impacts

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
A.	**Impacts due to Project Location**			
i.	Displacement of People	*		
ii.	Change of Land use and Ecology	*		
iii.	Loss of Cultural and Religious Structures		*	
iv.	Socio-economic Impacts	*		
v.	Loss of Trees	*		
vi.	Drainage & Utilities Problems	*		
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	
ii.	Ventilation and Lighting		*	
iii.	Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Top Soil Erosion, Pollution and Health risk	*		
ii.	Traffic Diversions and	*		
iii.	Risk to Existing Buildings	*		
iv.	Problems of Soil Disposal and Seepage Risk	*		
v.	Dust Generation	*		
vi.	Increased Water Demand	*		
vii.	Supply of Construction Material	*		
viii.	Construction and Demolition Waste	*		
ix.	Batching Plant and Casting Yard	*		
x.	Noise	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise	*		
iii.	Water supply and sanitation	*		
iv.	Pedestrian Issues		*	
v.	Visual Impacts		*	
vi.	Station Illumination		*	
vii.	Employment Opportunities			*
viii.	Enhancement of Economy			*
ix.	Mobility			*
x.	Safety			*
xi.	Traffic Congestion Reduction			*
xii.	Less fuel Consumption			*
xiii.	Less Air Pollution			*
xiv.	Carbon dioxide Reduction			*
xv.	Reduction in Buses			*
xvi.	Reduction in Infrastructure			*

9.12 ANALYSIS OF ALTERNATIVES AND PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

Analysis of Alternatives

Historically, 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 hereto.
- 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.

All the above reports have been submitted to MMRDA.
An SPV named as Mumbai Metro rail Corporation Ltd. (MMRC) was incorporated and implementation of Line -3 between Colaba- BKC-Aarey was proposed to be done by the SPV.

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.

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.

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

Charkop - Dahisar (7.5 Km)	M/s SPAN Consultants
Andheri (E) - Dahisar	M/s SPAN Consultants
BKC Kanjur Marg (19.5 Km) with extension from BKC to Mahim	M/s RITES
Ghatkopar - Mulund (12.5 Km)	M/s Consulting Engineering Services
Wadala - Carnac Bunder	M/s Consulting Engineering Services

All the above reports were submitted to MMRDA. An SPV named as Mumbai Metro rail Corporation Ltd. (MMRC) was incorporated and implementation of Line -3 between Colaba- BKC-Aarey was proposed to be done by the SPV. MMRDA now intends to implement all other corridors by itself.

Various alternatives were explored by the DMRC before arriving at the preferred mode of transport and technical design. The project is unique in the sense that alternative alignments were not evaluated as it was the principal objective of the Comprehensive Mobility Plan to connect various parts of suburbs.

Need to Increase Public Transport Share

The proposed corridor is part of MMRDA's Comprehensive Mobility Plan (CMP), which included strategies on motorized and non-motorized modes to enhance mobility and economic development. The metro was conceived in recognition to the heavy reliance of the population to private buses as public transport that is inadequate and routes are unregulated causing confusion and congestion.

9.13 PUBLIC CONSULTATION AND DISCLOSURE

Public consultation and participation is a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and unwanted political propaganda against the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly.

A. Consultation with Stakeholders

As required for Category A projects, preliminary consultations were conducted at the early stage of EIA preparation, mostly involving local communities. Successive consultations shall be conducted by the MMRDA after the finalization of this report that includes representatives of local communities and entities tasked with the regulation of the road development and environmental protection.

B. Compliance with Regulatory and Funding Agency Requirement

As per Indian Environmental Regulations, public hearing is not required, as railway projects do not attract EIA Notification 2006, amended 2009. Meaningful consultations will be undertaken consistent with the ADB requirements. All the five principles of information dissemination, information solicitation, integration, co ordination and engagement into dialogue will be incorporated in the consultation process.

C. Disclosure of the EIA and Monitoring Reports

In compliance to the ADB Safeguard and Disclosure policies, this report will be disclosed in the websites of MMRDA at least 120 days. Further, semi-annual monitoring reports will be prepared by the MMRDA will be disclosed in the websites of MMRDA.

9.14 ENVIRONMENTAL MANAGEMENT PLAN

9.14.1 Management Plans

The Mumbai Metro Project will provide employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand.

Protection, preservation and conservation of environment have always been a primary consideration in Indian ethos, culture and traditions. Management of Environment by provision of necessary safeguards in planning of the project itself can lead to reduction of adverse impacts due to a project. This chapter, therefore, spells out the set of measures to be taken during project construction and operation to mitigate or bring down the adverse environmental impacts to acceptable levels based on the proposed Environmental Management Plan (EMP).

The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components. For optimal integration of EMP into the project, there should be investment links for:

- Funding,
- Management and training, and
- Monitoring.

The purpose of the first link is to ensure that proposed actions are adequately financed. The second link helps in embedding training, technical assistance, staffing and other institutional strengthening items in the mitigation measures to implement the overall management plan. The third link provides a critical path for implementation and enables sponsors and the funding agency to evaluate the success of mitigation measures as part of project supervision, and as a means to improve future projects. This chapter has been divided into three sections:

- Mitigation measures,
- Disaster management, and
- Emergency measures.

9.14.2 Mitigation Measures

The main aim of mitigation measures is to protect and enhance the existing environment of the project. Mitigation measures have to be adopted during construction at all the construction sites including Batching Plant and Casting Yards on all the aspects. The mitigation measures to be adopted have been described under following heads:

- Compensatory Afforestation,
- Construction Material Management,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Environmental Sanitation,
- Utility Plan,
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Water Supply, Sanitation and Solid Waste management,
- Rain water harvesting
- Management Plans for Depot
- Training and Extension

9.14.3 Compensatory Afforestation

The objective of the afforestation program should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. According to the results of the present study, it is found that about 49 trees are likely to be lost due to the project. Ten saplings are to be planted for felling a single tree. Hence 147 trees need to be planted. Plantation program will be finalized in consultation with MCGM and project proponent would provide the funds for compensatory afforestation as per government policy.

9.14.4 Construction Material Management – Storage and Procurement

The major construction material to be used for construction of the proposed corridor are coarse aggregates, cement, coarse sand, reinforcement steel, structural steel, water supply, drainage and sanitary fittings etc. The material will be loaded and unloaded by engaging labour at both the locations by the contractor.

The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the MMRDA Officer and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor shall be responsible for management of such construction material during entire construction period of the project. Sufficient quantity of materials should be available before starting each activity. The contractor should test all the materials in the Government labs or Government approved labs in order to ensure the quality of materials before construction. This is also the responsibility of the contractor, which would be clearly mentioned in the contractor’s agreement. Care shall be taken to avoid spillage of material during construction. Procurement of material would be from environment friendly source. The materials shall be procured from nearest available source and shall be transported in coverd trucks. All the material would be stored in a manner to avoid multiple handling for use in construction activities.

9.14.5 Labour Camp

The Contractor during the progress of work will provide, erect and maintain the necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the MMRDA. All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Safe drinking water should be provided to the dwellers of the construction camps. Adequate washing and bathing places shall be provided, and kept in clean and drained condition. Construction camps are the responsibility of the concerned contractors and these shall not be allowed in the construction areas but sited away. Adequate health care is to be provided for the work force.

Sanitation Facilities: Construction sites and camps shall be provided sanitary latrines and urinals. Sewerage drains should be provided for the flow of used water outside the camp. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner

Shelter at Workplace: At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. Sheds shall be maintained in proper hygienic conditions.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances shall be provided. Suitable transport shall be provided to facilitate taking injured and ill persons to the nearest hospital.

Day Crèche Facilities: At every construction site, provision of a day crèche shall be worked out so as to enable women to leave behind their children. At construction sites where 25 or more women are ordinarily employed, at least a hut shall be provided for use of children under the age of 6 years belonging to such women. Huts shall be provided with suitable and sufficient openings for light and ventilation. Size of crèches shall vary according to the number of women workers employed.

9.14.6 Energy Management

The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon MMRDA request. Measures to conserve energy include but not limited to the following:

- Use of energy efficient motors and pumps,
- Use of energy efficient lighting, which uses energy efficient luminaries,
- Adequate and uniform illumination level at construction sites suitable for the task,
- Proper size and length of cables and wires to match the rating of equipment, and
- Use of energy efficient air conditioner.

The contractor shall design site offices maximum daylight and minimum heat gain. The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be explored.

9.14.7 Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file a 'Request for Authorization' with Maharashtra Pollution Control Board along with a map showing the location of storage area. Outside the storage area, the contractor shall place a 'display board', which will display quantity and nature of hazardous waste, on date. Hazardous Waste needs to be stored in a secure place. It shall be the responsibility of the contractor to ensure that hazardous wastes are stored, based on the composition, in a manner suitable for handling, storage and transport. The labeling and packaging is required to be easily visible and be able to withstand physical conditions and climatic factors. The contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the MMRDA.

9.14.8 Environmental Sanitation

Environmental sanitation also referred to as Housekeeping, is the act of keeping the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. Contractor shall understand and accept that improper environmental sanitation is the primary hazard in any construction site and ensure that a high degree of environmental sanitation is always maintained. Environmental sanitation is the responsibility of all site personnel, and line management commitment shall be demonstrated by the continued efforts of supervising staff towards this activity.

General environmental sanitation shall be carried out by the contractor and at all times at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals. The contractor shall employ a special group of environmental sanitation personnel to carry out following activities:

- Full height fence, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public. The barricade especially those exposed to public shall be aesthetically maintained by regular cleaning and painting as directed by the Employer. These shall be maintained in one line and level.
- The structure dimension of the barricade, material and composition, its colour scheme, MMRDA logo and other details.
- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
- All surplus earth and debris are removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. in order to avoid dust or odour impact shall be covered while moving.
- No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.
- Roads shall be kept clear and materials like: pipes, steel, sand boulders, concrete, chips and brick etc. shall not be allowed on the roads to obstruct free movement of road traffic.
- Water logging or bentonite spillage on roads shall not be allowed.
- Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals / compressed gas cylinders shall be safely stored.
- Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified location(s).
- Empty cement bags and other packaging material shall be properly stacked and removed.

9.14.9 Utility Plan

The proposed Metro alignment runs along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. A number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. exists along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule /costs, for which necessary planning / action needs to be initiated in advance. Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro alignment, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.
- The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where utility is crossing the proposed Metro alignment. In case of utility services running along the alignment either below or at very close distance, the layout of piles in the foundations shall be suitably modified such that the utility service is either encased within the foundation piles or remains clear of them.

9.14.10 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in PM_{10} along haul roads and emission from vehicles and construction machinery. Though the estimation of air quality during construction shows some impact on ambient air quality, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.
- The Contractor shall use construction equipment to minimize or control of air pollution. He shall maintain evidence of such design and equipment and make these available for inspection by Employer.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and

undertake remedial measures including replacement, if required, so as to operate within permissible norms.

- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.
- The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by Employer. Dust control activities shall continue even during any work stoppage.
- The Contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During dry weather, dust control methods must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

9.14.11 Construction and Demolition Waste

Waste prevention, reuse and recycling can not only save money, but also generate broad environmental benefits, including the conservation of natural resources. Reuse and waste prevention reduce the air and water pollution associated with materials manufacturing and transportation. This saves energy and reduces attendant greenhouse gas production. The recycling of many materials requires less energy than production from virgin stock, and can also reduce transportation requirements and associated impacts.

Opportunities for reducing C&D waste focus on three approaches, typically expressed as **Reduce-Reuse-Recycle**.

The source of C & D waste are pile caps, excess RMC and demolition material. An effort shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. The contractor shall store C&D waste separately at the site and sent to recycling facility periodically.

There shall be no disposal of any waste along storm water drains, canals and/ or any other water body or depression. Rather C & D waste shall be collected and sent to any authorized waste recycling facility.

9.14.12 Noise Control Measures

There will be an increase in noise level in nearby ambient air due to construction and operation of the Metro corridors. During construction the exposure of workers to high noise levels especially near the machinery need to be minimized. This could be achieved by:

- Job rotation,
- Automation,
- Construction of permanent and temporary noise barriers,
- Use electric instead of diesel powered equipment,
- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
- Scheduling and staggering truck loading, unloading and hauling operation,
- Schedule and stagger work to avoid simultaneous activities which generate high noise levels,
- 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 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, and
- Sound proof compartments control rooms etc.

Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible. Workers in sections where periodic adjustment of equipment/ machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. During construction, there may be high noise levels due to pile driving, use of compressors and drilling machinery. Effective measures should be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers.

The pile driving operation can produce noise levels up to 100 dB (A) at a distance of 25-m from site. Suitable noise barriers can reduce the noise levels to 70 dB (A) at a distance of 15m from the piles. A safety precaution as stipulated in IS: 5121 (1969) '*Safety Code for Piling and other Deep Foundation'* need to be adopted.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.

9.14.13 Traffic Diversion/ Management

During construction, traffic is likely to be affected. Hence Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction of the corridor. Any reduction of road space during Metro construction results in constrained traffic flow. In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads etc. Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

Various construction technologies are in place to ensure that traffic impedance is done at the minimum. They are:

- The requirement would be mainly along the central verge/ side of the road.
- As regards to the alignment cutting across a major traffic corridor, 'Box Girder Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind.

Only temporary diversion plans will be required during construction of the proposed Metro corridor. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from 'on-street' parking to informal activities.
Keeping in view the future traffic growth and reduction of carriageway due to Metro construction, implementation of traffic management/diversion plans shall become inevitable for ensuring smooth traffic movement and similar traffic diversion plans shall be formulated and followed during the execution stage.

Traffic Management Guidelines: The basic objective of the following guidelines is to lay down procedures to be adopted by contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen at construction sites.

- All construction workers should be provided with high visibility jackets with reflective tapes as most of viaduct and station works are on the right-of-way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- Provide adequate measures that control driver behavior through construction zones.
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

9.14.14 Soil Erosion Control

Prior to the start of the relevant construction, the Contractor shall submit to the MMRDA for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works are as applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and/ or other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the project authority.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. The Contractor may be directed to provide immediate control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Top soil shall be preserved by the contractor and stacked separately at designated place and utilize it to cover te refilled areas and to support vegetation.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion/sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage or associated with permanent control features on the Project. Under no conditions shall a large surface area of credible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the project authority.

The MMRDA may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule.

Temporary erosion is sometimes caused due to the Contractor's negligence, carelessness or failure to install permanent controls. Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the project authority, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the project authority.

9.14.15 Water Supply, Sanitation and Solid Waste Management

During Construction

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water should be treated before use up to national drinking water standards. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage solves the excreta disposal problems. The sewerage disposal systems should be adopted for sewage disposal. The water for domestic consumption shall be sourced from public water supply or alternatively designated bore well may be installed with due permission from statutory authority prior to installation of bore well.

For Construction activity, there is a restriction to utilize groundwater all over the nation as per order of National Green Tribunal (NGT). Thus, construction water shall be sourced from Mumbai Municipal Corporation which is responsible for sewage disposal in Mumbai area. Alternatively, contractor shall arrange tie up for surface water supply or tanker water supply for construction activity. Best option is to use treated STP water for construction activity.

Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed off through covered trucks to land fill site designated and authorized by MMRDA.

During Operations

Practically, public facilities at stations have to be operated by regular staff or may be designated to any NGO working in the area in the field of sanitation as per policy of MMRDA.

Requirement of drinking water supply at an elevated station is about 6 KL/day. The water consumption for an elevated station to meet the requirements of its activities is 17 KLD. This shall be provided from MCGM/ Mumbai authority sources.

Solid waste will be generated at station is about 0.8 – 1.2 m^3/Day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authority. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. This should be collected and transported to local municipal bins for onward disposal to disposal site by municipality. During operation, as mitigation measures rainwater harvesting will be carried out at stations and along the viaduct.

9.14.16 Rain water harvesting

To conserve and augment the storage of groundwater, it is suggested to construct rainwater harvesting structures of suitable capacity along the alignment and at stations. The stations shall be provided with the facility of rainwater harvesting and artificial recharge. The total length of the proposed extension is about 2.668 km and there would be 2 stations. The estimated cost of rain water harvesting for elevated corridor is about 11 lakhs per km(35.42 Lakh) and 3.5 lakhs per station (7.00 Lakhs). The total cost of rainwater harvesting would be Rs. 42.42 Lakh.

9.14.17 Tree Protection

There is requirement of felling 49 trees during construction of Metro corridors in Mumbai. An attempt shall be made to minimize the tree felling. As remediation of tree felling it is suggested to plant 3 trees for each tree felled. Thus 147 trees would be planted. Moreover, MMRDA would chalk out the plantation program in close coordination with Tree Authority MCGM or will get plantation done through MCGM by making the payment for plantation work including after care for three years. An attempt would be made to minimize the felling of trees to the bare minimum while working and undertaking construction work. The left out trees shall be protected by providing metal or brick tree guard around the tree at a distance of one meter surrounding the tree. Scope of transplantation of trees would also be explored with discussion with the Tree Authority MCGM. A provision of 2.94 Lakh has been made @ Rs. 2000/- per tree to be planted and maintained for a period of three years.

9.14.18 Management Plans for Depot

The management plans for depot site includes:

- Water Supply,
- Oil Pollution Control,
- Sewage/Effluent Pollution Control,
- Surface Drainage,
- Green belt development,
- Rain water harvesting, and
- Recycling of treated waste water.

Water supply: About 300KLD of water will be required for operation and functioning of depot. This could be either taken from water supply Authority or through boring tube well into the ground after taking permission from Central Ground Water Authority. The ground water will need treatment depending upon its use. Domestic and some of the industrial application, a reverse Osmosis (RO) plant of 8 liter/ minute capacity will be appropriate. The water treatment plant flow chart is given in **Figure 9.3**. The estimated cost of water supply plant is about 120.50 Lakh.

Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. Such tanks usually employ compressed air to coagulate the oil and grease and cause it to rise promptly to the surface. Compressed air may be applied through porous plates located in bottom of the tank. The tank may be designed for a detention period of 5 to 15 minutes.

Sewage/Effluent Pollution Control: About 80 KLD of sewage is likely to be generated at depot. The sewage could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream a process flow chart is presented in **Figure 9.4.** The estimated cost of sewage treatment plant is about Rs 78.00 Lakh.

Expectedly about 63 KLD effluents would be generated at Depot. The effluent will have oil, grease and, detergent as main pollutants. This has to be treated as per requirement of regulatory pollution control agency of the state (MSPCB). Process flow chart of effluent treatment plant is shown in **Figure 9.5.** The estimated cost of effluent treatment plant is about Rs 88.50 Lakh.

Surface Drainage: The depot area should have proper drainage. The Storm water of the depot will be collected through the drain. Rain water harvesting structures at different locations in the drains and for surplus storm water, the drainage system is to be connected to nearby disposal site. The drainage costs have been included in project cost.

Green belt development: The greenbelt development / plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical structures of proposed buildings with surrounding environment but also acts as pollution sink / noise barrier. In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance. It is recommended to have a provision of Rs 40.00 Lakh in the cost estimate for the green belt development.

Rain water harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the constructed depot site. A provision of Rs 35.00 Lakh for depot has been kept in the cost estimate.

Recycling of treated waste water: The Waste Water to be generated at depots shall be treated by ETP & STP in each Depot. The treated waste water shall be recycled for horticulture work of the depot. About 64 KLD of treated waste water will be used for horticulture. The estimated cost of recycling of treated waste water is about Rs 41 Lakh in the depot.

The costs of environment management measures have been included in the project cost as construction and civil costs of Depot.

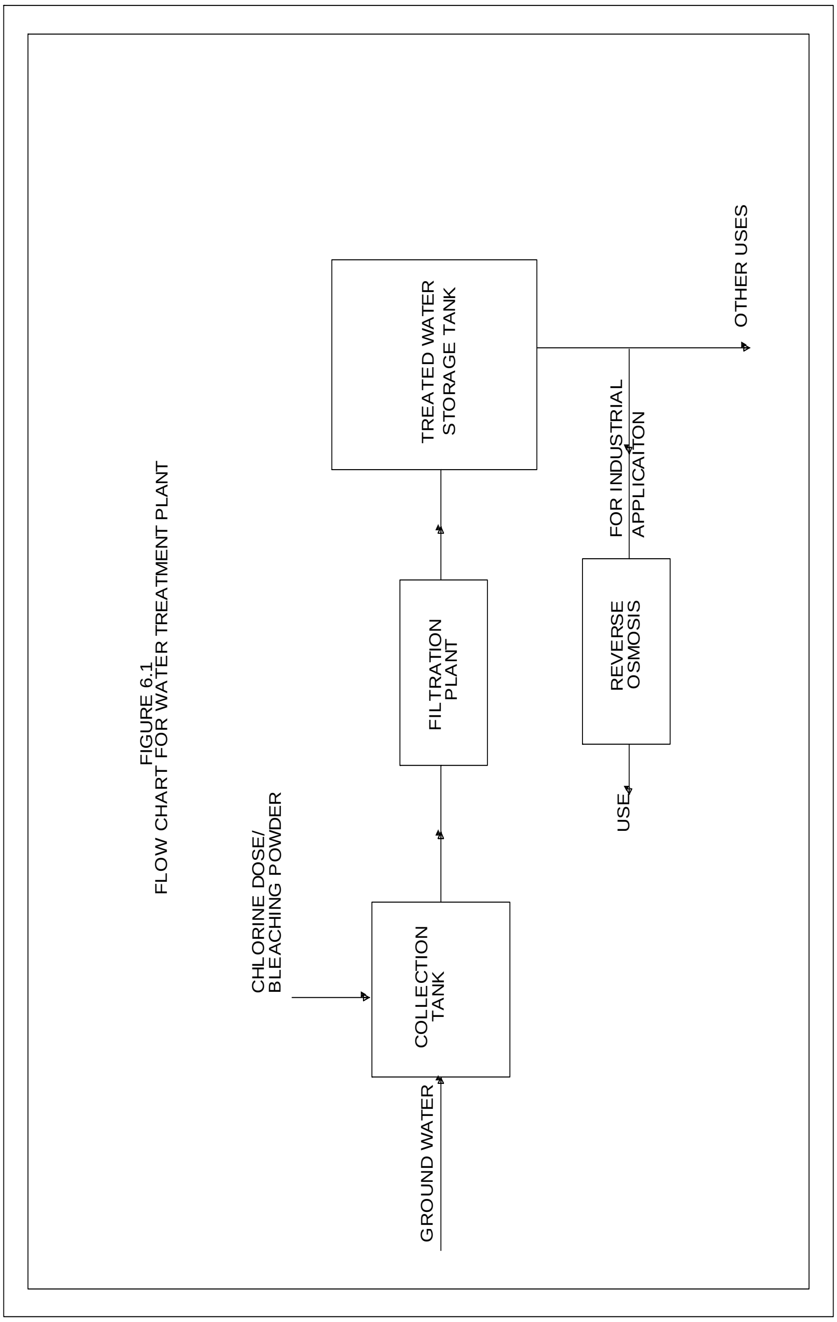


Fig. 9.3 Flow Chart for Water Treatment Plant

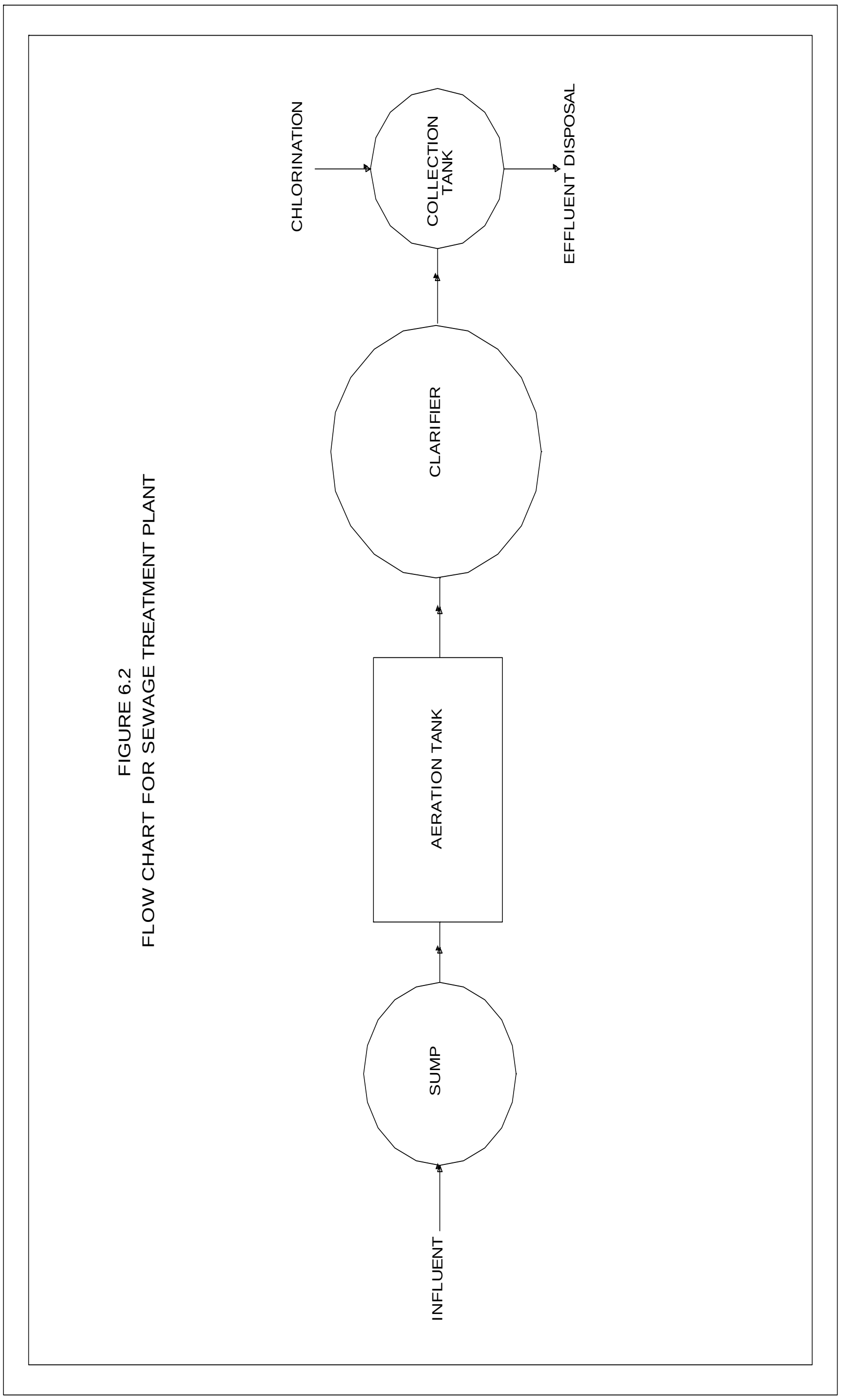


Fig. 9.4 Flow Chart for Sewage Treatment Plant

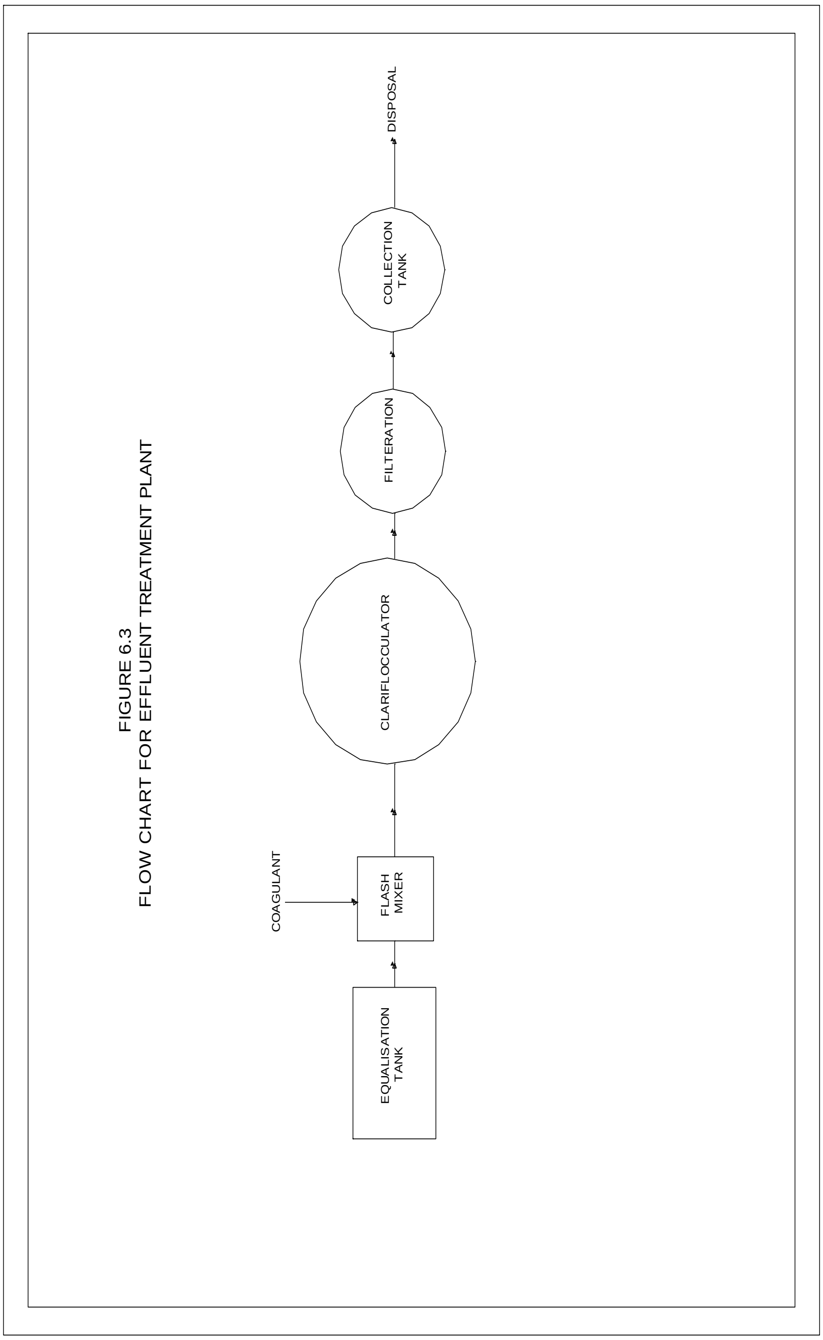


Fig. 9.5 Flow Chart for Effluent Treatment Plant

9.14.19 Disaster Management

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

- **Preventive Action**

  Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should identify sources of repair equipments, materials, labour and expertise for use during emergency.

- **Reporting Procedures**

  The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details.

  The Engineer-in-Chief should notify the officer for the following information:

  - Exit points for the public,
  - Safety areas in the tunnel/overhead rail, and
  - Nearest medical facility

- **Communication System**

  An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and fool proof communication system.

- **Emergency Action Committee**

  To ensure coordinates action, an Emergency Action Committee should be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

  - Station Manager concerned,
  - Police Officer of the area,
  - Mumbai Transport Corporation Representative,
  - Home Guard representative,
  - Fire Brigade representative,
  - Health Department representative,
  - Department of Information and Publicity, and
  - Non-Governmental Organization of the area

  Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

- Demarcation of the areas to be evacuated with priorities,
- Safe route to be used, adequacy of transport for evacuation, and traffic control,
- Safe area and shelters,
- Security of property left behind in the evacuated areas,
- Functions and responsibilities of various members of evacuation teams, and
- Setting up of joint control room

All personnel involved in the Emergency Action Plan should be thoroughly familiar with all the elements of the plan and their responsibilities. They should be trained through drills for the Emergency Action Plan. The staff at the site should be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan must be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.

It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

9.14.20 Emergency Measures

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape etc. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan should also include preventive action, notification, warning procedures and co-ordination among various relief authorities. These are discussed in following sections.

- **Emergency Lighting**

  The emergency lights operated on battery power should be provided at each station. The battery system should supply power to at least 25% of the lights at the station, platforms, viaduct for a period of 2 hours.

- **Fire Protection**

  The building materials should be of appropriate fire resistance standard. The fire resistance period should be at least 2 hours for surface or over head structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

  - Fire prevention measures,

- Fire control measures,
- Fire detection systems,
- Means of escape,
- Access for fireman, and
- Means of fire fighting.

A. Fire Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In stations planning, potential sources of fire can be reduced by:

i. Fire Prevention

- Use of non-combustible or smoke retardant materials where possible,
- Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provide,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Provision of special storage spaces for combustible materials such as paint and oil,
- Prohibition of smoking in fire prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

ii. Safety

Following provisions will be required from fire safety point of view:

- Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq.m
- One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks and pumps of suitable capacity with hydrants, first-aid reel, etc.
- Portable fire non-aqueous extinguishers of Carbon Dioxide, chemical dry powder etc. at suitable places.
- Automatic smokes venting facilities.
- Two separate means of exit shall be provided, if more than 10 persons are working and the area exceeds 1400 sq.m.
- Fire resisting doors shall be provided at appropriate places along the escape routes to prevent spread of fire and smoke.
- The travel distance for fire escape shall not exceed 20 m where escape is available in more than one direction; the distance could be upto 40 m.

B. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Mumbai Fire Services shall be provided through out each station and ancillary buildings including entrance passageways, subways and adits etc. to give visual and audible indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat detecting cables etc. The system shall be operated from 24 V DC Power sources.

Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

Beam detector or heat detector shall be installed at roof level, ceiling and floor cavity, whilst linear detecting cables shall be installed in under platform cable ducts and cable shafts. Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided an installed in the station controllers room, for the control, indication and monitoring of the whole detection and fire fighting systems. While designing the fire fighting system, Mumbai Fire Services shall be taken into account for linking with the same.

C. Fire Control Measures

Control of the spread of fire and smoke will be achieved by partition of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Partition is aimed at limiting the extent of a fire. The openings must be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500 m^2. Partition of the public areas in stations is not practicable for operational reasons. The fire resistance period of this separated area should be about 3 hours.

D. Access for Fireman

A secondary access to the station, not used by passengers for evacuation, shall be available to fireman should the need arise. The entry point shall be easily accessible from the road. Access shall be available to all levels of the station. The minimum width of the stairs is 1.0 m and maximum height should not exceed 25 cm.

E. Emergency Door

The rolling stock is provided with emergency doors at both ends of the cab to ensure directed evacuation of passengers in case of any emergency including fire in the train.

9.15 SUMMARY OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures. Adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A common problem encountered during implementation of environmental management plans of such projects is lack of environmental awareness among engineers and managers concerned with day to day construction activities, which can be solved through regular environmental training programs. A set of preliminary EMP is presented in **Table 9.12,** which defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

The major concern during the construction stage is that the contractors, due to lack of enforcement, would not practice good environmental sanitation (housekeeping) may intend to get unauthorized use of the easily available natural resources and other available infrastructure like roads and water resources. This would result in degradation of ambient air quality, water resources and land environment around the construction sites and workers camp. Improper management of earthwork and bridge construction activities would disrupt the natural drainage and increase soil erosion. Improper management may result in spillage of explosives into the hands of unsocial elements. Finally the implementation of the mitigation actions requires that the project implementation unit would record an end-of-construction mitigation checklist, before releasing the final payment of any work contract.

Additionally, project authority should prepare and establish Environmental and Health Policy and Procedures as per earlier Phases and that should become an integral part of contract document.

Operational phase mitigation would involve good environmental sanitation (housekeeping) practice at metro establishments including effective solid waste collection and disposal, wastewater disposal, upbringing of plantations and green area. Protection of earth slopes in landslide prone area would be a very important task. During the operation period, the metro operating unit will be required to confirm receipt of the construction period mitigation report through the MMRDA and prepare a follow on timetable of actions.

TABLE 9.12 ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMP)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimise the land disturbance to avoid environmentally sensitive areas.	During Design	DPR and design consultant	MMRDA
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	MMRDA
Flood	Bridges shall be well designed	During Design	DPR and design consultant	MMRDA
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	MMRDA
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water for construction purpose etc shall be planned and shall be arranged from available and authorized sources in order to avoid digging of Tube wells.	Pre constructi on stage	Contractor	MMRDA/ EMP implementing agency
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact on receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre constructi	Contractor	MMRDA/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
		on of treatment plant		
Batching Plant and Casting Yard	These facilities to be located away from habitation. Consent to Establish and Consent to Operate to be taken from MPCB and to comply with all stipulations.	During Pre-construction Stage	Contractor	MMRDA/ EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	MMRDA/ EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	MMRDA/ EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards. No vehicle without valid PUC certificate would be allowed at Construction Sites.	Beginning with and continuing throughout construction period	Contractor	MMRDA/ EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet acceptable standards for emissions and will be maintained and operated in a manner that ensures that relevant air, noise, and discharge regulations are met.	During construction	Contractor	MMRDA/ EMP implementing agency
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery to be provided noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	MMRDA/ EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak velocity as given in Environmental Manual	Beginning and through construction	Contractor	MMRDA/ EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into any rivers, drainage and irrigation system	Throughout construction period	Contractor	MMRDA/ EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	MMRDA/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters.	Throughout construction period	Contractor	MMRDA/ EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a tank and disposed off daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.	Before and during building of construction camps	Contractor	MMRDA/ EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only. All environmental mitigation measures shall be enforced at Quarry site also.	During construction	Contractor	MMRDA/ EMP implementing agency
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory Afforestation Policy under the Forest Conservation Act. Ten trees will be planted against every tree felled as per norms.	During and after completion of construction activities	MCGM	MCGM
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	MMRDA/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	MMRDA/ Traffic department
Safety with vehicles, people and livestock and signage	• Safety education and fines. • Allow for adequate traffic flow around construction areas • Provide adequate signage, barriers and flag persons for safety precautions.	During construction	Contractor	MMRDA/ Traffic department
	• Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions			
Increase in disease Water-borne	Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies.	During construction	Contractor	MMRDA/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Insect-borne Communicable diseases	Provide adequate sanitation and waste disposal at construction camps. Provide adequate health care for workers and locate camps away from vulnerable groups, if any	At start-up Throughout construction		
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	MMRDA/ EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	MMRDA/EMP implementing agency	MMRDA/ EMP implementing agency
WATER				
Maintenance of Storm Water Drainage System	The urban drainage systems will be periodically checked and cleared so as to ensure adequate storm water flow.	Beginning and end of monsoon	MMRDA/EMP implementing agency	MMRDA/ EMP implementing agency

9.16 ENVIRONMENTAL MONITORING PLAN

9.16.1 Pre-Construction Phase

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. This helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. Historically, environmental monitoring has been integral part of works of MMRDA towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation. Generation of dust and noise are two main issues during any large construction activity. Degradation of water quality is another. The parameters are monitored in pre-construction, construction and operation phase and are based on the need to evaluate the deviation of environmental conditions from baseline environmental conditions due to construction and operation of the Metro. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored:

- Water Quality,
- Air Quality,
- Noise and Vibration,
- Environmental Sanitation and Waste Disposal
- Ecological Monitoring and Afforestation,
- Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. Pre-construction phase monitoring has been done for the proposed project for air, noise, water, soil quality and ecology.

9.16.2 Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels and water quality. Keeping a broad view of the sensitive receptors and also the past experience of Phase I and II and Mumbai Metro, an estimate of locations has been made and are summarized in **Table 9.13.** The number could be modified based on need when the construction actually commences.

- **Water Quality**

  Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL certified laboratory. Water quality should be analyzed following the procedures given in standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

- **Air Quality**

  Air quality should be monitored at the locations of baseline monitoring as reported in Chapter 3. The parameter recommended is Particulate Matter (PM_{10}). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of project authority.

- **Noise and Vibration**

  The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of project authority.

- **Workers Health and Safety**

  Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites and workers camp will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans. The monitoring Schedule for Water Air, noise and ecology are presented in **Table 9.13.**

TABLE 9.13 CONSTRUCTION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24 hours Twice a month During entire civil construction stage or even later, if directed by MMRDA	2 locations

Item	Parameter	Frequency and Duration	Locations
Water	Groundwater quality (IS 10500:1991)	Once in 6months During entire civil construction stage or even later, if directed by MMRDA	1 locations
Noise	Noise Level (Leq and Lmax)	24hours Once a week During entire civil construction stage or even later, if directed by MMRDA	3 locations
Ecology	Felled and planted trees	Once a year till all trees that were to be planted by Maharashtra Government on behalf of project authority, are planted	All the trees felled and newly planted

9.16.3 Operation Phase

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, water, waste water, solid waste and ecology during operation phase of the project. The parameters monitored during operation will be PM_{10} for air, heavy metals for solid waste, pH, TSS, BOD, COD, oil and grease for waste water. However, water quality parameters that will be monitored will be as per BIS 10500. The monitoring schedule is presented in **Table 9.14**. The monitoring program shall be conducted by an external agency certified by NABL under the supervision of MMRDA. Project proponent (MMRDA) is responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE 9.14 OPERATION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Once a monthFor 3years	2 location
Water	Surface, Groundwater quality (IS 10500:1991)	Once a year For 3years	1+1 location
Noise	Noise Level (Leq)	24hours Once a year For 3years	2 locations (Sensitive Receptors)

The results of Air quality, water quality, waste water will be submitted to management quarterly during construction phase and half yearly during operation phase.

9.17 ESTABLISHMENT OF AN ENVIRONMENTAL DIVISION

MMRDA already has the setup for environmental Management and the proposed corridor is an extension of already existing operative line, additional set-up for environmental management is not recommended. Existing set up for environmental management can also handle this extension.

9.18 COST ESTIMATES

9.18.1 Summary of Costs

All costs involved in Environmental mitigation and management and monitoring to be put on the account of Mumbai Metro Project corridors**.** A summary of these is presented in **Table 9.15.**

Table 9.15 Environmental Costs

S. No.	ITEM	COST Rs. lakh
1.	Rain Water Harvesting at stations and along alignment	42.42
2.	Air, Noise, vibration, Water, Waste Water, Solid waste, during construction and operation	10.00
3.	Ecological monitoring	5.00
4.	Tree Plantation 850trees @ Rs.2000/- per tree	2.94
5.	Water Treatment Plant	120.50
6.	Sewage Treatment Plant	78.00
7.	Effluent Treatment Plant	88.50
8.	Green Belt at Depot	40.00
9.	Rain water harvesting at Depot	35.00
10.	Recycling of treated waste water	41.00
	Total	**463.36**

The compensation for loss of land, fire control, information systems and contractor's obligations have been incorporated in project costs.

The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

Table 9.16 Details of Cost of Resettlement and Rehabilitation (Rs. Lakh)

S. No.	Description	Entitlement	Unit	Quantity	Rate	Amount
1	Acquisition of Permanent land Private Land	Total Replacement Cost of land *	m^2	1926 m^2	0.50	963.00
2	Solatium	100% as per Act 30 of 2013.	m^2	46906 m^2	0.50	963.00
3	Acquisition of temporary private land	6% of total land cost per year for 3 years	m^2	-	-	-
4	Acquisition of structures					
4.1	Residential PAPs	Area equivalent to affected area 20.91 m2 free of cost	Per unit	-		**
4.2	Commercial PAPs	Area equivalent to affected area 20.91 m2 free of cost	Per unit	-		**
5.	Subsistence Allowance ***	For a period of one year @Rs.3000/ month	Family	-	0.36	-
6.	Shifting Allowance ***	A lump sum shifting allowance of Rs. 50,000/-	No.	-	0.50	-

S. No.	Description	Entitlement	Unit	Quantity	Rate	Amount
7.	One time resettlement allowance ***	For All the affected families excluding employees in shops	Per Family	-	0.50	-
8	Employees Transportation cost	12 Quarterly passes for differential distance	LS	-		-
9.	Independent Evaluation		LS		5.00	5.00
10.	Miscellaneous		LS		5.00	5.00
	Cost of R & R					**1931.00**

** Average rate of land for all the stations*
***refers the accommodation is available with MMRDA so additional cost is not given.*
**** applicable for only titleholders.*

9.19 CONCLUSION

The proposed Metro line is proved to have significant positive effects to the development of Mumbai City. Benefits to the economy, traffic congestion reduction, quick and safety transport, employment opportunities, fuel consumption reduction, and air quality improvement are the obvious positive effects from this Metro line. Besides, the potential adverse environmental impacts on air quality (during construction phase), water environment, noise, solid waste, ecology, population resettlement are also taken into consideration. Detailed potential adverse environmental impacts, appropriate mitigation measures have been developed for consideration. The EIA concluded that project impacts from both construction and operation will be minimal, and can be mitigated through the use of prevailing current practices and appropriate technologies. With the implementation of the EMP and the monitoring plan, the Project is not expected to have significant environmental impacts.

TEST REPORT
Water Sample Analysis

Test Report No.	DEMC/15-16/118W	**Sample Particulars**	Ground Water Collected from Manpada, Mumbai
Issue Date	08/04/2016	**Date of Collection**	12/02/2016
Issued To	Centre For Environment Research & Development. LGCS-27A, Ansal Plaza, Sec-03, Vaishali, Gaziabad, UP	**Sample Collected By**	DEMCPL, Manish
		Method of Sampling	IS 3025 & APHA
Job Order No.	DEMC/15-16/118W	**Order Booked by**	Shweta
Date	06/10/2015	**Page**	1of 1

RESULTS

Protocol Used	IS 3025, APHA & IS 1622
Date Of Testing	12/02/2016 to 19/02/2016
Cross Ref No.	IS 10500-2012

Sl No.	Parameter	Result	Permissible Limits (In the absence of alternate source)
1.	Colour, Hazen	Colourless	5 (15) Max
2.	Odour	Un objectionable	Un objectionable
3.	Taste	Agreeable	Agreeable
4.	Turbidity, NTU	3.4	1 (5) Max
5.	PH	7.87	6.5-8.5 Max
6.	Total Hardness as Caco3, Mg/l	243	200 (600) Max
7.	Chloride as Cl, Mg/l	136	250 (1000) Max
8.	Total Iron as Fe, Mg/l	0.08	0.3 Max
9.	Total Dissolved Solids, Mg/l	1478	500 (2000) Max
10.	RFC, Mg/l	Nil	0.2 (1) Max
11.	Sulphates as So4, Mg/l	168	200 (400) Max
12.	Nitrates as No3, Mg/l	64.2	45 Max
13.	Fluorides as F, Mg/l	3.17	1.0 (1.5) Max
14.	Lead as Pb, Mg/l	BDL	0.01 Max
15.	Copper as Cu, Mg/l	BDL	0.05 (1.5) Max
16.	Manganese as Mn, Mg/l	BDL	0.1 (0.3) Max
17.	Phenolic Compound as C6H5OH, Mg/l	BDL	0.001 (0.002) Max
18.	Mercury as Hg, Mg/l	BDL	0.001 Max
19.	Cadmium as Cd, Mg/l	BDL	0.01 Max
20.	Selenium as Se, Mg/l	BDL	0.01 Max
21.	Arsenic as As, Mg/l	BDL	0.05 Max
22.	Cyanide as Cn, Mg/l	BDL	0.05 Max
23.	Zinc as Zn, Mg/l	1.21	5 (15) Max
24.	Detergent as MBAS, Mg/l	BDL	0.2 (1.0) Max
25.	Chromium as Cr+6, Mg/l	BDL	0.05 Max
26.	Total Alkalinity as Caco3, Mg/l	185.2	200 (600) Max
27.	Aluminum as Al, Mg/l	BDL	0.03(2) Max
28.	Boron as B, Mg/l	BDL	0.5(1) Max
29.	**Bacteriological Analysis**		
	Coliform, MPN/100Ml	Nil	10 Max
	E-Coli/Ml	Negative	Negative

Note : BDL: Below Detection Limit

Remark : Terms & Conditions Mentioned Overleaf.

-O-

Authorized Signatory

DIRECTOR

Contact
Phone : +91 11 65000172
Fax : +91 11 28541817
Mob. : +91 9212770212
E-mail : demcdelhi@yahoo.co.in
demc@environment-labs.com
Web. : www.environment-labs.com

Regd. Office / Laboratory:
Dell Environmental Monitoring Centre Pvt. Ltd.
RZ-4A, Sita Puri, Pankha Road, Dabri Mode
Near V D Honda Service Center, New Delhi-45, India

An ISO 9001:2008, ISO 14001:2004 & OHSAS 18001:2007 Certified Laboratory.

DEMC
Where Science makes a splash

TEST REPORT

Ambient Air Quality Analysis

Test Report No.	DEMC/15-16/562AS	**Name of Location**	Manpada
Issue Date	08/04/2016	**Sampling Duration**	24.00 Hrs
Issue To	Centre For Environment Research & Development LGCS-27A,Ansal Plaza,Sec-03 Vaishali,Gaziabad,UP	**Average Flow Rate ForPM10,** (M3/Min)	1.1
Sample Collected By	DEMCPL, Gopal	**Average Flow Rate For Gases,** (LPM)	1.0
Remarks (If Any)	---	**Instrument Used**	RDS with gas attachment
		Method Of Sampling	IS 5182
Date of Sampling	11/02/2016	**Weather Condition**	Clear
Starting Time	12.55 PM (11/02/2016)	**Closing Time**	12.55 PM (12/02/2016)

RESULTS

Sl. No.	Parameter	Results	Regulatory Standards (NAAQS)
1.	Respirable Suspended Particulate Matter - PM-10 (µg/m3)	184	100
2.	Oxides of Sulphur - So2 (µg/m3)	41.3	80
3.	Oxides of Nitrogen – Nox (µg/m3)	51.2	80
4.	Carbon Monoxide for 8 Hours – Co (Mg/M3)	1.86	2.0

Note : NAAQS: National Ambient Air Quality Standard
Remark : Term & Conditions Mentioned Overleaf.

-O-

Authorized Signatory
DIRECTOR

Regd. Office / Laboratory:
Dell Environmental Monitoring Centre Pvt. Ltd.
RZ-4A, Sita Puri, Pankha Road, Dabri Mode
Near V D Honda Service Center, New Delhi-45, India

Contact :
Phone : +91 11 65090172
Fax : +91 11 28541817
Mob. : +91 9212770212
E-mail : demcdelhi@yahoo.co.in
demc@environment-labs.com
Web. : www.environment-labs.com

An ISO 9001:2008, ISO 14001:2004 & OHSAS 18001:2007 Certified Laboratory.

DEMC
Where Science makes a splash

TEST REPORT

Ambient Air Quality Analysis

Test Report No.	DEMC/15-16/563AS	**Name of Location**	Kasawadavali
Issue Date	08/04/2016	**Sampling Duration**	24.00 Hrs
Issue To	Centre For Environment Research & Development LGCS-27A,Ansal Plaza,Sec-03 Vaishali,Gaziabad,UP	**Average Flow Rate ForPM10,** (M3/Min)	1.1
Sample Collected By	DEMCPL, Gopal	**Average Flow Rate For Gases,** (LPM)	1.0
Remarks (If Any)	—	**Instrument Used**	RDS with gas attachment
		Method Of Sampling	IS 5182
Date of Sampling	12/02/2016	**Weather Condition**	Clear
Starting Time	11.20 AM (12/02/2016)	**Closing Time**	11.20 AM (13/02/2016)

RESULTS

Sl. No.	Parameter	Results	Regulatory Standards (NAAQS)
1.	Respirable Suspended Particulate Matter - PM-10 (μg/m3)	191	100
2.	Oxides of Sulphur - So2 (μg/m3)	53.5	80
3.	Oxides of Nitrogen – Nox (μg/m3)	69.1	80
4.	Carbon Monoxide for 8 Hours – Co (Mg/M3)	1.74	2.0

Note : NAAQS: National Ambient Air Quality Standard
Remark : Term & Conditions Mentioned Overleaf.

-O-

Authorized Signatory
DIRECTOR

Regd. Office / Laboratory:
Dell Environmental Monitoring Centre Pvt. Ltd.
RZ-4A, Sita Puri, Pankha Road, Dabri Mode
Near V D Honda Service Center, New Delhi-45, India

Contact :
Phone : +91 11 65090172
Fax : +91 11 28541817
Mob. : +91 9212770212
E-mail : demcdelhi@yahoo.co.in
demo@environment-labs.com
Web. : www.environment-labs.com

An ISO 9001:2008, ISO 14001:2004 & OHSAS 18001:2007 Certified Laboratory.

DEMC
Where Science makes a splash

TEST REPORT

Soil Sample Analysis

Test Report No.	DEMC/15-16/050	**Sample Particulars**	Soil
Issue Date	08/04/2016	**Date of Collection**	12/02/2016
Issued To	Centre For Environment Research & Development LGCS-27A,Ansal Plaza,Sec-03, Vaishali,Gazlabad,UP	**Sample Collected By**	DEMCPL
Sample Collected from	Near kasarwadavali	**Page**	1 of 1

RESULTS

Protocol Used	APHA & ASTM
Date Of Testing	12/02/2016 to 19/02/2016

Sl. No.	Parameter	Result	Permissible Limits (Referred International Standards)
1.	PH	6.85	8.03
2.	Nitrogen as N,%	0.016	0.030
3.	Phosphate as P,%	0.012	0.017
4.	Potassium as K,%	0.015	0.020
5.	Lead as pb, Mg/l	BDL	0.01 Max
6.	Mercury as Hg,Mg/l	BDL	0.0005 Max
7.	Cadmium as Cd,Mg/l	BDL	0.01 Max
8.	Arsenic as as, Mg/l	BDL	0.01 Max
9.	Cyanide as Cn,Mg/l	BDL	ND
10.	Chromium as Cr+6,Mg/l	BDL	0.05 Max

Note : BDL: Below Detection Limit

Remark : Terms & Conditions Mentioned Overleaf

-O-

Authorized Signatory
DIRECTOR

Regd. Office / Laboratory:
Dell Environmental Monitoring Centre Pvt. Ltd.
RZ-4A, Sita Puri, Pankha Road, Dabri Mode
Near V D Honda Service Center, New Delhi-45, India

Contact :
Phone : +91 11 65090172
Fax : +91 11 28541817
Mob. : +91 9212770212
E-mail : demcdelhi@yahoo.co.in
demc@environment-labs.com
Web. : www.environment-labs.com

An ISO 9001:2008, ISO 14001:2004 & OHSAS 18001:2007 Certified Laboratory.

TEST REPORT

Report No.	DEMC/15-16/1072 NS	Client Ref No.	Nil
Issue Date	08/04/2016	Ref. Date	--
Issued To	Centre For Environment Research & Development LGCS-27A,Ansal Plaza,Sec-03 Vaishali,Gaziabad,U.P	Sample Particulars	Ambient Noise Level Monitoring (24 Hours)

MONITORING DETAILS

File Name	Name of Location	Operator Name	Date of Logged
A.ODB B.ODB	Manpada	Mr.Amit	11/02/2016

Range	Freq Wtg.	Sample Time Sec	Instrument Used	Blue Print Active
R2	A	001	SLM 2511/2512	Y

RESULTS

Day Time (6.00 Am-10.00 Pm), dB(A) (A.ODB) Ln

LMax	LMin	Lequ	L10	L50	L90
84.4	58.3	69.1	74.5	63.9	61.1

Night Time (10.00 Pm-6.00Am),dB(A) (B.ODB) Ln

LMax	LMin	Lequ	L10	L50	L90
73.9	51.6	62.5	71.2	56.2	53.9

Allowable Noise Levels dB (A) :

Category of Area/Zone	Day Time	Night Time	
Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control), Rule-2000,PCLS/02/1992,IVth Edition .
Commercial Area	65	55	
Residential Area	55	45	
Silence Area	50	40	

Authorized Signatory

Contact
Phone : +91 11 65090172
Fax : +91 11 28541817
Mob. : +91 9212770212
E-mail : demcdelhi@yahoo.co.in
demc@environment-labs.com
Web. : www.environment-labs.com

Regd. Office / Laboratory:
Dell Environmental Monitoring Centre Pvt. Ltd.
RZ-4A, Sita Puri, Pankha Road, Dabri Mode
Near V D Honda Service Center, New Delhi-45, India

An ISO 9001:2008, ISO 14001:2004 & OHSAS 18001:2007 Certified Laboratory.

DEMC
Where Science makes a splash

TEST REPORT

Report No.	DEMC/15-16/1073 NS	Client Ref No.	Nil
Issue Date	08/04/2016	Ref. Date	--
Issued To	Centre For Environment Research & Development LGCS-27A,Ansal Plaza,Sec-03 Vaishali,Gaziabad,U.P	Sample Particulars	Ambient Noise Level Monitoring (24 Hours)

MONITORING DETAILS

File Name	Name of Location	Operator Name	Date of Logged
A.ODB B.ODB	Kasarwadavali	Mr.Amit	12/02/2016

Range	Freq Wtg.	Sample Time Sec	Instrument Used	Blue Print Active
R2	A	001	SLM 2511/2512	Y

RESULTS

Day Time (6.00 Am-10.00 Pm), dB(A) (A.ODB)

LMax	LMin	Lequ	L10	L50	L90
			Ln		
87.9	62.6	72.8	84.0	68.6	65.1

Night Time (10.00 Pm-6.00Am),dB(A) (B.ODB)

LMax	LMin	Lequ	L10	L50	L90
			Ln		
83.9	51.3	60.6	79.6	57.3	53.8

Allowable Noise Levels dB (A) :

Category of Area/Zone	Day Time	Night Time	
Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control) Rule-2000,PCLS/02/1992,IVth Edition .
Commercial Area	65	55	
Residential Area	55	45	
Silence Area	50	40	

Authorized Signatory

Regd. Office / Laboratory:
Dell Environmental Monitoring Centre Pvt. Ltd.
RZ-4A, Sita Puri, Pankha Road, Dabri Mode
Near V D Honda Service Center, New Delhi-45, India

Contact :
Phone : +91 11 65090172
Fax : +91 11 28541817
Mob. : +91 9212770212
E-mail : demcdelhi@yahoo.co.in
demc@environment-labs.com
Web. : www.environment-labs.com

An ISO 9001:2008, ISO 14001:2004 & OHSAS 18001:2007 Certified Laboratory.

Chapter – 10

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

10.1 INTRODUCTION

The extension of Mumbai Metro Line-4 from Kasarvadavali to Gaimukh will cover 2.668 km length in the Kasarvadavali and Gaimukh area. Line-4 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, 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 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 no significant increase, the Road length on main & arterial Roads may be anticipated which may relieve the congestive/chaotic/slow moving road traffic, a divergent policy of linking commuters directly through E-Rickshaw 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 reason 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 and uncomfortable. 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 with relatively more ease and comfort.

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. 2.55 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.

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. Metro Rail 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

2. Street Design
   - Footpath (Sidewalk)
   - Kerb Ramp
   - Road Intersection
   - Median/Pedestrian Refuge
   - Traffic Signals
   - Subway and Foot Over Bridge

3. Alighting and Boarding Area
   - Approach
   - Car Park
   - Drop-off and Pick-up Areas
   - Taxi/Auto Rickshaw Stand
   - Bus Stand/Stop

11.3 METRO RAIL STATION

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 Metro Rail 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 STATION AREA

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 (Fig. 11.4);
   - 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.

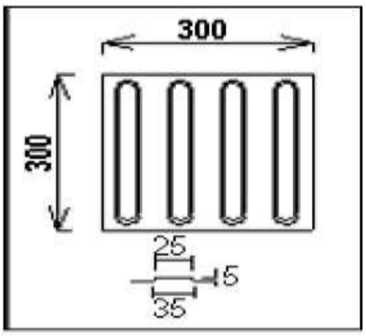


Fig. 11.3 - Guiding paver

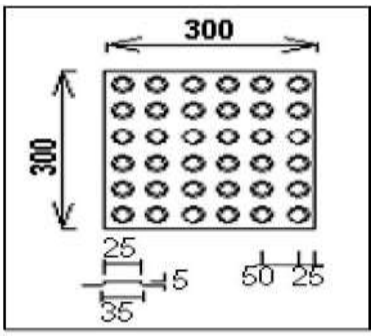


Fig. 11.4 - Warning paver

Fig. 11.5

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. 11.6 - 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 detectable.
- 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 NECESSITY 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;
(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 Array)
    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 Mumbai Metro Corridor No. 04 extension from Kasarvadavali to Gaimukh has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction etc. at June 2017 price level.

While preparing the 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, signaling and telecommunication, have been estimated on rate per route 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-III. A suitable escalation factor has been applied to bring these costs to June 2017 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, CGST, SGST and IGST 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 extension of Mumbai Metro Line-4 (Wadala - Ghatkopar - Mulund - Thane –Kasarvadavali) from Kasarvadavali to Gaimukh at June 2017 price level works out to **Rs.655 Crores** excluding applicable Taxes & Duties of **Rs. 131 crores** as tabulated hereunder.

Table 14.1 – Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Extension of Mumbai Metro Line-4 from Kasarvadavali to Gaimukh	655	131	786

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 minimized as far as possible. Elevated alignment is proposed within the Right of way as far as possible. The land acquisition is required to be done mainly for exit and entries and also for running section at few locations where alignment runs outside the ROW.

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 2013 (MUTP Act), MMRDA Act. 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 @ 5% per year for a period of 4 years have been provided for in project cost estimates.

Details of the land with costs have been shown in the cost estimate.

14.2.2 Formation and Alignment

Elevated section: Entire 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 June 2017 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 metro 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 except for washing lines, repair lines etc. Rates adopted are based on similar works done in Phase-II and ongoing Phase-III works duly updated to June 2017 price level.

14.3 DEPOT

Depot has been planned at Gaimukh for entire Mumbai Metro Line-4: Wadala - Ghatkopar - Mulund - Thane – Kasarvadavali – Gaimukh corridor. A provision of its cost and land was already considered in DPR of Line-4 from Kasarvadavali to Wadala, therefore it is not taken in the cost of this extension.

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- 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 elevated and at-grade section (Depot Connection).

Provisions towards cost of lifts, escalators for elevated 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 June 2017 price level.

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 June 2017 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 June 2017 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 kilometer 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. 2.55 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 @ 5% 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 Extension of Mumbai Metro Line-4 (Wadala - Ghatkopar - Mulund - Thane – Kasarvadavali) from Kasarvadavali to Gaimukh

The overall Capital Cost for Mumbai Metro Line-4 extension from Kasarvadavali to Gaimukh at June 2017 price level works out to **Rs. 655 Crores** excluding applicable Taxes & Duties of **Rs. 131 crores** as tabulated hereunder.

Table 14.2 - Capital Cost Estimate

Total length = 2.668 km (Entirely Elevated)
Total Station (All Elevated) = 2

June 2017 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Government	ha	20.00	0.00	0.00
b	Private	ha	100.00	0.19	19.00
1.2	Temporary Land (@5% pa for 4 years)	ha	4.00	0.00	0.00
1.3	**R & R incl. Hutments etc.**	R. Km.	4.12	3.17	13.05
	Subtotal (1)				**32.05**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	43.36	2.668	115.68
2.2	Depot entry connection	R. Km.	43.36	0.500	21.68
	Subtotal (2)				**137.36**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A)* - civil works	Each	34.16	1	34.16
b	Type (A)*- EM works including lifts and escalators	Each	9.47	1	9.47
e	Type (C)** -civil works	Each	38.11	1	38.11
f	Type (C** -EM works including lifts and escalators	Each	9.47	1	9.47
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.69	4	10.76
	Subtotal (3)				**101.97**
4.0	**P-Way**				
4.1	Ballast less track	R. Km.	9.44	3.17	29.91
	Subtotal (5)				**29.91**
5.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
5.1	Elevated section	R.Km.	11.18	3.17	35.42
	Subtotal (6)				**35.42**
6.0	**Signalling and Telecom.**				
6.1	Sig. & Telecom.	R. Km.	17.02	3.17	53.92
6.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	6.05	2	12.10
	Subtotal (7)				**66.02**
7.0	**Misc. Utilities, road works, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.95 cr/km)** + EM works (4 cr/km)	R. Km.	8.95	3.17	28.35
	Subtotal (8)				**28.35**
8.0	**Rolling Stock (3.2 m wide Coaches)**	Each	10.20	16	163.20
	Subtotal (9)				**163.20**
9.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.08	2.67	0.21
b	EM works etc	R.Km.	0.32	2.67	0.85
	Subtotal (10)				**1.07**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
10.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.91	2.67	5.10
b	EM works etc	R.Km.	0.48	2.67	1.28
	Sub Total (11)				**6.38**
11.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.55	2	5.10
	Sub Total (12)				**5.10**
12.0	**Total of all items except Land**				**587.83**
13.0	**General Charges incl. Design charges @ 5 % on all items except land#**				**29.39**
14.0	**Total of all items including G. Charges except land**				**617.22**
15.0	**Contingencies @ 3 %**				**18.52**
16.0	**Gross Total**				**635.74**
	Cost without land			**=**	**636**
	Cost with land including contingencies on land			**=**	**655**

* **Type (A): Way side station**

** **Type (C): Terminal station**

\# **In accordance with MoUD's letter F.No.K-14011/58/2013-MRTS-I(Vol.I)**

Table 14.3 - Details of Taxes and Duties

Basic Customs duty = 5.1500 %
CGST Customs Duty = 9.4635 %
SGST Customs Duty = 9.4635 %
Total Customs Duty = 24.0770 %
General IGST = 18 %
General CGST = 9 %
General SGST = 9 %

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated, at grade & entry to Depot	137.36		24.73	**24.73**
2	**Station Buildings**				
	Elevated station - civil works	72.27		13.01	**13.01**
	Elevated station - EM works	18.94	0.91	2.73	**3.64**
3	**P-Way**	29.91	5.76	1.08	**6.84**
4	**Traction & power supply**				
	Traction and power supply	35.42	3.41	5.95	**9.36**
5	**S and T Works**				
	S & T	53.92	10.39	3.02	**13.41**
	AFC	12.10	2.18	0.85	**3.03**
	PSD	10.76	2.07	0.60	**2.68**
6	**R & R hutments**	13.05		2.35	**2.35**
7	**Misc.**				
	Civil works	30.40	0.00	5.47	**5.47**
	EM works	10.50	0.00	2.94	**2.94**
8	**Rolling stock**	163.20	34.58	3.53	**38.10**
9	**Rent on Temporary Land**	0.00		0.00	**0.00**
10	**GST on General Charges**	29.39		5.29	**5.29**
	Total	**617.22**	**59.31**	**71.53**	**130.84**
	Total taxes & Duties				**131**
Rate of Taxes & Duties on Total cost without taxes & duties					**21.20%**
Total Central GST & Basic Customs duty					**71.76**
Total State GST					**59.08**
Total State Taxes & Duties					**130.84**

Chapter – 15

Financing Options, Fare Structure And Financial Viability

15.1 INTRODUCTION

The Mumbai Metro Rail Project for extension of Line no. 4 from Kasarvadavali to Gaimukh is proposed to be constructed at an estimated cost of Rs.727.00 Crore with central taxes and land cost. The route length of the proposed metro rail system and estimated cost at June-2017 price level with Land & without taxes, with Land & central taxes and with land & all taxes are placed in table 15.1 as under:

Table 15.1 Cost Details

Sr. No.	Name of Corridor	Distance (km)	Estimated cost with land & without taxes (Rs/Crore)	Estimated cost with land & Central taxes (Rs/Crore)	Estimated cost with land & all taxes (Rs/Crore)
1	Kasarvadavali to Gaimukh	2.668	655.00	727.00	786.00

The estimated cost at June-2017 price level includes an amount of Rs.1.07 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 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 and state taxes has been calculated by taking escalation factor @5% per annum. The taxes and duties consist of Custom Duty (CD), Central Goods and Service Tax (CGST), State Goods and Service Tax (SGST), Integrated Goods and Service Tax (IGST). 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 24.077% {Basic CD @ 5%, IGST (CGST & SGST) @ 18%} on the imported portions, CGST and SGST @ 9% each and IGST @ 18% on indigenously manufactured items have been considered for working out the estimated taxes and duties. The Interest Free Subordinate Debt is repayable in 5 equal instalments after repayment of Multilateral/Overseas Development Assistance Loan. It has been assumed that Maharashtra State Government will exempt the local taxes or reimburse the same and provide the land worth Rs. 35 crore on completion cost basis either free of cost or shall provide Interest Free Subordinate Debt.

It is assumed that the construction work will start on 01.04.2018 and is expected to be completed on 31.03.2022 with Revenue Opening Date (ROD) as 01.04.2022 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	Estimated Cost including cost of land and all taxes & duties at June -2017 Price Level	Completion Cost including cost of land and all taxes & duties
2018-19	54.50	56.00
2019-20	91.50	100.00
2020-21	151.00	173.00
2021-22	226.00	272.00
2022-23	151.00	190.00
2023-24	112.00	149.00
Total	**786.00**	**940.00**

15.2.1.2 Although the construction is expected to get over by 31st March 2022, the cash flow spill over up to March 2024 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.35 crore included in the above completion cost will be provided free of cost by the Maharashtra Government.

15.2.2 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 @ 30 persons per kilometre based on DMRC's current practice. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries. The impact towards IDA Wage revision due with effect from 01.01.2017 has not been considered in FIRR calculation.

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 5.00% per annum. The O&M costs have been tabulated in Table 15.3 as below:

Table 15.3 Operation and Maintenance Costs

Rs. In Crore

YEAR			Staff	Maintenance etc.	Energy	Total
2022	-	2023	5.78	4.00	11.77	21.55
2023	-	2024	6.30	4.20	12.36	22.86
2024	-	2025	6.87	4.41	12.98	24.25
2025	-	2026	7.49	4.63	13.62	25.74
2026	-	2027	8.16	4.86	14.31	27.33
2027	-	2028	8.89	5.11	15.02	29.02
2028	-	2029	9.69	5.36	15.77	30.83
2029	-	2030	10.57	5.63	16.56	32.76
2030	-	2031	11.52	5.91	17.39	34.82
2031	-	2032	12.55	6.21	21.60	40.36
2032	-	2033	13.68	6.52	22.68	42.88
2033	-	2034	14.91	6.84	23.81	45.57
2034	-	2035	16.26	7.19	25.00	48.45
2035	-	2036	17.72	7.55	26.25	51.52
2036	-	2037	19.32	7.92	27.57	54.81
2037	-	2038	21.05	8.32	28.94	58.32
2038	-	2039	22.95	8.74	30.39	62.08
2039	-	2040	25.01	9.17	31.91	66.10
2040	-	2041	27.26	9.63	33.51	70.40
2041	-	2042	29.72	10.11	35.18	75.01
2042	-	2043	32.39	10.62	36.94	79.95
2043	-	2044	35.31	11.15	38.79	85.25
2044	-	2045	38.49	11.71	40.73	90.92
2045	-	2046	41.95	12.29	42.76	97.01
2046	-	2047	45.73	12.91	44.90	103.54
2047	-	2048	49.84	13.55	47.15	110.54

15.2.3 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.

15.2.4 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, 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.

15.3.1.1 Traffic

The projected ridership figures as provided by MMRDA based on their transportation model are indicated in table 15.4 below:

Table 15.4 Projected Ridership

Financial Year	Trips per day (lakhs)
2022-23	1.33

Although the ridership figures provided by MMRDA for Line 4 extension of 2.668 km seems to be on higher side, the FIRR has been calculated based on the projected figures confirmed by MMRDA.

15.3.1.2 Trip Distribution

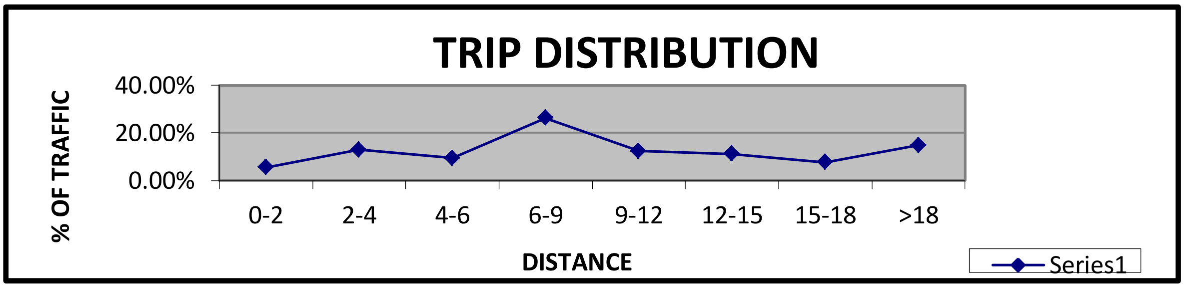
The trip distribution data provided by MMRDA based on their traffic study conducted by them for the year 2022-23 is shown in Table 15.5 below: -

Table 15.5 Trip Distribution

Distance in km	Percent distribution
0-2	5.43%
2-4	12.90%
4-6	9.37%
6-9	26.23%
9-12	12.37%
12-15	11.19%
15-18	7.71%
>18	14.80%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-15.1.

Figure 15.1 –Trip Distribution



15.3.1.3 Fare Structure

The fare structure for the FY 2022-23 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 fare structure has been escalated by using @12.00% once in every two years. The fare structure for the FY 2022-23 as per the proposed fare slabs is shown in the table 15.6 below:

Table 15.6 Fare Structure in 2022-23

Sr. No.	Distance (km)	Proposed Fare (Rs.)
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
8	>18	30

The above fare structure has been taken as furnished by MMRDA with the approval GOM. DMRC proposed that the under mentioned fare structure in a multiple of Rs. 10 be adopted at the time of commissioning of this Line to have convenience in making use of ticket vending machine and eliminate the problems of non-availability of changes for tendering changes to the passengers.

Year 2022-23	
SLAB	**FARE (Rs.)**
0-3 km	10.00
3-12 km	20.00
12-18 km	30.00
18 km and More	40.00

15.3.2 Other Sources of Revenues

Other revenues from Property Development and advertisement have been assumed @ 10% of the fare box revenues during the 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) obtained costs for 30 years business model including construction period is 12.68%. The FIRR with central taxes & duties is produced in Table 15.7:

Table 15.7 – FIRR with Central Taxes

Figs in cr. (Rs.)

Year			Outflow					Cash Flow			
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2018	-	2019	56				56			0	-56
2019	-	2020	100				100			0	-100
2020	-	2021	173				173			0	-173
2021	-	2022	272				272			0	-272
2022	-	2023	190		22		212	94	9	103	-109
2023	-	2024	149	0	23		172	94	9	103	-69
2024	-	2025	0	0	24		24	105	11	116	92
2025	-	2026	0	0	26		26	105	11	116	90
2026	-	2027	0	0	27		27	118	12	130	103
2027	-	2028	0	0	29		29	118	24	142	113
2028	-	2029	0	0	31		31	132	26	158	127
2029	-	2030	0	0	33		33	132	26	158	125
2030	-	2031	0	0	35		35	147	29	176	141
2031	-	2032	0	0	40		40	147	29	176	136
2032	-	2033	0	0	43		43	166	33	199	156
2033	-	2034	0	0	46		46	166	33	199	153
2034	-	2035	0	0	48		48	184	37	221	173
2035	-	2036	0	0	52		52	184	37	221	169
2036	-	2037	0	0	55		55	208	42	250	195
2037	-	2038	0	0	58		58	208	42	250	192
2038	-	2039	0	0	62		62	233	47	280	218
2039	-	2040	0	0	66		66	233	47	280	214
2040	-	2041	0	0	70		70	260	52	312	242
2041	-	2042	0	0	75		75	260	52	312	237
2042	-	2043	0	0	80		80	292	58	350	270
2043	-	2044	0	0	85	121	206	292	58	350	144
2044	-	2045	0	0	91	127	218	327	65	392	174
2045	-	2046	0	0	97	0	97	327	65	392	295
2046	-	2047	0	0	104	0	104	367	73	440	336
2047	-	2048	0	0	111	0	111	367	73	440	329
Total			**940**	**0**	**1433**	**248**	**2621**	**5266**	**1000**	**6266**	**12.68%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 15.8 below:

Table 15.8 – FIRR Sensitivity Analysis

Capital Cost with Central Taxes but without land cost			
20% increase in capital cost	**10% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
10.91%	11.73%	13.78%	14.98%
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**
9.61%	11.23%	14.05%	15.38%

Capital Cost with Central Taxes but without land cost	
O&M COSTS	
10% increase in O&M cost	**10% decrease in O&M cost**
12.37%	13.00%

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, Mumbai Line-3, Nagpur, Lucknow Metro 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), and

(ii) Built, Operate & Transfer (BOT)

15.5.1.1 SPV (DMRC/CMRL/BMRC) Model

The State Government has already formed a fully owned SPV in the name of Mumbai Metro Rail Corporation (MMRC), which is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project.

ODA/Multilateral funding/JICA Loan: - Overseas Development assistance from Japan International Cooperation Agency (JICA) may be availed of for the Mumbai metro rail projects with interest @ 1.40%PA (excluding onetime front end fee @0.20% on the sanctioned loan) by GOI and lend it to the SPV on back to back basis. The loan is repayable in 30 years including moratorium period of 10 years. The loan is being provided by JICA to GOI which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Normally, JICA funds for underground civil including track works, Electrical, Signalling &Telecom and Rolling Stock only. Since the loan will be in Japanese Yen, fluctuation in exchange rate at the time of repayment shall be borne by the Central Government and Government of Maharashtra in proportion to which their share holding. Alternatively, JICA can release the loan to the SPV for which a sovereign guarantee will be required from Central Government. Foreign exchange variation in such eventuality will be borne either by the SPV or GOM. In either case loan shall be repaid by SPV from the income streams of metro operations.

Modified JICA Loan: The union cabinet chaired by the PM has given its approval for modification of existing guidelines of the policy on bilateral official development assistance for Development Corporation from with bilateral partners. As per the discussions with JICA officials, JICA may extend only the modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan is 40 years with 10 years moratorium period. JICA shall fund the project to the extent of 85% of the cost of the project excluding the cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. In case JICA agree to fund the project, the full loan i.e., Rs.499 crore shall be funded by JICA. In that case there will be no need to borrow from Market Borrowing. The loan can also be availed from AFD, KFW, EIB etc whose interest rate is linked with six monthly LIOBOR.

Loan from Asian Development Bank (ADB)/World Bank: - The Loan shall be available from ADB/World Bank, but as per the experience it's processing and approval normally takes 8-12 months. The interest rate is linked with prevailing 6 monthly LIBOR. These bilateral funding institutions also charge some margin ranging from 200 basis points to 300 basis points. Loan from these institutions may delay the implementation of the project resulting in avoidable increase in the completion cost due to time taken during finalization of loan agreement. Recently, Bangalore Metro availed ADB loan; however loan is yet to be disburse.

Loan from Bank and Financial Institutions: - Funds can be arranged from domestic Financial Institutions like India Infrastructure Finance Company Limited (IIFCL), India Development Financing Corporation (IDFC), Life Insurance Corporation of India (LIC), IDBI Bank, ICICI Bank Ltd etc. These institutions are increasingly engaged to fund infrastructure projects subject to their commercial viability against guarantee from GOI. There are many models available under which the funds can be arranged by these financial institutions with or without syndicating with other commercial banks. IIFCL e.g. fund 20% of the project cost and arrange balance through the syndication of commercial banks with a lead banker among the consortium of bankers. The loan can be given for a period of 20-30 years with interest rate ranging from 9.50% to 12% PA. IIFCL can also provide 100% funding against GOI guarantee. They arrange ECB to the extent of foreign currency requirement at very competitive rate. The funding arrangement may require the central government guarantee as well. Since the rate of interest of these financial institutions is much higher than the interest rates of soft loan provided by JICA considering the exchange rate variation will be to GOI & GOM account, GOI and GOM shall have to bear the interest difference and provide suitable subsidy to the SPV to make the project financially sustainable.

The funding pattern under this model (SPV) is placed in table 15.11 as under: -

Table 15.11 Funding pattern under SPV model (with all taxes and land)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	**% of contribution**
Equity By GOI	123.50	14.83%
Equity By GOM	123.50	14.83%
SD for CT by GOM	43.50	5.22%
SD for CT by GOI	43.50	5.22%
2.13% Loan from Multilateral/Overseas Development Agencies (ODA) or 12% Domestic Market Borrowings	499.00	59.90%
Total	833.00	100.00%
SD for Land by GOM	35.00	
SD/Exemption/Reimbursement for State Taxed by GOM	72.00	
Total	940.00	
PTA for Interest During Construction @2.13% (*)	9.00	
Grand Total	949.00	

(*) In the case of loan @12% from domestic borrowings, the IDC works out to Rs.16 crore.

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. The extension of Line 4 of Mumbai Metro project is of 2.668 km only. Accordingly, the BOT operator may not be interested for construction, operation and maintenance of such a small interchange extension.

15.6. RECOMMENDATIONS

The FIRR of the corridor with all taxes and land is 12.68%. Considering the positive FIRR, 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 detail given below:

Option	Table No.
SPV Model with Multilateral/ODA Loan	15.12
SPV Model with Market Borrowings	15.13

The funding pattern assumed under SPV model with Multilateral/ODA Loan or Market Borrowing is depicted in the pie chart i.e., Figure 15.2 as under: -

Figure 15.2
Funding pattern under SPV Model

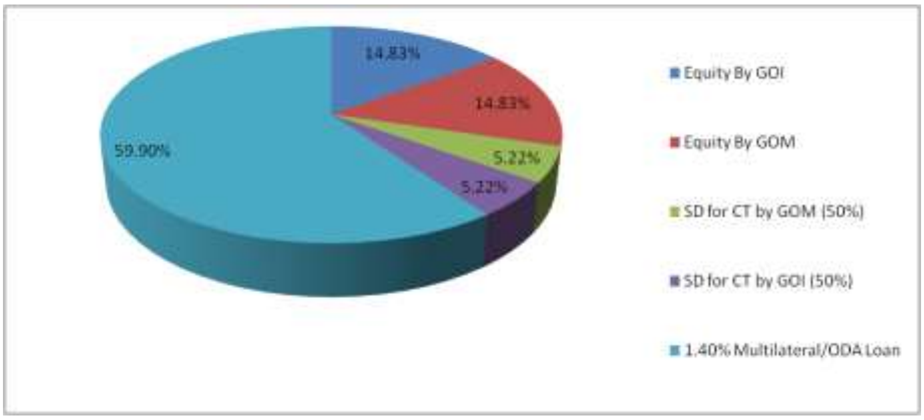


Table 15.12

Mumbai Metro (Kasarvadavali to Gaimukh) Corridor

CAPITAL COST-FIXED	727	MB	0%	0.00%
CAPITAL COST - CURRENT	940	Multilateral Loan	2.13%	100.00%
DOMESTIC FUNDING - BASE CASE		Front end Fee (one time)	1.50%	
		Tenure of JICA Loan	4+16 Years	

MB	0.00%	
Multilateral Loan	2.13%	
Front end Fee (one time)	2.13%	

	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	2018 - 2019	56					56			0	-56	79	23	23	0	0	0	0	0				
2	2019 - 2020	100					100			0	-100	120	20	43	0	0	0	0	0				
3	2020 - 2021	173					173			0	-173	102	-71	-28	28	28	0	7	35				
4	2021 - 2022	272					272			0	-272	101	-171	-199	199	171	0	2	208				
5	2022 - 2023	190		22	28		212	94	9	103	-109	39	-151	-350	350	151	32		327	6	47	43	43
6	2023 - 2024	149	0	23	28		172	94	9	103	-69	0	-149	-499	499	149	32		445	9	43	40	83
7	2024 - 2025	0	0	24	28		24	105	11	116	92		0	-499	499	0	32		413	9	55	51	134
8	2025 - 2026	0	0	26	28		26	105	11	116	90		0	0	0	0	32		381	9	53	49	183
9	2026 - 2027	0	0	27	28		27	118	12	130	103		0	0	0	0	32		349	8	67	63	246
10	2027 - 2028	0	0	29	28		29	118	24	142	113		0	0	0	0	32		318	7	78	74	320
11	2028 - 2029	0	0	31	28		31	132	26	158	127		0	0	0	0	32		286	7	92	88	409
12	2029 - 2030	0	0	33	28		33	132	26	158	125		0	0	0	0	32		254	6	91	87	496
13	2030 - 2031	0	0	35	28		35	147	29	176	141		0	0	0	0	32		222	5	108	104	600
14	2031 - 2032	0	0	40	28		40	147	29	176	136		0	0	0	0	32		191	5	103	100	699
15	2032 - 2033	0	0	43	28		43	166	33	199	156		0	0	0	0	32		159	4	124	120	819
16	2033 - 2034	0	0	46	28		46	166	33	199	153		0	0	0	0	32		127	3	122	118	937
17	2034 - 2035	0	0	48	28		48	184	37	221	173		0	0	0	0	32		95	3	142	139	1076
18	2035 - 2036	0	0	52	28		52	184	37	221	169		0	0	0	0	32		64	2	139	135	1211
19	2036 - 2037	0	0	55	28		55	208	42	250	195		0	0	0	0	32		32	1	166	162	1373
20	2037 - 2038	0	0	58	28		58	208	42	250	192		0	0	0	0	32		0	1	163	160	1532
21	2038 - 2039	0	0	62	28		62	233	47	280	218		0	0	0	0	0		0	0	190	218	1750
22	2039 - 2040	0	0	66	28		66	233	47	280	214		0	0	0	0	0		0	0	186	214	1964
23	2040 - 2041	0	0	70	28		70	260	52	312	242		0	0	0	0	0		0	0	214	242	2206
24	2041 - 2042	0	0	75	28		75	260	52	312	237		0	0	0	0	0		0	0	209	237	2443
25	2042 - 2043	0	0	80	28		80	292	58	350	270		0	0	0	0	0		0	0	242	270	2713
26	2043 - 2044	0	0	85	32	121	206	292	58	350	144		0	0	0	0	0		0	0	233	144	2857
27	2044 - 2045	0	0	91	36	127	218	327	65	392	174		0	0	0	0	0		0	0	265	174	3031
28	2045 - 2046	0	0	97	36	0	97	327	65	392	295		0	0	0	0	0		0	0	259	295	3326
29	2046 - 2047	0	0	104	36	0	104	367	73	440	336		0	0	0	0	0		0	0	300	336	3662
30	2047 - 2048	0	0	111	36	0	111	367	73	440	329		0	0	0	0	0		0	0	293	329	3991
		940	**0**	**1433**	**764**	**248**	**2621**	**5266**	**1000**	**6266**	**12.68%**	**441**				**499**	**508**	**9**		**86**	**3983**	**3991**	
											3645												

Table 15.13

Mumbai Metro (Kasarvadavali to Gaimukh) Corridor

CAPITAL COST-FIXED 727

CAPITAL COST - CURRENT 940

DOMESTIC FUNDING - BASE CASE

MARKET BORROWING 12.00%

	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertiseme nt	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	2018 - 2019	56					56			0	-56	79	23	23	0	0	0	0	0				
2	2019 - 2020	100					100			0	-100	120	20	43	0	0	0	0	0				
3	2020 - 2021	173					173			0	-173	102	-71	-28	28	28	0	2	30				
4	2021 - 2022	272					272			0	-272	101	-171	-199	199	171	0	14	215				
5	2022 - 2023	190		22	29		212	94	9	103	-109	39	-151	-350	350	151	0		366	35	17	46	46
6	2023 - 2024	149	0	23	29		172	94	9	103	-69	0	-149	-499	499	149	52		463	53	-2	-25	21
7	2024 - 2025	0	0	24	29		24	105	11	116	92		0	-499	499	0	52		411	56	7	-16	6
8	2025 - 2026	0	0	26	29		26	105	11	116	90		0	0	0	0	52		359	49	12	-11	-6
9	2026 - 2027	0	0	27	29		27	118	12	130	103		0	0	0	0	52		307	43	31	8	2
10	2027 - 2028	0	0	29	29		29	118	24	142	113		0	0	0	0	52		255	37	47	24	26
11	2028 - 2029	0	0	31	29		31	132	26	158	127		0	0	0	0	52		203	31	67	44	71
12	2029 - 2030	0	0	33	29		33	132	26	158	125		0	0	0	0	52		151	24	72	49	120
13	2030 - 2031	0	0	35	29		35	147	29	176	141		0	0	0	0	52		99	18	94	71	190
14	2031 - 2032	0	0	40	29		40	147	29	176	136		0	0	0	0	52		47	12	95	72	263
15	2032 - 2033	0	0	43	29		43	166	33	199	156		0	0	0	0	47		0	6	121	103	366
16	2033 - 2034	0	0	46	29		46	166	33	199	153		0	0	0	0	0		0	0	124	153	519
17	2034 - 2035	0	0	48	29		48	184	37	221	173		0	0	0	0	0		0	0	144	173	692
18	2035 - 2036	0	0	52	29		52	184	37	221	169		0	0	0	0	0		0	0	140	169	861
19	2036 - 2037	0	0	55	29		55	208	42	250	195		0	0	0	0	0		0	0	166	195	1056
20	2037 - 2038	0	0	58	29		58	208	42	250	192		0	0	0	0	0		0	0	163	192	1248
21	2038 - 2039	0	0	62	29		62	233	47	280	218		0	0	0	0	0		0	0	189	218	1466
22	2039 - 2040	0	0	66	29		66	233	47	280	214		0	0	0	0	0		0	0	185	214	1680
23	2040 - 2041	0	0	70	29		70	260	52	312	242		0	0	0	0	0		0	0	213	242	1922
24	2041 - 2042	0	0	75	29		75	260	52	312	237		0	0	0	0	0		0	0	208	237	2159
25	2042 - 2043	0	0	80	29		80	292	58	350	270		0	0	0	0	0		0	0	241	270	2429
26	2043 - 2044	0	0	85	33	121	206	292	58	350	144		0	0	0	0	0		0	0	232	144	2573
27	2044 - 2045	0	0	91	37	127	218	327	65	392	174		0	0	0	0	0		0	0	264	174	2747
28	2045 - 2046	0	0	97	37	0	97	327	65	392	295		0	0	0	0	0		0	0	258	295	3042
29	2046 - 2047	0	0	104	37	0	104	367	73	440	336		0	0	0	0	0		0	0	299	336	3378
30	2047 - 2048	0	0	111	37	0	111	367	73	440	329		0	0	0	0	0		0	0	292	329	3707
		940	**0**	**1433**	**790**	**248**	**2621**	**5266**	**1000**	**6266**	**12.68%**	**441**				**499**	**515**	**16**		**363**	**3680**	**3707**	
											3645												

Chapter – 16

ECONOMIC APPRAISAL

16.0 ALIGNMENT DESCRIPTION AND ISSUES

Traffic study was conducted for Wadala to Kasarvadavali Metro Corridor (Mumbai Line 4) and ridership was estimated. Revenue earning length of the entire section is 32.691 km. In the present chapter, the section namely Kasaravadavali-Gaimukh (length 2.7 km), which an extended part of the Metro Line 4 is considered for the economic appraisal. Traffic input will be the boarding on the stations within the section and the passenger km travelled within the section. All other parameter values will remain unchanged.

At June-2017 price level estimated cost with all taxes, Octroi & land cost (Rs/Crore) is derived as Rs. 727 Cr. which is the sum of different cost components such as Civil Construction, Rolling Stock, Electrical Work, Signalling, Electronics and telecommunication equipments, land cost etc. Recurring costs include Power consumption, Staff Cost and Other Maintenances. These are distributed year wise known as cost stream. Details may be seen in the Financial appraisal chapter.

16.1 INTRODUCTION TO ECONOMIC APPRAISAL METHODOLOGY

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 the fuel and vehicle maintenance cost which are estimated from market cost. Economic factors which are used for each component 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	100%
2	Maintenance Cost	100%
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%

	Cost/Benefit Components	Economic Factors
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. 1.07/min (2017 value)	Weighted value of Travel Time is derived from the cost paid for average length travel (table 16.4) minus respective vehicle operation cost (table 16.3) for same length for every mode used (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. 1.0/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km
9	3.59 min/km	Average Time Saved for average trip length (km) journey after Shifting (Derived from modal split -Table 16.7 and speed and delay survey) and then multiplied by mode wise journey discomfort factor
10	24.54 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 charge is taken as Rs. 8 per KWH.

Table 16.4 Journey Time, VOC and Time Cost

Mode	Initial Fare	Running Fare	VOC /passenger km (Rs.)	Time Cost /passenger km (Rs.)
Bus	10	0.5	0.66	0.826
Train	10	0.1	0.05	1.042
Two Wh.	10	2	1.67	1.291
Four Wh.	25	12.5	5.69	9.326
Three Wh.	20	10	2.60	9.358
Private Bus & Others	10	0.6	0.70	0.885

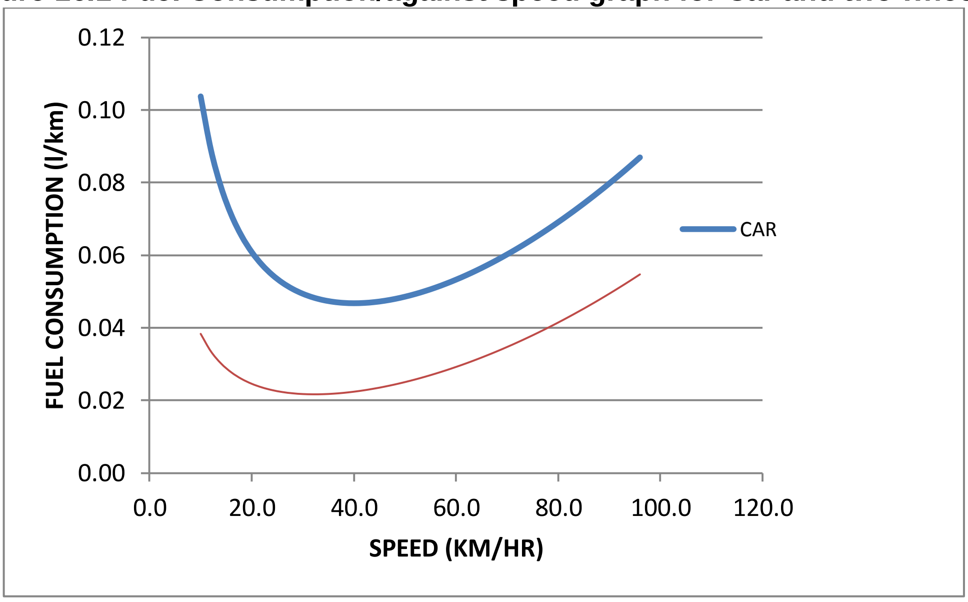
Table 16.5: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

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 16.6: 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 tables 16.7.

Table 16.7: Summary of the Ridership for MUMBAI Line 4 (Kasarvadavali to Gaimukh)

Particulars	2021	2031	2041
Trips/day	133480	159440	190449
Average Trip length km	2.50	2.50	2.50
Passenger km	333700	398600	476122
Passenger km/km	123593	147630	176342

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 16.8.

Table 16.8 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. Tables 16.9, show components of benefit values (economic) .

Table 16.9 Stream of Economic Benefit Values for MUMBAI Line 4 (Kasarvadavali to Gaimukh)

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
2022	2023	101.67	20.93	6.49	0.94	0.13	1.88	0.13	1.70	133.87
2023	2024	109.75	22.43	6.94	1.00	0.14	2.08	0.14	1.75	144.24
2024	2025	118.48	24.03	7.42	0.92	0.15	2.27	0.16	1.80	155.24
2025	2026	127.90	25.77	7.93	0.82	0.16	2.48	0.18	1.85	167.09
2026	2027	135.64	27.10	8.33	0.86	0.17	2.28	0.19	1.87	176.43
2027	2028	146.43	29.06	8.90	0.92	0.18	2.46	0.21	1.92	190.08
2028	2029	158.07	31.07	9.51	0.98	0.20	2.65	0.23	1.97	204.68
2029	2030	170.64	33.32	10.17	1.05	0.21	2.85	0.25	2.03	220.52
2030	2031	184.21	35.61	10.86	1.12	0.22	3.06	0.27	2.09	237.44
2031	2032	198.85	38.19	11.61	1.20	0.24	3.33	0.29	2.15	255.86
2032	2033	214.67	40.78	12.41	1.28	0.26	3.61	0.32	2.21	275.53
2033	2034	231.74	43.74	13.27	1.37	0.27	3.90	0.35	2.27	296.91
2034	2035	250.16	50.92	15.47	1.60	0.29	4.76	0.42	2.54	326.17
2035	2036	274.90	55.60	16.83	1.74	0.32	5.22	0.46	2.66	357.74
2036	2037	291.53	58.27	17.67	1.83	0.33	5.52	0.49	2.69	378.33
2037	2038	314.71	62.51	18.89	1.96	0.36	5.94	0.53	2.76	407.65
2038	2039	339.73	66.65	20.19	2.09	0.38	6.38	0.57	2.84	438.84
2039	2040	415.33	80.97	24.43	2.53	0.46	7.76	0.70	3.31	535.49
2040	2041	444.20	85.73	25.87	2.68	0.49	8.25	0.75	3.37	571.33
2041	2042	475.08	90.77	27.39	2.84	0.52	8.76	0.80	3.43	609.59
2042	2043	508.10	96.11	29.01	3.00	0.55	9.31	0.85	3.49	650.42
2043	2044	543.43	101.76	30.71	3.18	0.58	9.90	0.91	3.55	694.02
2044	2045	581.20	107.74	32.52	3.37	0.62	10.52	0.97	3.62	740.55
2045	2046	621.60	114.08	34.43	3.56	0.65	11.18	1.03	3.68	790.22
2046	2047	664.81	120.78	36.46	3.77	0.69	11.88	1.10	3.75	843.25
2047	2048	711.03	127.89	38.60	4.00	0.73	12.63	1.17	3.82	899.86

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 2018-19 to 2047-48 out of which 5 years (2018-2023) are marked as construction period. In 2043-45 major repairing and replacement cost is envisaged. Operation is expected to start in 2022-23 (5th Year).

To obtain economic cost, escalation factors (5%) are removed from the completion cost. Tax is removed from fixed cost which is 12.38%. 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 16.10.**

Table 16.10: 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
2018	2019	56	0	49	0
2019	2020	100	0	83	0
2020	2021	173	0	137	0
2021	2022	272	0	206	0
2022	2023	190	22	137	16
2023	2024	149	23	102	16
2024	2025	0	24	0	16
2025	2026	0	26	0	16
2026	2027	0	27	0	16
2027	2028	0	29	0	16
2028	2029	0	31	0	17
2029	2030	0	33	0	17
2030	2031	0	35	0	17
2031	2032	0	40	0	19
2032	2033	0	43	0	19
2033	2034	0	46	0	19
2034	2035	0	48	0	19
2035	2036	0	52	0	20
2036	2037	0	55	0	20
2037	2038	0	58	0	20
2038	2039	0	62	0	20
2039	2040	0	66	0	21
2040	2041	0	70	0	21
2041	2042	0	75	0	21
2042	2043	0	80	0	22
2043	2044	121	85	31	22

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2044	2045	127	91	31	22
2045	2046	0	97	0	23
2046	2047	0	104	0	23
2047	2048	0	111	0	24

16.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **Table 16.11.** Project period is 2017-2047,

On the basis of **completion** cost, EIRR is **18.35%,** B/C Ratio is 4.08 and NPV is 8080 Cr, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **23.06%,** B/C ratio as 8.36 and NPV as 9421 Cr. With 12 % discount, EIRR (completion cost) is **5.67%** and B/C ratio is 1.59. NPV is Rs 534 Cr. and with 12% discount rate, EIRR (economic cost) is **9.88%** and B/C ratio is 2.30. NPV is Rs 812 Cr.

Table 16.11: Economic Indicator Values

KASARVADAVALI-GAIMUKH	(Completion Cost Basis)		(Economic Cost)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	2621	904	1280	626
Cumulative benefit(Cr.)	10701	1438	10701	1438
Benefit Cost Ratio	4.08	1.59	8.36	2.30
NPV(Cr.)	8080	534	9421	812
EIRR	18.35%	5.67%	23.06%	9.88%

16.6 Sensitivity Analysis for KASARVADAVALI-GAIMUKH

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 16.12A** (Completion Cost basis) and **table 16.12B** (Economic Cost basis). 2047-48 is taken for the year of comparison.

Table 16.12A Sensitivity of EIRR (Completion Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	18.35%	4.08	2621	5.67%	1.59	904
-10%	0%	16.79%	3.67	2621	4.28%	1.43	904
-20%	0%	15.14%	3.27	2621	2.80%	1.27	904
0%	10%	16.93%	3.71	2883	4.41%	1.45	995
0%	20%	15.70%	3.40	3145	3.31%	1.33	1085
-10%	10%	15.45%	3.34	2883	3.08%	1.30	995
-20%	20%	12.74%	2.72	3145	0.66%	1.06	1085

Sensitivity analysis in **table 16.12A** 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 12.74%.

Table 16.12B Sensitivity of EIRR (Economic Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	23.06%	8.36	1280	9.88%	2.30	626
-10%	0%	21.35%	7.52	1280	8.35%	2.07	626
-20%	0%	19.57%	6.69	1280	6.76%	1.84	626
0%	10%	21.51%	7.60	1408	8.49%	2.09	689
0%	20%	20.17%	6.97	1536	7.30%	1.91	752
-10%	10%	19.90%	6.84	1408	7.05%	1.88	689
-20%	20%	17.04%	5.57	1536	4.50%	1.53	752

Sensitivity analysis in **table 16.12B** 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 17.04%.

16.7 QUANTIFIED BENEFITS

Benefits which are shown in previous tables are money value of the benefits. These benefits are first quantified and then converted into money value. For brevity, only 5 year estimates (2024-2028) are shown in **table 16.13** (Reduction of Vehicle gas Emission). It is seen that reduction of CO2 will be 2592 tons in 2024 and particulate matters (PM) is reduced by 1.28 tons in 2024.

Table 16.13 Environmental Benefits Quantified for option 3

Tons/Year	2024	2025	2026	2027	2028
CO	29.08	29.60	30.13	30.67	31.22
HC	10.09	10.27	10.45	10.64	10.83
NOX	13.14	13.38	13.62	13.86	14.11
PM	1.28	1.30	1.32	1.35	1.37
SO2	0.10	0.10	0.10	0.10	0.11
CO2	2592	2638	2685	2733	2782
Total Emission Saved	2645	2693	2741	2790	2840

From **Table 16.14**, it may be seen that in 2024, due to shifting, metro passengers time saving will be 1.51 Cr. (10 million) hour, fuel saving by metro passengers will be 2.82 thousand tons. Amount of travel in terms of passenger km reduced due to shifting to Metro Rail is 1.84 Cr. KM which is equivalent to reduction of 986 vehicles from the road. About 0.41 fatal accidents and 2.94 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the area.

Table 16.14 Travel Benefits Quantified for option 3

Quantified Benefits in Horizon Years	2024	2025	2026	2027	2028
Annual Time Saved by Metro Passengers in Cr. Hr.	1.51	1.55	1.59	1.64	1.68
Annual Fuel Saved by Metro	2.82	2.88	2.93	3.00	3.05

Quantified Benefits in Horizon Years	2024	2025	2026	2027	2028
Passengers in thousand Tons.					
Daily vehicles reduced (off the road)	986	1004	1022	1040	1059
CO2 reduced in thousand tons	2.59	2.64	2.69	2.73	2.78
Other gases reduced in thousand tons	0.05	0.05	0.06	0.06	0.06
Reduced No of Fatal Accidents in Year	0.41	0.42	0.42	0.43	0.44
Reduced No of Other Accidents in year	2.94	2.99	3.05	3.10	3.16
Annual Vehicle km Reduced in Cr. Km.	1.84	1.87	1.91	1.94	1.98

Chapter – 17

IMPLEMENTATION

17.1 INTRODUCTION

The extension of Mumbai Metro Corridor Line-4 (Wadala - Ghatkopar - Mulund - Thane – Kasarvadavali) from Kasarvadavali to Gaimukh is 2.668 km long with 2 stations and the entire extension is elevated.

Estimated Cost of the project at June 2017 price level with all taxes and duties including land cost is Rs. 786.00 crores. Completion cost with all taxes and duties and escalation at 5.0% p.a. is estimated to be Rs.940 Crores including land.

It is recommended that Government of India will fund the central taxes and duties to the extent of 50% through grant by subordinate debt. The State Government will also contribute 50% of the Central taxes and duties.

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 KASARVADAVALI – GAIMUKH EXTENSION

World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for this corridor is **12.68%.**

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 km 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 this extension of Mumbai Metro Line-4 from Kasarvadavali to Gaimukh.

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

Same implementation strategy may be adopted for this extension also as it is being used for implementation of Mumbai Metro Line-4 from Wadala to Kasarvadavali.

17.6 CONTRACT PACKAGES FOR IMPLEMENTATION OF THE PROJECT

As this is a small extension of Line-4, therefore it is proposed to include this section in Contract Package-3 mentioned in DPR of Mumbai Metro Line-4 submitted in May 2016.

Contract Package-3, instead of upto Kasarvadavali Dead end it can now be upto Gaimukh Dead end.

17.7 IMPLEMENTATION SCHEDULE

MMRDA has already initiated the work of Mumbai Metro Line-4 from Wadala to Kasarvadavali. As this is an extension of Line-4, thus it can be implemented along with that corridor.

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 MMRDA. 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.
- GST on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- GST on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- GST 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 State Goods and Services Tax (SGST) 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 Metro Corridor may 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.

रजिस्ट्री सं॰ डी॰ एल॰-33004/99

REGD. NO. D. L.-33004/99

भारत का राजपत्र

The Gazette of India

असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

प्राधिकार से प्रकाशित

PUBLISHED BY AUTHORITY

सं. 1418] नई दिल्ली, सोमवार, सितम्बर 7, 2009/भाद्र 16, 1931

No. 1418] NEW DELHI, MONDAY, SEPTEMBER 7, 2009/BHADRA 16, 1931

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

Printed by the Manager, Govt. of India Press, Ring Road, Mayapuri, New Delhi-110064 and Published by the Controller of Publications, Delhi-110054.

रजिस्ट्री सं॰ डी॰ एल॰—(एन)04/0007/2003—09 REGISTERED NO. DL—(N)04/0007/2003—09

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग II — खण्ड 1
PART II — Section 1
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं॰ 38] नई दिल्ली, बृहस्पतिवार, अगस्त 27, 2009/भाद्र 5, 1931
No. 38] NEW DELHI, THURSDAY, AUGUST 27, 2009 / BHADRA 5, 1931

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

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009. Short title and commencement

(*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:—

2 of 1985. '(*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;'.

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.

24 of 1989. "(*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.".

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.

T.K. VISWANATHAN,
Secretary to the Govt. of India.

PRINTED BY THE GENERAL MANAGER, GOVT. OF INDIA PRESS, MINTO ROAD, NEW DELHI
AND PUBLISHED BY THE CONTROLLER OF PUBLICATIONS, DELHI, 2009

GMGIPMRND—3842GI(S5)—28-8-2009

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 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. It is proposed to take a new Metro Rail Corridor from Wadala - Ghatkopar - Mulund - Thane – Kasarvadavali – Gaimukh immediately for implementation.

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 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.

Estimated Cost of this extension at June 2017 price level is 786.00 Crore with all the taxes and duties including land and completion cost at 5.0% p.a. escalation is estimated to be Rs.940 Crores including all the taxes & duties and land cost.

18.2 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 the 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 12% every two years.

18.5 As in the case of Delhi Metro, the State Government should exempt/reimburse the State Goods and Services Tax (SGST) to MMRC/MMRDA. 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/MMRDA.

18.7 Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR)

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **12.68%.** The Economic Internal Rate of Return (EIRR) works out to **18.35%.**

18.8 It is recommended to implement this project under SPV model.

18.9 Meanwhile the State Government should freeze all future developments along the proposed route of Kasarvadavali – Gaimukh Metro extension to avoid in-fructuous expenditure.

18.10 It is recommended the State Govt. should set up a non-lapsable, 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.

Appendix

MMRDA's Comments/Observations & DMRC's Responses on Extension of Mumbai Metro Line 4 from Kasarvadavali to Gaimukh.

Sr. No.	Chapter No. /Section/ Page No.	Comments/Observations	DMRC's response
1.	Chapter 1, Section 1.3, Page No. 44, Envisaged Transport Network of MMR.	The monorail network to be updated as per current scenario.	Current scenario of MMRDA is not available with DMRC. Kindly provide the same to update in the DPR.
2.	Section 0.6.3, Executive Summary, Page No. 22, Year wise Rake Requirement	According to the office Memorandum of GoI the standardization of Rolling Stock & signalling systems for Metro Rail the rakes should be 6/9 rather than 8 as considered for Kasarvadavali to Gaimukh.	As it is extension of Line 4 which has been submitted with 8 car rake configuration. Hence, same rake for configuration has been adopted.
3.	Chapter 3, System Design 3.4.3, page no. 77, Telecommunication System and Transmission Media	Keeping in view latest technological developments IP based fault tolerant Ethernet Network may be catered.	It is already mentioned in the same page that "Alternatively totally IP based High capacity, high reliable & fault tolerant Ethernet network (MAN/LAN) can be provided in lieu of SDH backbone." It can be considered.
4.	Chapter 3, System Design, 3.3.3.1.2, Page No. 73, Automatic Train Operation (ATO)	ATO should cater for Unattended Train Operation also.	This DPR is for Metro Line 4 extension from Kasarvadavali to Gaimukh (only two station/depot). Signalling system recommended for Line-4 (Wadala to Kasarvadavali). Should be same for its extension (Kasarvadavali to Gaimukh). No UTO is proposed for this extension as the same has not been recommended for this corridor between Wadala to Kasarvadavali.
5.	Chapter No. 8, Power Supply Arrangements Section/chapter no. 8.13, Page No. 198	Since, the sub-chapter i.e. "Sewage Treatment System Using Integrated Construction Wetlands (ICW)" is not dealing with electric and power, therefore it cannot be the part of Power and Supply arrangement chapter. It may be considered in Environment and social Impact Assessment Chapter.	As per DMRC practice, RSS tender of Electrical and Civil are combined and executed by Electrical Wing with concern to Civil work therefore, **"Sewage Treatment System Using Integrated Construction Wetlands (ICW)"** is considered as a part of Receiving Sub-Station. Hence included in Power Supply Chapter.
6.	Chapter 14- Cost Estimate Table 14.2 – Capital Cost Estimate	The length of metro line considered for calculation is not uniform. Some places its 3.17 km and other it is 2.67 (Actual total	The length of extension is 2.67 km. It is 3.17 km including 0.5 km length of depot connection. 3.17 km

Sr. No.	Chapter No. /Section/ Page No.	Comments/Observations	DMRC's response
		length is 2.668 km) Total length of 2.668 km quantity should be considered for all items calculations.	length has been considered for all cost calculation except for security and staff quarters.
7.	Cover Page	On cover page "Client" word need to be removed.	Deleted
8.	Station Length	Station length need to be increased according to the 6/9 no. of cars per rake.	As it is extension of Line 4, therefore, station length will remain same as it is for line 4.
9.	Headway	The headway for 6 cars per rake is 3.75min for line-4 and including extension it is 5 min for 8 cars. Due to increase in headway, the waiting/dwelling time (Of Passenger) also increases which may need more capacity for platforms (due the cumulative passenger). Therefore the headway need to be maintain 3.75 min for entire line-4 including extension.	As extension is on the one end of the corridor. PHPDT on the ends of Corridor remains less. All trains will not run from end to end. Hence, headway at the ends may be more.
10.	Chapter 15 financial Options, fare structure & financial viability	The excel sheet for calculation taken for escalation is need to be submitted to MMRDA to calculated escalation of civil and other component.	Will be provided.
11.	Alignment Drawing	Alignment drawing soft & hard copy of the corridor is needed for checking the horizontal and vertical curves. Kindly submit the same.	Will be submitted.
12.	Chapter 3, System Design, General Remarks	Since metro line 4 is proposed to be extended to Gaimukh, Signalling & Telecommunication system as well as AFC systems should be planned exactly in the same manner as for Line 4. The system will have to be procured from the same vendor who shall be selected for Line-4.	Noted. Exact same signalling. Telecommunication & AFC System are recommended for Line – 4 extension in DPRs similar to Line – 4.
13.	Depot Location	The depot is located in Gaimukh which is comes under small CRZ area and it is available 15 hectare land without CRZ so, the feasibility of the same need to be check.	Length of this line from Wadala to Kasarvadavali is 32.322 km. Kasarvadavali to Gaimukh is 2.67 km. Total length is 34.99 km. It is also proposed to extend this line 11.00 km to Mira Bhayander and 13.322 km. from Wadala to CST. Thus total length will be 59.312 km. It is not possible to accommodate depot for 59.3km length in 15 Ha land. In fact, one more depot will be required for this line.

ABBREVIATIONS

AAQM	:	Ambient Air Quality Monitoring
AC	:	Alternating Current
ACC/POL	:	Accident/Pollution
ADB	:	Asian Development Bank
AFC	:	Automatic Fare Collection
AMC	:	Additional Metropolitan Commissioner
APL	:	Above Poverty Line
ASHARE	:	American Society of Heating And Refrigeration Engineering
ATP	:	Automatic Train Control
BGL	:	Below Ground Level
BIS	:	Bureau of Indian Standards
BMS	:	Building Management System
BPL	:	Below Poverty Line
BS	:	British Standard
CATC	:	Continuous Automatic Train Control
CCTV	:	Closed-Circuit Television
CBTCS	:	Communication Based Train Control System
CENELEC	:	Committee European De Normalization Electro Technique
CER	:	Certified Emission Reductions
CIBSE	:	Chartered Institute of Building Services Engineering
CIDCO	:	City & Industrial Development Corporation Of Maharashtra Ltd.
CMH	:	Cubic Meter Hour
CPCB	:	Central Pollution Control Board
CRZ	:	Coastal Regulation Zone
CSTM	:	Chhatrapati Shivaji Terminus
CTS	:	Comprehensive Transportation Study
CWR	:	Continuous Welded Rails
DB	:	Dry Bulb
DC	:	Direct Current
DCBM	:	Dahisar - Charkop - Bandra - Mankhurd
DCOS	:	Deputy Controller Of Store
DMRC	:	Delhi Metro Rail Corporation
DMRTS	:	Delhi Mass Rapid Transit System
DPR	:	Detailed Project Report
DTC	:	Driving Trailer Car
EIRR	:	Economic Internal Rate of Return
EMC	:	Electromagnetic Compatibility
EMI	:	Electromagnetic Interference
EPABX	:	Electronic Private Automatic Branch Exchange
ESIA	:	Environmental And Social Impact Assessment
FIRR	:	Financial Internal Rate of Return
G.C.	:	General Consultants
GC	:	Generalized Cost
GOI	:	Government of India
GTKM	:	Gross Ton Kilometer
IDC	:	Interest During Construction
IEC	:	International Electro Technical Commission
IEEE	:	Institute Of Electrical And Electronics Engineers

IET	:	International Emission Trading
IMD	:	India Meteorological Department
IPT	:	Intermediate Public Transport
IRS	:	Indian Railway Standard
ITU	:	International Telecommunication Union
JICA	:	Japan Bank For International Cooperation
KLD	:	Kilo Litres Per Day
KMPH	:	Kilo Meter Per Hour
KVA	:	Kilo Volt Ampere
LAA	:	Land Acquisition Act
LACP	:	Link Aggregation Control Protocol
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
LOS	:	Level Of Service
LWR	:	Long Welded Rails
M.C.	:	Metropolitan Commissioner
MC	:	Motor Car
MCB	:	Miniature Circuit Breaker
MCGM	:	Municipal Corporation Of Greater Mumbai
MLD	:	Million Litres Per Day
MMR	:	Mumbai Metropolitan Region
MMRC	:	Mumbai Metro Rail Corporation Ltd.
MMRDA	:	Mumbai Metropolitan Region Development Authority
MMTPL	:	Mumbai Metro Transport Pvt Ltd
MOEF	:	Ministry Of Environment And Forest
MOUD	:	Ministry Of Urban Development
MRT	:	Mass Rapid Transit
MRTS	:	Mass Rapid Transit System
MRVC	:	Mumbai Rail Vikas Corporation
MUTP	:	Mumbai Urban Transport Project
MVA	:	Mega Volt Ampere
NAAQS	:	National Ambient Air Quality
NFPA	:	National Fire Protection Association
NGO	:	Non-Government Organization
NMIA	:	Navi Mumbai International Airport
NMS	:	Network Management System
O&M	:	Operation And Maintenance
OCC	:	Operation Control Center
OHE	:	Over Head Equipment
ONAF	:	Oil Natural Air Forced
PAFS	:	Project Affected Families
PAPS	:	Project Affected Persons
PHPDT	:	Peak-Hour-Peak-Direction-Traffic
Pnvl	:	Panvel
PV	:	Personalized Vehicles
QOS	:	Quality of Service
R&R	:	Rehabilitation And Resettlement
RAP	:	Resettlement Action Plan
RMC	:	Regional Meteorological Centre
RMPU	:	Roof Mounted Packaged Units
ROR	:	Rest of The Region

RSS	:	Receiving Sub-Station
SBES	:	Small Business Enterprises
SCADA	:	Supervisory Control And Data Acquisition
SCR	:	Station Control Room
SDH	:	Synchronous Digital Hierarchy
SEEPZ	:	Santacruz Electronics Export Processing Zone
SEIAA	:	State Environmental Impact Assessment Authority
SNMP	:	Simple Network Management Protocol
SPM	:	Suspended Particulate Matter
SPV	:	Special Purpose Vehicle
TBM	:	Tunnel Boring Machine
TC	:	Trailer Car
TETRA	:	Terrestrial Trunked Radio
TR	:	Ton of Refrigeration
TSS	:	Traction Sub-Station
UA	:	Urban Agglomeration
UIC	:	Union Internationale Des Chemins De Fer
UPS	:	Uninterrupted Power Supply
VLAN	:	Virtual Local Area Network
VOC	:	Vehicle operating Cost
WB	:	World Bank
WB	:	Wet Bulb
WFSL	:	Western Freeway Sea Link