DETAILED PROJECT REPORT(UPDATED)

D.N. NAGAR – MANDALA CORRIDOR

CLIENT : MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY (MMRDA)

Prepared By

DELHI METRO RAIL CORPORATION LTD.

February, 2016

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PREFACE

DMRC prepared the Master Plan for Mumbai Metro Rail Project in 2005 consisting of 9 corridors of metro network with the total length of 146.5 kms. Subsequently, MMRDA got prepared DPR from DMRC for Varsova – Andheri – Ghatkopar corridor, Colaba – Charkop corridor and Mahim – Mankhurd corridor. Thereafter, MMRDA got prepared DPR combining the part corridor of Colaba – Charkop with Mahim – Mankhurd corridor as entirely elevated corridor between Charkop and Mankhurd. This DPR was submitted by DMRC in 2007.

The Government of Maharashtra is keen to implement expeditiously the Master Plan Corridor recommended by DMRC on a fast track mode and to complete them in the next 3-4 years. To start with, MMRDA entrusted the task of updation & review of DPRs for the following potential elevated metro corridors:

S. No.	Description of Corridors	Length (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 RA Kidwai Rd. –Barrister Nath Pai Rd. – P. D. Mellow Rd.	8.00
B	**Review of Metro alignment and updation 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)	09.00
	Total	**118.00**

DMRC has already submitted DPR for Andheri (E) to Dahisar (E) and Dahisar (E) to D.N. Nagar Corridor in August 2015 and September 2015 respectively. MMRDA is also taking help of DMRC for implementation of these corridors and they have awarded Dahisar (E) to D.N. Nagar Corridor on turnkey basis and for Andheri (E) to Dahisar (E) Corridor, DMRC has been appointed as Interim Consultant. This updated DPR is for D.N. Nagar – MMRDA – Mankhurd – Mandala Corridor.

This corridor is part of the Master Plan line 2 and extended beyond DN Nagar upto Mandala. Originally this corridor was terminating at Mankhurd, but for the depot location it is proposed for extension up to Mandala.

Basically this DPR has been prepared by modifying the chapters of the earlier DPR of Charkop – Bandra – Mankhurd Corridor. Four more chapters namely Multi

Modal Integration, Friendly Features for differently abled, Security Measures and Disaster Management have also been incorporated. Environmental Impact Assessment Study and Social Impact Assessment study are in progress, separate reports are under preparation.

We are of the opinion that entire corridor between Dahisar (East) and Mandala should be taken up for implementation for full benefit to the public.

We thank MMRDA who have made available old data for Charkop – Bandra – Mankhurd DPR and also traffic projections for this corridor.

Delhi Metro Rail Corporation
Dated 10.12.2015

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SALIENT FEATURES

1. GAUGE (NOMINAL): 1435 mm

2. ROUTE LENGTH: 23.643km (Entirely Elevated)

3. NUMBER OF STATIONS: 22(All Elevated)

4. TRAFFIC PROJECTION:

YEAR	TOTAL TRIP	AVERAGE LEAD (KM)	MAXIMUM PHPDT
2016	564430	11.21	21346
2021	890430	13.23	35141
2031	1049100	11.67	38509

5. TRAIN OPERATION:

Section	Year	PHPDT demand	Headway planned	No. of cars	Train carrying capacity @ 6 person/sqm
Dahisar to LIC	2019	**13977**	**7**	6	**15051**
LIC to ITO		**29373**	**3.5**		**30103**
ITO to Mandala		**17169**	**7**		**15051**
Dahisar to LIC	2021	**15999**	**6**		**17560**
LIC to ITO		**35142**	**3**		**35120**
ITO to Mandala		**21167**	**6**		**17560**
Dahisar to LIC	2031	**18282**	**5.5**		**19156**
LIC to ITO		**38509**	**2.75**		**38313**
ITO to Mandala		**17426**	**5.5**		**19156**

S.No	Item	Horizon Year		
		2019	**2021**	**2031**
a.	Rakes required	34	39	40
b.	Coaches required	204	234	240

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 Stations	One near MMRDA Office Station and second in Maintenance Depot at Mandala.

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 3 coach unit With 6 standees / sqm.	900
e.	Class of accommodation	One (Air conditioned)

9. MAINTENANCE FACILITIES:

Maintenance Depot has been proposed near Mandala station in 22.0 Ha. land area.

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 segment Box girders on Single pier with pile / Open foundationsupto radius 300m and flatter, for sharper curves I-Girder.

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

13. TOTAL ESTIMATED COST:

i) Estimated cost with all taxes, Octroi& land cost (At July 2015 prices)	**Rs. 8261.00 Crore.**
ii) Estimated completion cost with central taxes only (by April 2019 At 7.5% p.a escalation)	**Rs.10261.00 Crore.**
iii) Estimated completion cost with all taxes	**Rs. 10970.00 Crore**
iv) FIRR	**10.78%**
v) EIRR	**25.20%**

Executive Summary

EXECUTIVE SUMMARY

0.1 INTRODUCTION:

0.1.1 Background:

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

The city offers lot of job and professional opportunities in different sectors. This is the reason for large number of migrants from all over India being attracted to Mumbai to earn their livelihood. This, however, results in very heavy pressure on the city's infrastructure like housing, water supply, transport etc.

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

0.1.2 Population:

The total population of Greater Mumbai in 2011 was 124.42 Lakhs, more than double of population of 59.7 Lakhs in 1971. The rise in population was about 38 % during 1971 – 81 but was about 20 % during 1981 – 91 and 1991 – 2001. Between 2001 to 2011, the growth in population is only 4.5%. **Table 0.1** shows the trend of population in Island City, Western Suburbs, Eastern Suburbs and total for greater Mumbai.

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

Year	Island City		Western Suburbs		Eastern Suburbs		Total Greater Mumbai	
		Decadal Growth		Decadal Growth		Decadal Growth		Decadal Growth
1971	3.07 (51.42%)		1.71 (28.64%)		1.19 (19.93%)		5.97 (100%)	

Year	Island City		Western Suburbs		Eastern Suburbs		Total Greater Mumbai	
1981	3.28 (39.81%)	6.84	2.86 (34.71%)	67.25	2.10 (25.49%)	76.473	8.24 (100%)	38.02%
1991	3.17 (31.92%)	-3.35	3.95 (39.78%)	38.11	2.80 (28.20%)	33.33	9.93 (100%)	20.51%
2001	3.35 (28.13%)	5.68	5.10 (42.82%)	29.11	3.46 (29.05%)	23.57	11.91 (100%)	19.94%
2011	3.08 (31.92%)	-0.27	5.53 (39.78%)	0.43	3.83 (28.20%)	0.37	12.44 (100%)	4.5%

0.1.3 Employment:

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

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

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

0.1.4 Land Use Policy:

Mumbai Metropolitan Regional Development Authority (MMRDA) prepared a Regional Plan 1996 – 2011, for Mumbai Metropolitan Region (MMR) as required under the Maharashtra Regional & Town Planning Act 1966, which was approved by GOM. Unlike the past, it should also promote modern, technologically advanced, environment friendly industries in Mumbai Municipal limits, and encourage changes in Mumbai's industrial structure, by facilitating revival of sick and obsolete industries. As per the recommendations in the Plan, a new industrial Growth Policy should be framed with specific economic, environmental and urban development objectives. The plan has proposed a poly-nucleated land use structure for the Mumbai Metropolitan Region.

0.1.5 Road Vehicles:

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

0.1.6 Suburban Rail Network:

The main skeleton of the rail network in Mumbai was laid over 150 years ago, initially to link Mumbai and adjacent townships. Suburban Rail Network in Mumbai is run by Central and Western Railways. Central Railway Suburban Trains on main lines run from Mumbai CST to Kasara towards Nashik and to Karjat on Pune side. The Harbour Branch trains go from CST to Panvel in Navi Mumbai and to Andheri on Western Railway. Western Railway suburban section is from Churchgate to Virar. It will be extended to Dahanu this year.

Suburban services operate Electric Multiple Units (EMU's) predominantly formed as 9 car rakes (being upgraded to 12 car rakes). A start has been made by Western Railway to run 15 coach trains on a limited schedule and limited stops.

All Western and Central railway lines within the Mumbai suburban area are Broad Gauge (1.676 m) and electrified using the 1500 volt D.C. overhead system. The traction system is now being converted to 25 kV A.C.

0.1.7 Road Network:

Road Network developed over many years, predominately in north-south direction radial to the CBD within the constraints of the islands. Lately Eastern Suburbs / Navi Mumbai have also developed commercially and better East–West connectivity is necessary.

0.1.8 Bus Transport System:

Public stage carriage bus services in the region are provided by BEST, (within BMC and up to 20 km beyond the corporation boundary), TMT in Thane and MSRTC elsewhere. Bus routes from Mumbai City to Navi Mumbai are provided by BEST, MSRTC and Navi Mumbai Municipal Corporation (NMMC).

With over 3,030 buses, BEST is by far the largest provider of bus services in the region.

The dispersal of rail commuters from the main railway terminals to their final destinations in the Mumbai CBD such as Fort, Ballard Estate, Colaba or Nariman point is at present carried out primarily by the bus system.

0.1.9 Air Pollution:

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

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

0.1.10 Need for Metro:

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

The proposed corridor from D.N. Nagar to Mandala is extension of metro corridor from Dahisar (E) to D.N. Nagar. This corridor runs in North-South direction upto Bandra. Hereafter, it runs in West-East direction upto Mandala. The route where this corridor is suggested is heavily loaded and connects market places, residential areas and Control Business District (CBD) like Bandra- Kurla Complex (BKC). The capacity of the road is much less than the demand. Hence there is a need for Grade separated MRTS System. Metro rail is most energy efficient and tested system and has the capacity to carry high traffic PHPDT. Therefore it is recommended to provide metro system of medium to heavy capacity.

0.1.11 Advantages of a Metro System:

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

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

0.1.12 Past Studies:

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

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

0.2 EVOLUTION OF MUMBAI METRO MASTER PLAN:

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

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

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

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

Table 0.3

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

0.2.5 Present Status:

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

0.2.5.2 A special purpose vehicle (SPV) was formed for line no 2, viz. Charkop – 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.

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

0.2.5.4 MMRDA is intending to implement other corridors by itself.

0.3 TRAFFIC FORECAST:

0.3.1 Proposed Metro Stations on D. N. Nagar – Mandala Corridor

It is proposed to have twenty-two stations on the D. N. Nagar to Mandala Metro corridor. This corridor is an extension of Dahisar (E) to D. N. Nagar Metro corridor. The Index Plan of this corridor is put up at Fig 0.1. The locations of proposed stations are as under

Table 0.4 Station Locations

DN Nagar to Mandala Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations**	**U/G/ ELEVATED**
0	D N NAGAR	17578.6		
	DEAD END	**18175.0**		
1	ESIC Nagar	18637.6	1059	ELEVATED
2	Prem Nagar	20302.6	1665	ELEVATED
3	Indira Nagar	20829.2	526.6	ELEVATED
4	Nanavati Hospital	21902.5	1073.3	ELEVATED
5	Khira Nagar	23509.4	1606.9	ELEVATED
6	Saraswat Nagar	24466	956.6	ELEVATED
7	National College	25559	1093	ELEVATED
8	Bandra Metro	26699.7	1140.7	ELEVATED
9	MMRDA Office	28292	1592.3	ELEVATED
10	Income Tax Office	28913.9	621.9	ELEVATED
11	ILFS	30188	1274.1	ELEVATED
12	MTNL Metro	30982.8	794.8	ELEVATED
13	S G Barve Marg	32720.2	1737.4	ELEVATED
14	Kurla Terminal	33194.7	474.5	ELEVATED
15	Kurla (E)	34349.2	1154.5	ELEVATED
16	EEH	35356.3	1007.1	ELEVATED
17	Chembur	35996.7	640.4	ELEVATED
18	Diamond Garden	36959	962.3	ELEVATED
19	Shivaji Chowk	37819	860	ELEVATED
20	B S N L Metro	38939.6	1120.6	ELEVATED
21	Mankhurd	40546.7	1607.1	ELEVATED
22	Mandala Metro	41507.4	960.7	ELEVATED
	DEAD END	**41818.1**		

The station to station segment flows, station loading for the entire corridor, i.e. from Dahisar (E) to Mandala are given as under.

Table 0.5
Peak Hr. Ridership for Metro line -2 for 2016, 2021 and 2031 (via SCLR)

Sr. No.	**Station Name**	**Year 2016**		**Year 2021**		**Year 2031**	
		Volume from D-M	**Volume from M-D**	**Volume from D-M**	**Volume from M-D**	**Volume from D-M**	**Volume from M-D**
1	Dahisar (E)	1155	0	4546	0	6300	0
2	Dahisar	3296	2147	5709	3439	8580	4749
3	Rishi Sankul	10581	6981	14907	5228	16764	7957
4	IC Colony	10532	3248	14883	11046	16721	14147
5	LIC Colony	10945	3217	15999	10822	18282	13567
6	Don Bosco	11141	3622	16859	11666	20252	15509
7	Kasturi Park	11774	3686	18986	11981	23759	16576
8	Ekata Nagar	13048	3827	21187	12629	25691	17889
9	Kandivali	15866	4728	24950	13426	29881	19090

Sr. No.	Station Name	Year 2016		Year 2021		Year 2031	
		Volume from D-M	Volume from M-D	Volume from D-M	Volume from M-D	Volume from D-M	Volume from M-D
10	Charkop	17625	5916	27808	14713	32359	20798
11	Malad Metro	16698	6564	29582	15598	33061	21664
12	Kasturi Park	16205	7570	29156	17672	32451	24436
13	Bangur Nagar	19391	7997	33072	17763	36684	24358
14	Oshiwara Metro	20719	9586	**35142**	19819	38509	27063
15	Samartha Nagar	20774	10011	28789	20219	29979	27376
16	Shastri Nagar	**21346**	11335	29615	16620	30675	20236
17	D.N. Nagar	17858	11711	28922	17096	29221	21072
18	ESIC Nagar	18201	9095	29795	16110	29738	19559
19	Prem Nagar	18996	10110	30819	17140	30683	21010
20	Indira Nagar	18612	10505	30758	17415	30209	21284
21	Nanavati Hospital	18614	10737	30875	17724	30277	21335
22	Khira Nagar	18179	10963	30914	17833	29630	21490
23	Saraswat Nagar	17751	11163	31088	17855	29494	21575
24	National College	17653	10988	31326	17651	29627	21329
25	Bandra Metro	12414	10940	23754	17565	19630	21270
26	MMRDA Office	11648	8296	21544	14760	17550	16316
27	Income Tax Office	12530	7834	22720	13564	19110	15004
28	ILFS	11173	8552	21167	13926	17426	18386
29	MTNL Metro	11120	8534	21140	13873	17413	18644
30	S G Barve Marg	6647	8504	15234	13835	11794	18690
31	Kurla Terminal	6431	5360	14677	11217	11481	13625
32	Kurla (E)	6214	5291	14251	11084	10821	13528
33	EEH	6747	4788	14166	10291	11016	12305
34	Chembur	5552	7398	13112	12501	9893	16386
35	Diamond Garden	3247	6961	11436	12307	8845	16098
36	Shivaji Chowk	2475	6156	10816	12483	7988	15777
37	B S N L Metro	1556	2343	9169	7992	6294	10913
38	Mankhurd	252	950	771	6341	3443	8873
39	Mandala Metro	0	329	0	885	0	4819
	PHPDT	**21346**	**11711**	**35142**	**20219**	**38509**	**27376**
	Daily Ridership	**834636**		**1298260**		**1658943**	

0.3.2 Daily Trips and PHPDT

The projected Daily ridership and PHPDT for the proposed Corridor from D. N. Nagar to Mandala for various horizon years are given in Table 0.6

Table No 0.6
Daily Ridership and PHPDT

Year	Daily Ridership (lakhs)	PHPDT
2016	5.64	21346
2019	7.60	29373
2021	8.90	35142
2031	10.49	38509

0.4 SYSTEM SELECTION:

0.4.1 Permanent Way:

0.4.1.1 Choice of Gauge:

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

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

0.4.1.2 Track Structure:

Two types of track 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. The track will be completely welded and even the turn outs will be incorporated in LWR / CWR. The rails section used will be UIC – 60 (60 kg/m). The grade of rails on main lines will be 1080 Head Hardened as per IRS-T-12-96. As these rails are not manufactured in India at present, these are to be imported. For the Depot lines, the grade of rails should be 880, which can be easily manufactured indigenously.

0.4.2 Traction System:

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

0.4.3 Signalling:

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

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

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.

0.4.4 Telecommunication:

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

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

The proposed telecom system will cater to the following requirements:

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

0.4.5 Automatic Fare Collection:

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

AFC system proves to be cheaper than semi-automatic (Manual System) in long run due to reduced manpower cost of ticketing staff, reduced maintenance in comparison to paper ticket machines, overall less cost of recyclable tickets (Smart Card / Token) in comparison to paper tickets and prevention of leakage of revenue.

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.

Relative advantages of automatic fare collection system over manual system are as follows.

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

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

B. Automatic fare collection systems have the following advantages:

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

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

0.4.5.4 Choice of Control Gates:

Retractable Flap type Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern metros internationally.

0.4.5.5 Passenger Operated Machines:

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

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

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

The proposed AFC system shall provide interfaces to other operators such as Suburban Rail, Bus, Parking, Toll etc so that these systems may also be integrated with common smart card based fare products. This will facilitate the passengers as they need not carry different cards for different applications.

0.4.6 Rolling Stock:

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

- Proven equipment with high reliability
- Passenger safety features
- Energy efficiency
- Light weight equipment and coach body

- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low life cycle cost
- Flexibility to meet increase in traffic demand
- Anti-telescopic

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

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

Table 0.7 - 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:

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

Table 0.8 shows the carrying capacity of Medium Rail Vehicles.

Table 0.8 Carrying Capacity of Medium Rail Vehicles

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

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

The recommended performance parameters are:

Traction Power Supply: 25Kv ac
Motoring capacity: 67%
Maximum Design Speed: 90 kmph
Maximum Operating Speed: 80 kmph

Max. Acceleration: $1\ m/s^2 \pm 5\%$

Max. Deceleration: $1.0\ m/s^2$ (Normal brake)

$1.35 m/s^2$(Emergency Brake)

0.5 CIVIL ENGINEERING:

0.5.1 Geometric Design Norms:

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

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

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

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

0.5.1.2 Gradients:

Normally stations should be on a level stretch. In limiting cases, stations may be on a grade of 0.1%. In this corridor all stations are on level gradient.
Between stations, normally grades may not be steeper than 2.0%. However, in where existing road gradients are steeper than 2%, gradients up to 4% (compensated) can be provided in short stretches.

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

0.5.2 Alignment:

0.5.2.1 D.N. Nagar (excluded) – Mandala corridor of Mumbai Metro Project is an extension of corridor from Dahisar (E) to D.N. Nagar. First station on this corridor is ESIC Nagar and last station is Mandala.

0.5.2.2 As this corridor is an extension therefore chainage of Dahisar (E) proposed station is taken as 0.0 for reference.

0.5.2.3 Total length of the corridor from dead end to dead end is 23.643 km. The entire corridor proposed is elevated.

0.5.2.4 Twenty-two stations have been proposed on the corridor. Names of stations are ESIC Nagar, Prem Nagar, Indra Nagar, Nanawati Hospital, Khira Nagar, Saraswat Nagar, National College, Bandra Metro, MMRDA Office, Income Tax Office, ILFS, MTNL Metro, S G Barve Marg, Kurla Terminal, Kurla (E), EEH, Chembur, Diamond Garden, Shivaji Chowk, BSNL Metro, Mankhurd and Mandala Metro. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one Km. distance apart. The maximum and minimum inter station distances are 1738.9 m and 474.5 m respectively. Depot for this extension has been planned at Mandala.

0.5.2.5 This corridor runs in North to South direction between DN Nagar to Bandra. Hereafter it takes turn and runs West to East direction. It connects heavily populated area of city, market places, Airport, Railway Stations and Central Business District (CBD) of Bandra Kurla Complex.

0.5.3 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. The average spacing of stations is close to one km.

0.5.3.1 All stations will be two level stations except ILFS station, which has been planned two tower station and Mandala Station has been planned at height of 10 m with ground concourse on the side of road to reduce length of ramp to enter in Depot. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level.

0.5.4 Terminals:

As this corridor is an extension of Dahisar (E) to D.N. Nagar corridor, therefore there is only one terminal station for this corridor as mentioned below.

- **Mandala Metro Terminal:**

  This Station is proposed on median of the road just before depot location. Scissors cross overs are proposed on both sides of the station but at little more distance due to geometry of alignment not allowing placement of X-overs in the vicinity of the platform.

0.5.5 Scissors Crossovers:

Scissors Crossovers will be provided at the terminal station viz. Mandala Metro. In between, crossovers are proposed at one intermediate station i.e. Income Tax Office, for making one of the platform line as common loop for its use in emergencies.

0.5.6 Maintenance Depot:

It is proposed to provide depot at Mandala (low lying area) in the Government land identified by MMRDA. The land parcel available is of 22 Ha and of D-shaped.

0.5.7 Station Planning:

The proposed corridor runs from Dahisar (E) to Mandala (M). This report deals with the section of the corridor from D.N. Nagar (excluded) to Mandala (M)

The length of the proposed corridor from ESIC Nagar to Mandala (M) is approximately 24km. Along this section of the proposed corridor, 22 stations have been planned and are all elevated. The locations of the station have been identified taking into consideration the constraints in land acquisition and congestion issues. Stations are proposed in such a way so as to attract maximum demand from the traffic nodal points.

0.5.7.1 Planning and Design Criteria for Stations

Salient features of a typical station are as follows:

1. The stations can be divided into public and non-public areas (those areas where access is restricted). The public areas can be further subdivided into paid and unpaid areas.
2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
3. The platform level is determined by a critical clearance of 5.50-m under the concourse above the road intersection, allowing 3.00-m for the concourse height, about 2-m for concourse floor and 2.00-m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the platforms in an elevated situation around 14.0-m above ground.
4. 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.
5. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.
6. Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.
7. Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS.
8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station.

9. The DG set, bore well pump houses and ground tank would be located generally in one area on ground under an entrance structure.

10. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:
    - Minimum distance of travel to and from the platform.
    - Adequate capacity for passenger movements.
    - Convenience, including good signage relating to circulation and orientation.
    - Safety and security, including a high level of protection against accidents.

12. Following requirements have been taken into account:
    - Minimum capital cost is incurred consistent with maximizing passenger attraction.
    - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    - Flexibility of operation including the ability to adapt to different traffic conditions, changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.
    - Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
    - Provision of display of passenger information and advertising.

13. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions.

14. 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**.**

15. Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

0.5.8 Viaduct–Elevated Structure:

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

(A) Pre-cast segmental box girder using external unbounded tendon.
(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.
(C) Precast prestressed Twin U girders

Considering ‘’pros and cons’’ of the three type of superstructures, the segmental box girder is recommended for this corridor.

0.5.9 Geo Technical Investigations:

DMRC has not done any fresh borehole for investigating the soil data. Details of the borehole as done for the DPR preparation of Charkop, Bandra, Mankhurd by DMRC in the year 2006 has only been relied upon. There is no geotechnical data provided in this report for the stretches of the corridor detoured from the previous route. The details of borehole and type of strata are given in Civil Engineering chapter. There will be need of fresh boreholes at the stage of Detailed Design of sub-structure

0.5.10 Utility Diversions:

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

0.5.11 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)

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0.5.11.1 Summary of Land Requirements

Abstract of land requirements for different components of this corridor is given in **Table 0.9 and Table 0.10**.

Table 0.9 Summary of Permanent Land Requirement (All figures in Sq. m)

S. No.	Description	Govt.	Pvt.
1	Stations	15473	17892
2	Running Section	9573	13857

S. No.	Description	Govt.	Pvt.
3	Depot	220000	0
4	Staff Quarter	15000	0
5	Office Complex and OCC	0	0
6	RSS	11200	0
	Total (Area in sq m)	**271246**	**31749**

Total Permanent Land	=	**30.2995 ha**
Permanent Land (Govt.)	=	**27.1246 ha**
Permanent Land (Pvt.)	=	**3.1749 ha**

Note: Permanent land requirement has been reduced by 2971 sqm and 210 sqm due to change in align at JVPD and relocation of exit/entry structure at National College respectively. This reduction in land requirement has not been taken in account in the cost estimate calculation as it will not have significant effect.

Table 0.10 - Summary of Temporary Land Requirement

S. No.	Description	AREA (m^2)	OWNER-SHIP
1	Temporary Office/ Site Office	10000	Government
2	Segment Casting Yard	100000	Government
	Total	**110000**	

Total land required for temporary acquisition is **11 ha,** which is assumed that it will be government land.

0.5.12 Safety & Security Systems:

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

0.5.12.1 Requirements:

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

ii. The system shall protect vulnerable premises from fire.

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

iv. The system shall include

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

0.6 TRAIN OPERATION PLAN:

The underlying operation philosophy is to make the Metro System more attractive and economical, the main features being:

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period. Multi-tasking of train operation and maintenance staff.

Details of stations for Mumbai Metro (DN Nagar to Mandala Metro Corridor) are given below:

Table 0.11 - Details of stations

DN Nagar to Mandala Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G/ ELEVATED**
0	D N NAGAR	17578.6		
	DEAD END	**18175.0**		
1	ESIC Nagar	18637.6	1059	ELEVATED
2	Prem Nagar	20302.6	1665	ELEVATED
3	Indira Nagar	20829.2	526.6	ELEVATED
4	Nanavati Hospital	21902.5	1073.3	ELEVATED
5	Khira Nagar	23509.4	1606.9	ELEVATED
6	Saraswat Nagar	24466	956.6	ELEVATED
7	National College	25559	1093	ELEVATED
8	Bandra Metro	26699.7	1140.7	ELEVATED
9	MMRDA Office	28292	1592.3	ELEVATED
10	Income Tax Office	28913.9	621.9	ELEVATED
11	ILFS	30188	1274.1	ELEVATED
12	MTNL Metro	30982.8	794.8	ELEVATED
13	S G Barve Marg	32720.2	1737.4	ELEVATED
14	Kurla Terminal	33194.7	474.5	ELEVATED
15	Kurla (E)	34349.2	1154.5	ELEVATED
16	EEH	35356.3	1007.1	ELEVATED
17	Chembur	35996.7	640.4	ELEVATED
18	Diamond Garden	36959	962.3	ELEVATED
19	Shivaji Chowk	37819	860	ELEVATED
20	B S N L Metro	38939.6	1120.6	ELEVATED
21	Mankhurd	40546.7	1607.1	ELEVATED
22	Mandala Metro	41507.4	960.7	ELEVATED
	DEAD END	**41818.1**		

0.6.1 Salient Features:

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

0.6.2 Train Formation

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

Composition

DMC : Driving Motor Car

MC : Motor Car

TC : Trailer Car

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

Capacity@ 6 passengers per square meter of standee area

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

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

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

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

The PHPDT capacity provided on this corridor in different years of operation is given in Table 0.12 :

Table 0.12 PHPDT Capacity Provided

Section	Year	PHPDT demand	Headway planned	No. of cars	Train carrying capacity @ 6 person/sqm
Dahisar to LIC	2019	13977	7	6	15051
LIC to ITO		29373	3.5		30103
ITO to Mandala		17169	7		15051
Dahisar to LIC	2021	15999	6		17560
LIC to ITO		35142	3		35120
ITO to Mandala		21167	6		17560
Dahisar to LIC	2031	18282	5.5		19156
LIC to ITO		38509	2.75		38313
ITO to Mandala		17426	5.5		19156

0.6.3A YEARWISE 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 0.13:

Table 0.13: Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	No. of car per rake	No. of Coaches
D. N. Nagar to Mandala	**2019**	**7**	**34**	**6**	**204**
	2021	**6**	**39**		**234**
	2031	**5.5**	**40**		**240**

0.7 MAINTENANCE DEPOT:

Train operation has been planned in two loops to meet the PHPDT demand. One train on given headway will run from Dahisar(E) to Mandale section and other train would be run on LIC to Income tax office(ITO) section. This would generate more PHPDT capacity on the common section between LIC to ITO.

Two depots have been planned. Main depot is present at Mandala and satellite depot at Charkop. For D.N. Nagar to Mandala corridor, only one depot is considered i.e. at Mandala.

0.7.1 DEPOT- CUM- WORKSHOP AT MANDALA

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 to cater to the required stability facilities.

In broad terms, based on the planned Rolling Stock requirements, this chapter covers conceptual design on following aspects and will work as a guide for detailed design later:

- Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

0.7.2 MAINTENANCE PHILOSOPHY

- Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, “A” checks, “B” type checks, “IOH” and “POH”.

- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation is given due attention.

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, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 80 KWh/1000 GTKM
(ii) Regeneration by rolling stock – 30%
(iii) Elevated/at –grade station load – initially 250 kW, which will increase to 500 kW in the year 2031
(iv) Depot auxiliary load - initially 2000 kW, which will increase to 2500 kW in the year 2031.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2019, 2021 and 2031 are summarized in table 0.14 below:

Table 0.14 Power Demand Estimation (MVA)

Corridor	Load	Year		
		2019	2021	2031
D N Nagar to Mandala Metro 22 Stations (23.643 km)	Traction	16.84	19.65	21.53
	Auxiliary	8.96	11.86	16.06
	Total	**25.80**	**31.51**	**37.59**

0.8.2 Sources of Power Supply

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

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

Table 0.15 Sources of Power Supply

	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length cables from GSS to RSS
	D N Nagar to Mandala Metro 22 Stations (23.643 km)	110 kV Grid Sub Station (GSS) Near MMRDA Office	RSS at MMRDA Office Station	To be confirmed by TATA Power
		110 kV Grid Sub Station (GSS) Near Mankhurd	RSS at Mandala Depot	To be confirmed by TATA Power

For Supply of RSS Near MMRDA Office Station and Mandala Depot, a letter No. DMRC/Elect/Mumbai/2015, dated 12.11.2015 has been sent to TATA Power Company for confirmation of source of power supply. In view of this, during the detail design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 0.16.

Table 0.16 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand** – Emergency (MVA)	
		Year (2019)	Year (2031)	Year (2019)	Year (2031)
D N Nagar to Mandala Metro 22 Stations (23.643 km)	**RSS Near MMRDA Office Station**				
	Traction	7.67	9.765	16.84	21.53
	Auxiliary	3.48	6.78	8.96	16.06
	Sub-total (A)	**11.15**	**16.545**	**25.80**	**37.59**
	RSS at Mandala Depot				
	Traction	9.17	11.765	16.84	21.53
	Auxiliary	5.48	9.28	8.96	16.06
	Sub-total (B)	**14.65**	**21.045**	**25.80**	**37.59**

** Incase of failure of other source of power

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, 2x25 kV AC traction system is suggested for Dahisar to Mandale corridor, otherwise 25 kV ac system is preferred.

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 180 kVA capacity at the elevated stations to cater to the following essential services:

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

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

0.8.5 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 25-35% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 80.14 million units in initial years 2019, which will be about 116.49 Million Units in the year 2031. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for Mumbai Metro should be at effective rate of purchase price (at 110 kV voltage level) plus nominal administrative Charges i.e. on a no profit no loss basis. The power tariff of Maharashtra Electricity Regulatory Commission for TATA power Company, FY 2015 – 16 demand charges Rs 200/ kVA per month and energy charges Rs 7.63/ kWh. Therefore it will be in the range of **Rs 7.91 to Rs 8.00 per unit**. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro.

0.9 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

0.9.1 Environmental Baseline Data

The main aim of the EIA study is to ascertain the existing baseline conditions and to assess the impacts of all the factors as a result of the proposed corridor during its construction and operation phases. The changes likely to occur in different components of the environment viz. Natural Physical Resources, Natural Ecological (or Biological) Resources, Human/Economic Development Resources (Human use values), Quality of life values (socio-economics), would be studied and assessed to a reasonable accuracy. The environment includes Water Quality, Air Quality, Soils, Noise, ecology, Socio-economic issues, archaeological /historical monuments etc.

0.9.2 Socio-Economic Assessment

Development of proposed Mumbai metro rail project in Charcop-Bandra-Kurla-Mankhurd corridor involve acquisition of land for entry, exit and for other facilities of station and running section. For different components of this corridor, out of total requirement of land, 0.5 ha of private land shall be acquired. Acquisition of this private land may cause social disruption and economic loss for the project affected families/people. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimise any negative impacts. Governed by this consideration, a Socio-Economic Survey (SES) was undertaken in order to assess the socio-economic condition of project-affected families/people and to examine the impacts of the proposed MRTS on their conditions.

0.9.3 Positive Environmental Impacts

Based on project particulars and existing environmental conditions, potential impacts have been identified that are likely to result from the proposed MRTS project. The positive environmental impacts are listed below:

1 Traffic congestion reduction,
2 Quick service and safety,
3 Less fuel consumption,
4 Reduction in Air Pollution,
5 Improvement in roads
6 Reduction in number of busses, private vehicles on road etc.,
7 Greenery through compensatory afforestation,
8 Improvement of Quality of Life,
9 Better transport facilities to masses.

0.9.4 Negative Environmental Impacts

Based on project particulars and existing environmental conditions, potential negative impacts likely to result from the proposed development have been identified. Negative impacts have been listed under the following headings:

1 Impacts due to project location,
2 Impacts due to construction works, and
3 Impacts due to project operation.

0.9.5 Environmental Management Plan

Based on environmental baseline conditions, planned project activities and its impacts assessed, the set of measures to be taken during implementation and operation to avoid or offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which needs to be taken to implement them.

0.9.6 Environmental Monitoring Plan

The environmental monitoring will be required for the construction and operational phases. The parameters need to be monitored are: Water Quality, Air quality and Noise levels etc.

0.9.7 Environmental Management System

The Environmental Management System constitutes provision of an Environmental Division, which should be staffed by an Environmental Engineer/Officer, an Environmental Assistant and two other assistants (miscellaneous works). The task assigned should include supervision and co-ordination of studies, monitoring and implementation of environmental mitigation measures. An Environmental Advisor shall review progress of the division every year.

0.10 MULTI MODAL TRAFFIC INTEGRATION:

The Metro Rail System in Mumbai D.N. Nagar to Madala Corridor will cover a length of approximately 23.643km. It will be augmented through enhanced flexibility of criss-cross interchanges to other modes and reduce the travel time of commuters. While Metro is a high capacity mode of transport, the need for integration with other secondary/intermediate transport mode is getting highlighted more than ever to ensure a seamless journey. This concept is to provide first mile and last mile connectivity to the commuters with their places of stay. With top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Rail Systems.

0.10.1 Way Forward

In view of above, 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.

0.11 FRIENDLY FEATURES FOR DIFFERENTLY ABLED:

The objective 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. Rail Transport
2. Light Metro Station
   - Way finding
   - Signage
   - Automated Kiosks
   - Public Dealing Counters
   - Audio-visual Displays
   - Public Telephones
   - Rest Areas/Seating
   - Tactile Paving - Guiding & Warning
   - Doors
   - Steps & Stairs
   - Handrails
   - Ramps
   - Lifts/Elevators
   - Platform/Stair Lift
   - General and Accessible toilets
   - Drinking Water Units
   - Visual Contrasts
   - Emergency Egress/Evacuation

3. Street Design
   - Footpath (Sidewalk)
   - Kerb Ramp
   - Road Intersection
   - Median/Pedestrian Refuge
   - Traffic Signals
   - Subway and Foot Over Bridge

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

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 D. N. Nagar (excluded) - Mandala Metro Corridor has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction at July 2015 price level.

The overall Capital Cost for the D. N. Nagar (excluding D. N. Nagar Station) - Mandala Metro Corridor of Mumbai at July 2015 price level works out to **Rs. 6947 Crores** excluding applicable Taxes & Duties of **Rs. 1314 crores** as tabulated hereunder.

Table 0.17 –Summary of Cost Estimate

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	D. N. Nagar - Mandala Metro Corridor (23.643 Km, 22 stations)	6947	1314	8261

Table 0.18 - Capital Cost Estimate

July 2015 level

S. No.	Item	Amount (Rs. in Cr.) Without taxes
1.0	Land and R & R	1026.99
2.0	Alignment and Formation	902.36
3.0	Station Buildings	925.38
4.0	Depot at Mandala	200.00
5.0	P-Way	233.32
6.0	Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators	256.65
7.0	Signalling and Telecom.	511.94
8.0	Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection	195.54
9.0	Rolling Stock (3.2 m wide Coaches)	1999.20
10.0	Capital expenditure on security	8.80
11.0	Staff quarter for O & M	53.29
12.0	Capital expenditure on Multimodal Traffic Integration	50.82
13.0	Total of all items except Land	5428.88
14.0	General Charges incl. Design charges @ 7 % on all items except land	380.02
15.0	Total of all items including G. Charges except land	5808.91
16.0	Contingencies @ 3 %	174.27
17.0	Gross Total	5983.17
	Cost without land	5983
	Cost with land including contingencies on land	6947

Table 0.19 - Details of Taxes and Duties

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT(Cr.)		
1	**Alignment & Formation**						
	Elevated, at grade & entry to Depot	902.36		78.96	88.83	19.63	**187.41**
2	**Station Buildings**						
	Elevated station - civil works	748.02		65.45	73.63	16.27	**155.35**
	Elevated station-EM works	177.36	8.31	15.08	16.96	5.62	**45.96**
	OCC bldg-civil works	0.00		0.00	0.00	0.00	**0.00**
	OCC bldg-EM works	0.00	0.00	0.00	0.00	0.00	**0.00**
3	**Depot**						
	Civil works	80.00	5.62	4.90	5.51	1.81	**17.84**
	EM works	120.00	5.62	10.20	11.48	3.80	**31.10**
4	**P-Way**	233.32	43.71	4.96	5.58	7.90	**62.14**
5	**Traction & power supply**						
	Traction and power supply	256.65	24.04	16.36	18.41	8.32	**67.12**
6	**S and T Works**						
	S & T	390.94	73.23	9.77	11.00	13.27	**107.27**
	AFC	121.00	21.25	3.78	4.25	4.09	**33.37**
7	**R & R hutments**	91.59			5.72	1.83	**7.56**
8	**Misc.**						
	Civil works	229.01		20.04	22.54	4.98	**47.56**
	EM works	79.43		8.44	9.49	2.46	**20.40**
9	**Rolling stock**	1999.20	411.95	19.49	21.93	77.78	**531.15**
	Total	**5428.88**	**593.72**	**257.43**	**295.33**	**167.76**	**1314.24**
	Total taxes & Duties						**1314**

0.15 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY:

The Mumbai Metro Rail Project (DN Nagar to Mandala) is proposed to be constructed at an estimated cost of Rs.7798.00 Crore with central taxes and land cost. The route length of the proposed metro rail system and estimated cost at July-2015 price level without central taxes, with central taxes and with all taxes are placed in table 0.20 as under:

Table 0.20 Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)	Estimated cost with all taxes, Octroi& land cost (Rs/Crore)
1	D N Nagar to Mandala	23.643	6947.00	7798.00	8261.00

The estimated cost at July-2015 price level includes an amount of Rs.8.80 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 01.04.2016 and is expected to be completed on 31.03.2020 with Revenue Opening Date (ROD) as 01.04.2020 for the corridor. The total completion costs duly escalated and shown in the table 0.21 have been taken as the initial investment. The cash flow of investments separately is placed in Table –0.21 as below.

Table 0.21 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Price level July 2015

Financial Year	Amount (Rs.)	Completion Cost including land cost and central taxes
2015-16	132.00	139.00
2016-17	1005.00	1134.00
2017-18	1949.00	2364.00
2018-19	2016.00	2628.00
2019-20	1348.00	1889.00
2020-21	674.00	1015.00
2021-22	674.00	1092.00
Total	**7798.00**	**10261.00**

Completion cost including land cost and all taxes: Rs. 10970.00 Crore

Fare Structure:

The fare structure for the FY 2020-21 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 0.22 below:

Table 0.22 Fare Structure in 2020-21

Sr. No.	Distance	Proposed Fare
1	0-2	11
2	2-4	13

Sr. No.	Distance	Proposed Fare
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 since it has been approved by 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.

Year 2020-21	
SLAB	**FARE (Rs)**
0-3 km	**10.00**
3-12 km	**20.00**
12 km and More	**30.00**

The proposed Fare Structure will have convenience in making use of ticket vending machine and eliminate the problems of non-availability of changes for tendering changes to the passengers.

The **Financial Internal Rate of Return (FIRR)** obtained costs for 30 years business model including construction period is **10.78%.**

Alternative Models of Financing:

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

(i) Special Purpose Vehicle under the State Government Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC)

(ii) Built, Operate & Transfer (BOT)

SPV Model: - The State Government has already constituted a fully owned company in the name of Mumbai Metro Rail Corporation (MMRC), a SPV company and is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The funding pattern under this model (SPV) is placed in table 0.23 as under:

Table 0.23 Funding pattern under SPV model (with central taxes and land)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	1216.00	13.53%
Equity By GOM	1216.00	13.53%
SD for CT by GOM	581.00	6.47%
SD for CT by GOI	581.00	6.47%
0.30% Loan from Multilateral Funding Agencies/ 12% Market Borrowings	5393.00	60.00%
Total	8987.00	100.00%
SD for Land by GOM	1274.00	
Total	10261.00	
Interest During Construction	16.00	
Grand Total	10277.00	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.709.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

BOT Model: - In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Maharastra 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 funding pattern assumed under this model excluding the cost of land is placed in table 0.24 as under: -

Table 0.24 Funding pattern under BOT –Combined (16% EIRR)

(With central taxes and without land cost)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1797.00	20.00%
VGF by GOM	905.00	9.49%
Equity by Concessionaire	2095.00	23.51%
Concessionaire's debt @12% PA	4190.00	47.00%
Total	8987.00	100.00%
Land Free by GOM	1274.00	
Total	10261.00	
IDC	110.00	
Total	10371.00	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.709.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 0.25 excluding state taxes.

Table 0.25

Particulars	SPV Model	BOT Model
GOI	1797.00	1797.00
GOM	3071.00	2179.00
Total	**4868.00**	**3976.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.709.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

0.15.1 RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 10.78%. The pre-tax Equity FIRR to the BOT operator worked out to 16% with total VGF of Rs. 3976.00 crore.

Though in case of BOT Model cash out flow from the government is less by Rs. 892/- crore, yet considering other factors such as delay in the implementation, inflation of cost etc. 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 **25.20%** B/C Ratio is 9.03 and NPV is 240162, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **31.80%,** B/C ratio as **24.43** and NPV as 259009. With 12 % discount, EIRR (completion cost) is **11.51%** and B/C ratio is **3.04**. NPV is Rs **18677** Cr. and with 12% discount rate, EIRR (economic cost) is **15.89%** and B/C ratio is **4.81**. NPV is Rs **22046** Cr.

Table 0.26: Economic Indicator Values (2044-45)

DN NAGAR-MANDALA	(Completion Cost Basis)		(Economic Cost)	
OPTION 2	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	29903	9162	11057	5794
Cumulative benefit(Cr.)	270065	27839	270065	27839
Benefit Cost Ratio	9.03	3.04	24.43	4.81
NPV(Cr.)	240162	18677	259009	22046
EIRR	25.20%	11.51%	31.80%	15.89%

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 25.14%.

0.17 IMPLEMENTATION PLAN:

The D.N. Nagar to Mandala Corridor is carved out of corridors recommended in Phase-I and Phase-II with route length of 23.643 km and completion cost of **Rs 10261 Crores.** World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for this corridor is **10.78%.**

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

A suggested project implementation schedule for Project Implementation on Turnkey Basis (Deposit Terms) is given in Table 0.27

Table 0.27 Project Implementation on Turnkey basis (Deposit Terms)

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

0.17.2 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 **D.N. Nagar – Mandala 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 about 88%, which is very high. Since the existing transport infrastructure has been heavily loaded, it has been observed that the population of private vehicles is increasing and it was also predicted that, the modal split in favour of public transport may also recede. Hence, it is proposed by MMRDA to introduce a rail based Mass Transportation System in Greater Mumbai and a master plan has been prepared for the same. It is proposed to take up the extension of Dahisar (E) - D. N. Nagar Corridor upto Mandala with route length of 23.643km 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 Project Cost:

Estimated Cost of the project at July 2015 price level with central taxes and duties only is Rs. 7798 crores exclusive of State taxes and Octroi of Rs 463 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs.10261 Crores excluding State taxes and Octroi of Rs.709 Crores.

0.18.4 After examining the various options for execution of extension of Dahisar (E) - D. N. Nagar Corridor upto Mandala is 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 **10.78 %.** The Economic Internal Rate of Return (EIRR) works out to 25.20%.

0.18.6 It is recommended to hand over the project to an agency like DMRC on turnkey basis as was done by Rajasthan and Kerala Governments in regard to Jaipur and Kochi Metro projects respectively to complete it within the time period of about three and half year.

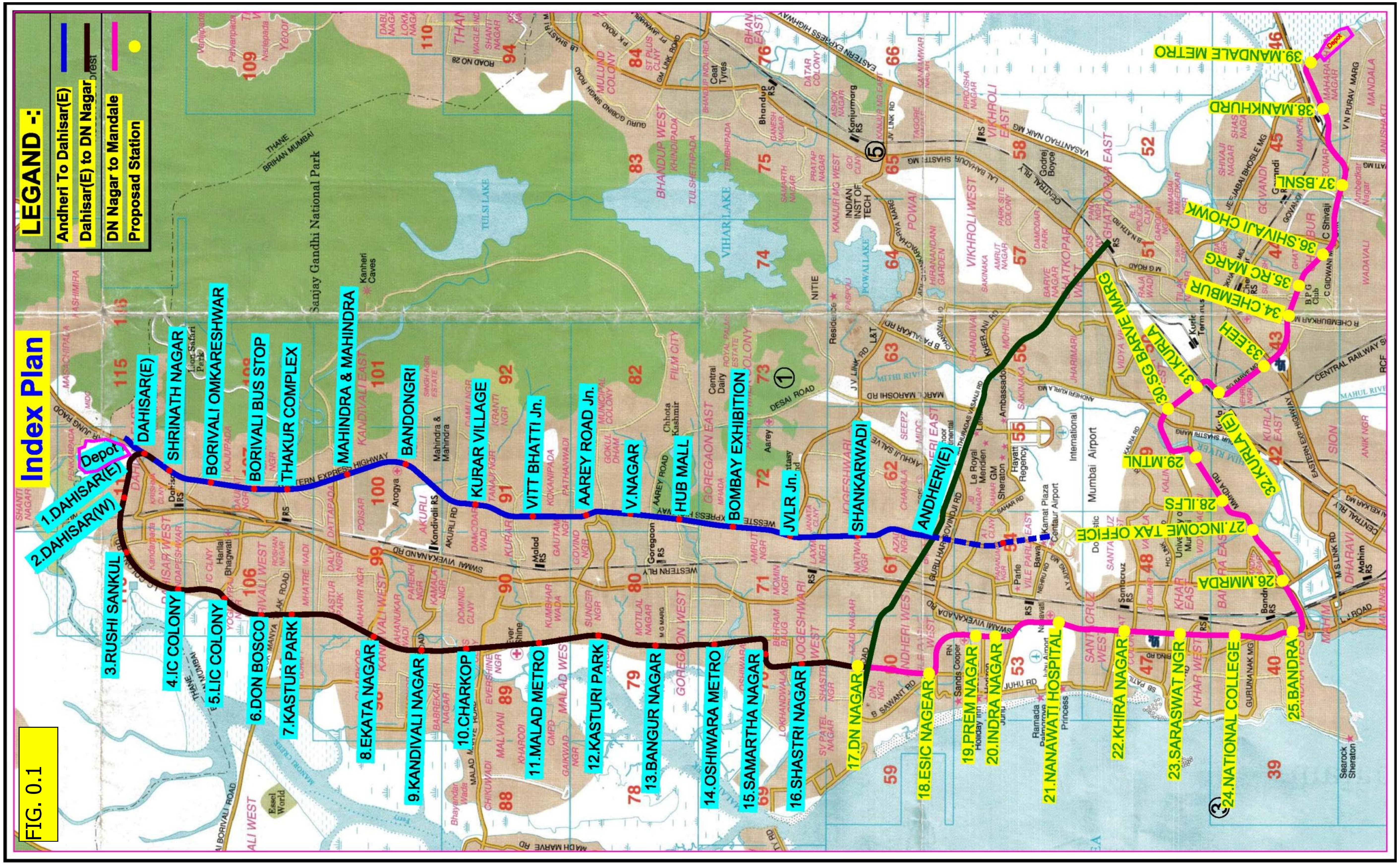


FIG. 0.1
Index Plan
LEGAND -:
Andheri To Dahisar(E)
Dahisar(E) to DN Nagar
DN Nagar to Mandale
Proposad Station
Depot
1.DAHISAR(E)
2.DAHISAR(W)
3.RUSHI SANKUL
4.IC COLONY
5.LIC COLONY
6.DON BOSCO
7.KASTUR PARK
8.EKATA NAGAR
9.KANDIVALI NAGAR
10.CHARKOP
11.MALAD METRO
12.KASTURI PARK
13.BANGUR NAGAR
14.OSHIWARA 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
27.INCOME TAX OFFICE
28.ILFS
29.MTNL
30.SG BARVE MARG
31.KURLA
32.KURLA (E)
33.EEH
34.CHEMBUR
35.RC MARG
36.SHIVAJI CHOWK
37.BSNL
38.MANKHURD
39.MANDALE METRO
DAHISAR(E)
SHRINATH NAGAR
BORIVALI OMKARESHWAR
BORIVALI BUS STOP
THAKUR COMPLEX
MAHINDRA & MAHINDRA
BANDONGRI
KURAR VILLAGE
VITT BHATTI Jn.
AAREY ROAD Jn.
V.NAGAR
HUB MALL
BOMBAY EXHIBITION
JVLR Jn.
SHANKARWADI
ANDHERI(E)
Sanjay Gandhi National Park
TULSI LAKE
VIHAR LAKE
POWAI LAKE
Mumbai Airport

Chapter 1 - Introduction

Chapter - 1

INTRODUCTION

1.1 BACKGROUND:

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

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

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

1.1.4 The city offers lot of job and professional opportunities in different sectors. This is the reason for large number of migrants from all over India being attracted to Mumbai to earn their livelihood.

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

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

1.2 DEMOGRAPHIC PROFILE

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

Table 1.1
Trend of population in Greater Mumbai (in Millions)

Year	Island City		Western Suburbs		Eastern Suburbs		Total Greater Mumbai	
		Decadal Growth		Decadal Growth		Decadal Growth		Decadal Growth
1971	3.07 (51.42%)		1.71 (28.64%)		1.19 (19.93%)		5.97 (100%)	
1981	3.28 (39.81%)	6.84	2.86 (34.71%)	67.25	2.10 (25.49%)	76.473	8.24 (100%)	38.02%
1991	3.17 (31.92%)	-3.35	3.95 (39.78%)	38.11	2.80 (28.20%)	33.33	9.93 (100%)	20.51%
2001	3.35 (28.13%)	5.68	5.10 (42.82%)	29.11	3.46 (29.05%)	23.57	11.91 (100%)	19.94%
2011	3.08 (31.92%)	-0.27	5.53 (39.78%)	0.43	3.83 (28.20%)	0.37	12.44 (100%)	4.5%

1.2.2 There is hardly any population growth in the Island City during 1971 – 2011. The population growth during 1971 – 2011 in Western Suburbs is 223% and in Eastern Suburbs is 222%. It is evident that the share of Island City population is declining continuously. The proportion of population in Island City compared to total population of Greater Mumbai declined from 51% in 1971 to 25% in 2011. In the same period the proportion for Western Suburbs went up from 28% to 44% and that in Eastern Suburbs from 20 % to 31%.

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

Table 1.2: Spatial Growth Profile of Greater Mumbai

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

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

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

1.2.5 As per the Comprehensive Traffic Study (CTS) for Mumbai Metropolitan Region, the planning parameters as per CTS study of MMRDA are as given in Table 1.4:

Table 1.4: Planning Parameters

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

1.3 EMPLOYMENT SCENARIO

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

1. Agriculture, Forestry and Fishing
2. Mining and Quarrying
3. Manufacturing and Repair services
4. Electricity, Gas and Water
5. Construction
6. Wholesale & Retail trade and Restaurants & Hotels
7. Transport, Storage and Communication
8. Financing, Insurance, Real estate and Business services
9. Community, Social and Personal services
10. Others

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

Table 1.5

Employment in Different Areas of Greater Mumbai (in Millions)

Year	Island City	Western Suburbs	Eastern Suburbs	Greater Mumbai
1971	1.09	0.24	0.19	1.52
1981	1.39	0.51	0.29	2.19

Year	Island City	Western Suburbs	Eastern Suburbs	Greater Mumbai
1991	1.34	0.64	0.44	2.42
1998	1.59	0.65	0.38	2.62
2011	2.25	2.32	1.23	5.80
2015	2.30	2.40	1.24	5.94

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

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

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

1.4 LAND USE POLICY:

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

1.4.1 Major recommendations of the Regional Plan are as follows:

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

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

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

Table 1.7
Proposed Redevelopment of Textile Mill Land Area

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

1.5 VEHICLE REGISTRATION

1.5.1 The data on private vehicles in Greater Mumbai is available for three regions, namely, the Island City, the Western suburbs and Eastern suburbs. The number of private vehicles registered in Greater Mumbai is given in Table 1.8. The ratio of private vehicles per thousand population is growing steadily, and has reached 150.32 in 2011. This clearly shows the inclination of people towards private vehicles. The trend is combined effect of the rising income level and saturation of public transport systems in Mumbai.

Table 1.8
Greater Mumbai Motor Vehicle Statistics

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

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

Table 1.9
Distribution and Growth of Vehicles in Island and Suburbs

Year	Island	Western suburbs	Eastern Suburbs	Total
2010	593902 (33.6%)	809225 (45.78%)	364671 (20.6%)	1767798 (100%)
2011	601176 (32.14%)	870558 (46.55%)	398577 (21.3%)	1870311 (100%)
2012	637768 (31.44%)	950394 (46.85%)	440338 (21.7%)	2028500 (100%)
2013	676514 (30.93%)	1026821 (46.94%)	484063 (22.1%)	2187398 (100%)

1.6 SUBURBAN RAIL SYSTEM

1.6.1 The main skeleton of the rail network in Mumbai was laid over 150 years ago, initially to link Mumbai and adjacent townships. Electric suburban rail services were started in 1925 in Mumbai by the Great Indian Peninsular Railway (Forbearer of the Central Railway in Mumbai).

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

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

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

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

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

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

1.6.8 In addition to Suburban Railway, one Metro Line from Varsova to Ghatkopar also has been commissioned recently in year 2014. Length of the corridor is 11.40 km.

1.7 THE ROAD NETWORK

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

1.7.2 The East – West vehicular movement is constrained by the Western and Central Railway tracks which also run for the majority of the length of the Island city.

Consequently major traffic movements are concentrated on relatively few roads, resulting in major points of congestion where East-West movements intersect the north-south corridor at points such as Parel Junction, Khodadad Circle, Gadkare Chowk and Sion intersection.

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

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

1.8 BUS TRANSPORT SYSTEM

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

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

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

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

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

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

1.8.7 Non Motorized System: Large number of Public is also walking using sky walks provided by MMRDA.

1.9 AIR POLLUTION

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

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

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

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

1.10 NEED FOR METRO

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

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

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

The proposed corridor from D.N. Nagar to Mandala is extension of metro corridor from Dahisar (E) to D.N. Nagar. This corridor runs in North-South direction upto Bandra. Hereafter, it runs in West-East direction upto Mandala. The route where this corridor is suggested is heavily loaded and connects market places, residential areas and Control Business District (CBD) like Bandra - Kurla Complex (BKC). The capacity of the road is much less than the demand. Hence there is a need for Grade separated MRTS System. Metro rail is most energy efficient and tested system and has the capacity to carry high traffic PHPDT. Therefore it is recommended to provide metro system of medium to heavy capacity.

1.11 TYPES OF METROS AND THEIR CAPACITY

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

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

1.12 ADVANTAGES OF A METRO SYSTEM:

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

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

1.13 REVIEW OF PAST STUDIES:

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

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

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

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

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

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

(iv) **Comprehensive Transport Study (CTS) for MMR:** A study was commissioned by the World Bank and MMRDA in 1993 to develop a strategy for transport development in MMR. The Study focused on the strategies for transport development, institutional strengthening for effective implementation of the proposed strategies and suggesting an investment program with appropriate prioritization.

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

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

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

The TEWET study also identified total network for Greater Mumbai after examining 3 alternatives. The recommended Network is of 57 km length with an estimated cost of Rs. 12,000 crore and in Island city it follows the 7th Corridor alignment. In the suburbs, the line is extended North upto Andheri with two branches; one going upto Charkop in Western suburbs & other leading to Mulund via Ghatkopar.
The detailed feasibility study was done for part of the Master Plan namely Andheri – Ghatkopar section with a spur to Sahar Airport. Total length was about 10 km and estimated cost Rs. 800 crore. Most of the alignment was elevated except small underground stretch of 1.5 km below flyover at Andheri.

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

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

Following were the objectives of the study:

I. Identify travel pattern of residents of MMR

II. Select, develop and operationalise an Urban Transport Planning model using state-of-the-art modeling techniques and software package, appropriate to the conditions and planning needs of MMR;

III. Assess the relevance of the1994 strategy, identify the consequences of pursuing alternative transport strategies, and recommend/update a long-term comprehensive transport strategy for MMR

IV. Identify for all modes a phased program of appropriate and affordable investments and policy proposals up to 2016; and

V. Help strengthen transport planning skills, and transfer all data, planning model/tools and knowledge obtained through the study to MMRDA and other agencies such as Mumbai Rail Vikas Corporation (MRVC), City & Industrial Development Corporation (CIDCO) and Municipal Corporation of Greater Mumbai (MCGM).

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

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

Figure 1.1

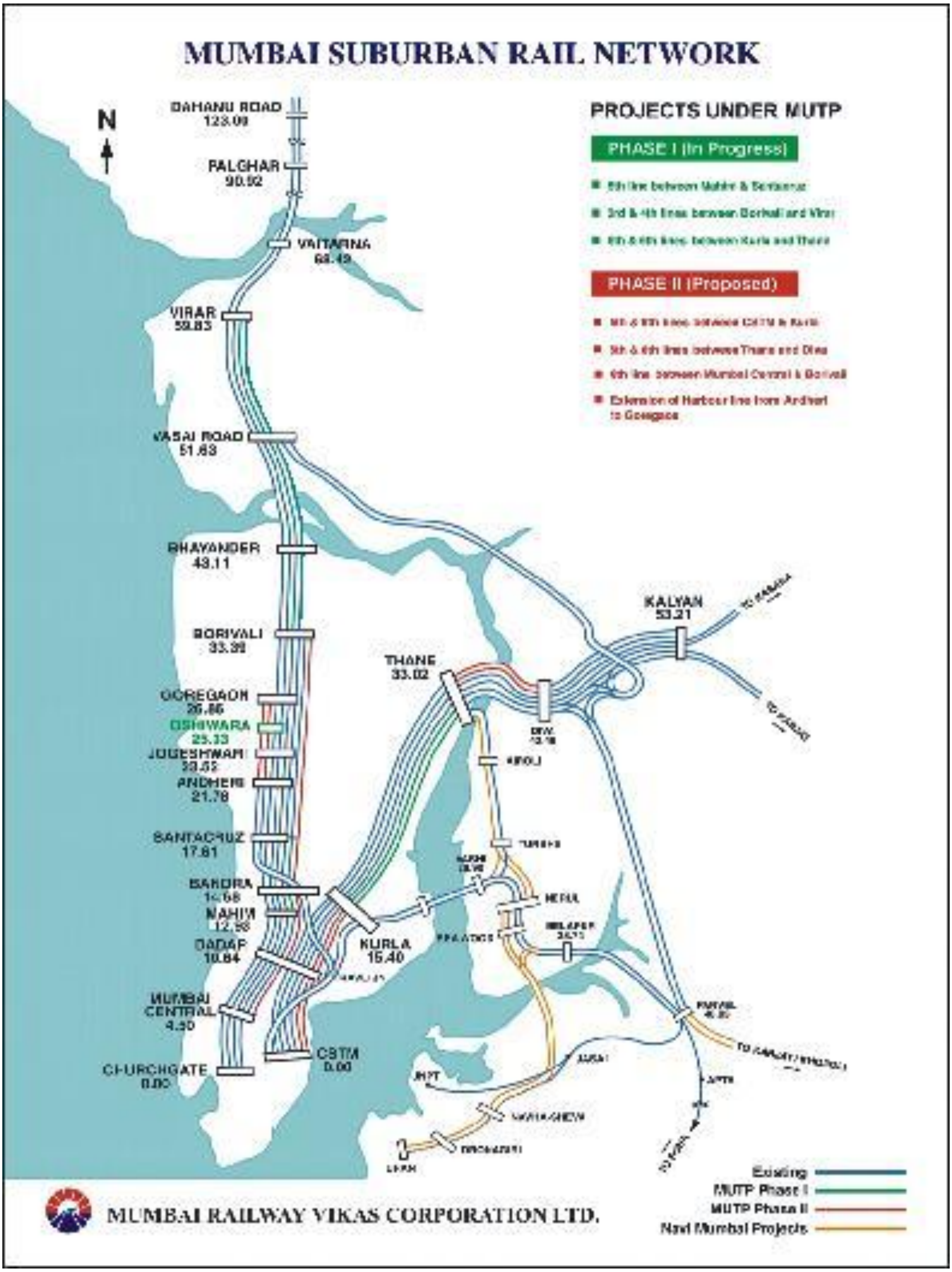
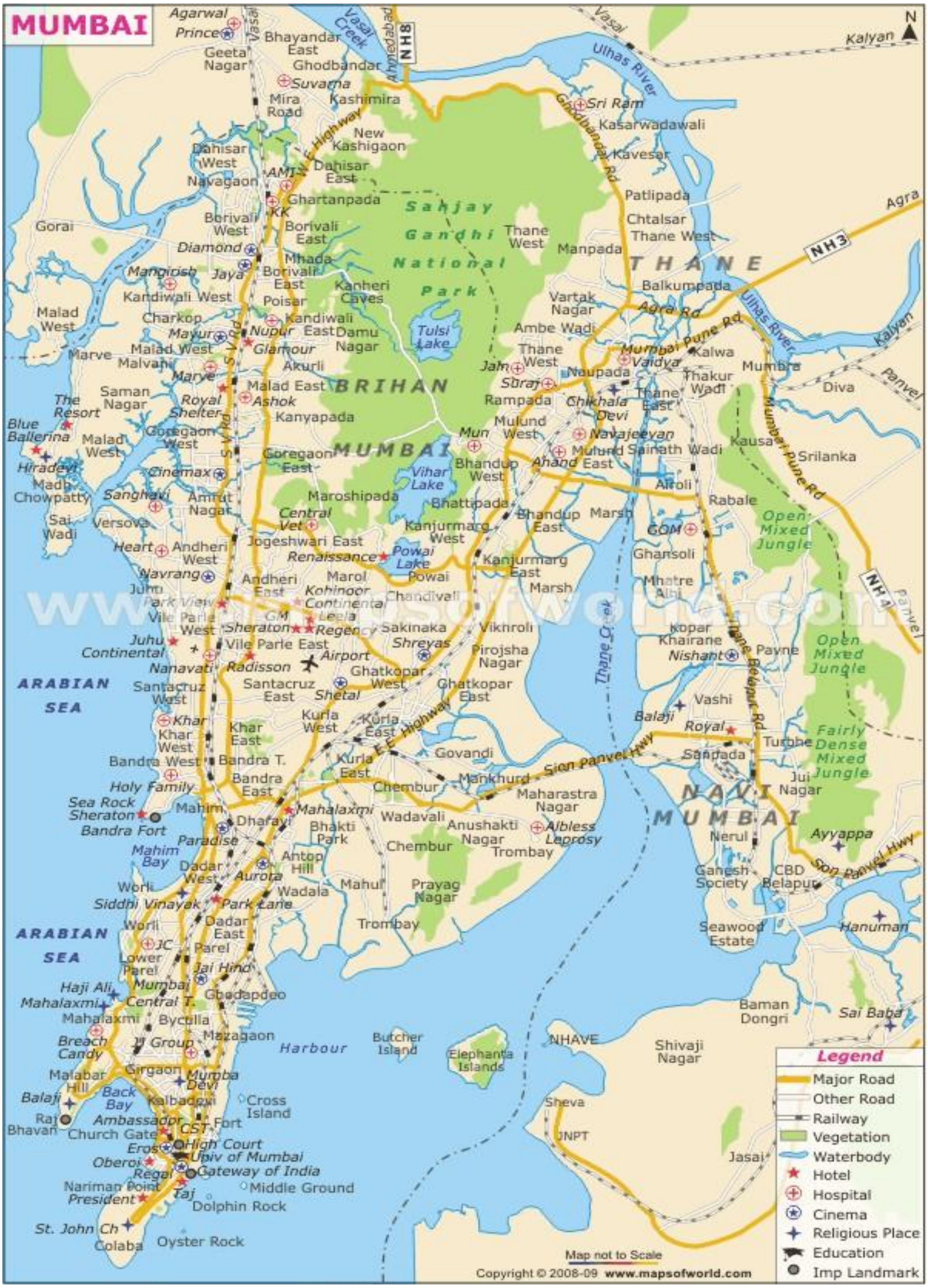

MUMBAI SUBURBAN RAIL NETWORK
N
DAHANU ROAD
PALGHAR
90.92
VAITARNA
VIRAR
59.83
VASAI ROAD
51.63
BHAYANDER
43.11
BORIVALI
GOREGAON
OSHIWARA
25.33
JOGESHWARI
ANDHERI
21.78
SANTACRUZ
17.81
BANDRA
MAHIM
DADAR
10.84
MUMBAI CENTRAL
CHURCHGATE
CSTM
0.00
KURLA
15.40
THANE
33.02
KALYAN
53.21
PROJECTS UNDER MUTP
PHASE I (In Progress)
PHASE II (Proposed)
Existing
MUTP Phase I
MUTP Phase II
Navi Mumbai Projects
MUMBAI RAILWAY VIKAS CORPORATION LTD.

Figure 1.2


MUMBAI
Kalyan
Ulhas River
Vasai
Vasai Creek
Bhayandar East
Ghodbandar
NH8
Suvarna
Mira Road
Kashimira
New Kashigaon
Dahisar West
Dahisar East
Navagaon
Gorai
Borivali West
Borivali East
Diamond
Jaya
Kandiwali West
Charkop
Malad West
Marve
Malvani
Poisar
Kanheri Caves
Kandiwali East
Damu Nagar
Akurli
Glamour
Malad East
Kanyapada
Sanjay Gandhi National Park
Tulsi Lake
Sri Ram
Kasarwadawali
Kavesar
Ghodbandar Rd
Patlipada
Chtalsar
Thane West
Manpada
THANE
Balkumpada
Agra Rd
Agra
NH3
Vartak Nagar
Ambe Wadi
Thane West
Mumbai Pune Rd
Kalwa
Vaidya
Naupada
Thakur Wadi
Mumbre
Diva
Panvel
Ulhas River
Suraj
Rampada
Chikhala Devi
Thane East
Mulund West
Navajeevan
Mulund East
Sainath Wadi
Kausa
Srilanka
Mumbai Pune Rd
BRIHAN MUMBAI
Goregaon East
Goregaon West
Vihar Lake
Bhandup West
Airoli
Rabale
Saman Nagar
The Resort
Blue Ballerina
Malad West
Madh
Chowpatty
Sai Wadi
Versova
Amrut Nagar
Maroshipada
Bhattipada
Bhandup East
Marsh
Open Mixed Jungle
Central
Kanjurmarg West
Jogeshwari East
Renaissance
Powai Lake
Powai
Kanjurmarg East
Marsh
Ghansoli
Andheri West
Navrang
Andheri East
Marol
Kohinoor
Continental
Chandivali
Mhatre Alhi
NH4
Juhu
Vile Parle West
Sheraton
Regency
Sakinaka
Vikhroli
Kopar Khairane
Nishant
Payne
Open Mixed Jungle
Continental
Vile Parle East
Airport
Pirojsha Nagar
Thane Creek
Nanavati
Radisson
Ghatkopar West
Ghatkopar East
ARABIAN SEA
Santacruz West
Santacruz East
Shetal
Vashi
Khar West
Khar East
Kurla West
Kurla East
E.E. Highway
Balaji
Royal
Turbhe
Fairly Dense Mixed Jungle
Bandra West
Bandra T.
Govandi
Sion Panvel Hwy
Sanpada
Holy Family
Bandra East
Chembur
Mankhurd
Maharastra Nagar
NAVI MUMBAI
Juinagar
Sea Rock Sheraton
Bandra Fort
Mahim
Dharavi
Mahalaxmi
Bhakti Park
Wadavali
Anushakti Nagar
Albless Leprosy
Nerul
Ayyappa
Mahim Bay
Paradise
Dadar West
Aurora
Antop Hill
Chembur
Trombay
Ganesh Society
CBD Belapur
Sion Panvel Hwy
Worli
Wadala
Mahul
Prayag Nagar
Siddhi Vinayak
Park Lane
Dadar East
Trombay
Seawood Estate
Hanuman
ARABIAN SEA
Worli
Parel
Lower Parel
Jai Hind
Haji Ali
Mahalaxmi
Mumbai Central T.
Ghodapdeo
Mahalaxmi
Byculla
Baman Dongri
Sai Baba
Breach Candy
JJ Group
Mazagaon
Harbour
Butcher Island
Elephanta Islands
NHAVE
Shivaji Nagar
Malabar Hill
Girgaon
Mumba Devi
Balaji
Back Bay
Kalbadevi
Cross Island
Sheva
Raj Bhavan
Ambassador
Church Gate
CST
Fort
JNPT
Eros
High Court
Univ of Mumbai
Jasai
Oberoi
Regal
Gateway of India
Nariman Point
President
Taj
Middle Ground
Dolphin Rock
St. John Ch
Colaba
Oyster Rock
Map not to Scale
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Legend
Major Road
Other Road
Railway
Vegetation
Waterbody
Hotel
Hospital
Cinema
Religious Place
Education
Imp Landmark

Chapter 2- Evolution of Mumbai Metro Master Plan & Present Status

Chapter - 2

EVOLUTION OF MUMBAI METRO MASTER PLAN AND PRESENT STATUS

2.1 BACKGROUND

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

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

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

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

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

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

2.2 PRELIMINARY NETWORK

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

i) Recommendation of the earlier studies for various rail based systems such as $6^{th}/7^{th}$ corridor, SMART study, MMPG study.

ii) Existing and future land use plans including Regional plan for MMR which indicate the locations and intensity of population and employment growth and development of alternate City centers.
iii) Suburban Rail Improvement Plans arising out of Departmental budgetary schemes and MUTP (phase I & II).
iv) Availability of suitable pieces of land for depot to minimize dead running and land cost.
v) Arterial road network expansion programme envisaged under the sanctioned projects of MUTP and MUIP.
vi) The suggestion of the members of the study review committee. Accordingly, a primary network of about 200 km was identified.

2.3 MASTER PLAN

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

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

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

Table 2.1

S. No.	Corridor	Length (Km)		
		Total	Elev.	U.G
1	Versova – Andheri – Ghatkopar	15.00	15.00	-
2	Coloba – Mahim (Bandra)	18.00	8.10	9.90
	Mahim (Bandra) – Charkop	18.00	18.00	
3	Mahim – Kurla – Mankhurd	12.80	10.70	2.10
4	Charkop – Dahisar	7.50	7.50	
5	Ghatkopar – Mulund	12.40	12.40	
6	BKC – Kanjur Marg via Airport	19.50	11.00	8.50
7	Andheri (E) – Dahisar (E)	18.00	18.00	
8	Hutatma Chowk – Ghatkopar	21.80	13.30	8.50
9	Sewri – Prabhadevi	3.50		3.50
	Grand Total	**146.50**	**114.00**	**32.50**

2.4 PHASING OF MASTER PLAN

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

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

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

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

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

i) Ridership per unit length = 40 %
ii) Ridership per unit investment = 25%
iii) Sectional traffic loads = 25 %
iv) Environmental Impact = 10 %

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

Table 2.2

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

2.5 PREVIOUS DPRs AND STATUS OF MUMBAI METRO RAIL PROJECT

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

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

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

i) Charkop – Dahisar (7.50 Km.) – M/s SPAN Consultants Pvt. Ltd.
ii) Andheri(E) – Dahisar(E) (18.00 Km.) – M/s SPAN Consultants Pvt. Ltd.
iii) BKC Kanjur Marg (via Airport) (19.50 Km.) with Extension from BKC to Mahim (4.0 Km.) – M/s RITES.
iv) Ghatkopar – Mulund (12.50 Km.) – M/s Consulting Engineering Services.
v) Wadala-Carnac Bunder (DPR) – M/s Consulting Engineering Services

2.5.4 All the above reports had submitted to MMRDA.

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

2.6 ASSIGNMENT TO DMRC

2.6.1 Delhi Metro Rail Corporation Ltd. were appointed as Consultant for the preparation of 'Mumbai Metro Master Plan' in May, 2003. This Master Plan was having total length of 146.50 kms metro network comprising of 9 corridors and to be implemented in 3 phases.

2.6.2 The Government of Maharashtra is keen to implement expeditiously the Master Plan Corridor 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 for the following potential elevated metro corridor:

Table 2.3

Sr. No.	Alignment	Length in kms
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

Sr. No.	Alignment	Length in kms
B	**Review of Metro alignment and updation of DPRs**	
	(a) D.N. Nagar - BKC	10.00
	(b) Jogeshwari Vikhroli Link Road – Seepz-Kanjur Marg	10.00
	(c) Wadala-Ghatkopar-Thane-Kasarvadavali. (Via EEH instead of LBS Rd.)	22.00 10.00
	(d) Wadala-GPO along R.A. Kidwai Rd. – Barrister Nath Pai Rd. – P.D. Mello Rd	08.00
	(e) Andheri (E) – BKC (Via WEH)	09.00
	Total	**118.00**

2.7 OBJECTIVE OF THE ASSIGNMENT

2.7.1 The objective of the assignment was to review, update & prepare Detailed Project Report (DPR) for the above proposed elevated Metro Corridors.

2.8 PRESENT STATUS

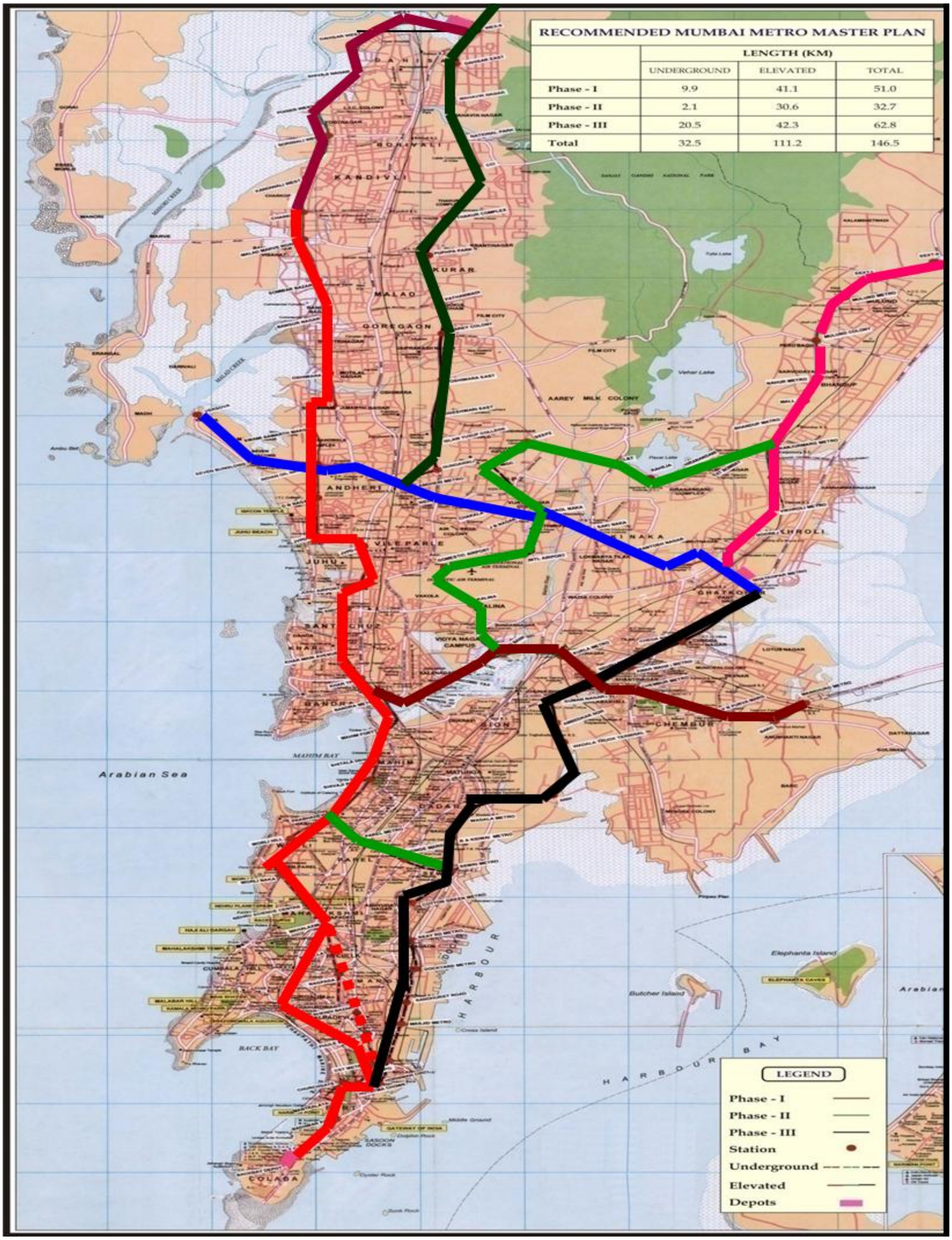
2.8.1 DMRC already has submitted DPR for Andheri (E) to Dahisar (E) and Dahisar (E) to D.N. Nagar Corridor in August 2015 and September 2015 respectively.

2.8.2 Updated DPR submitted for Andheri (E) to Dahisar (E) and Dahisar (E) to D.N. Nagar already have been approved by the State Government.

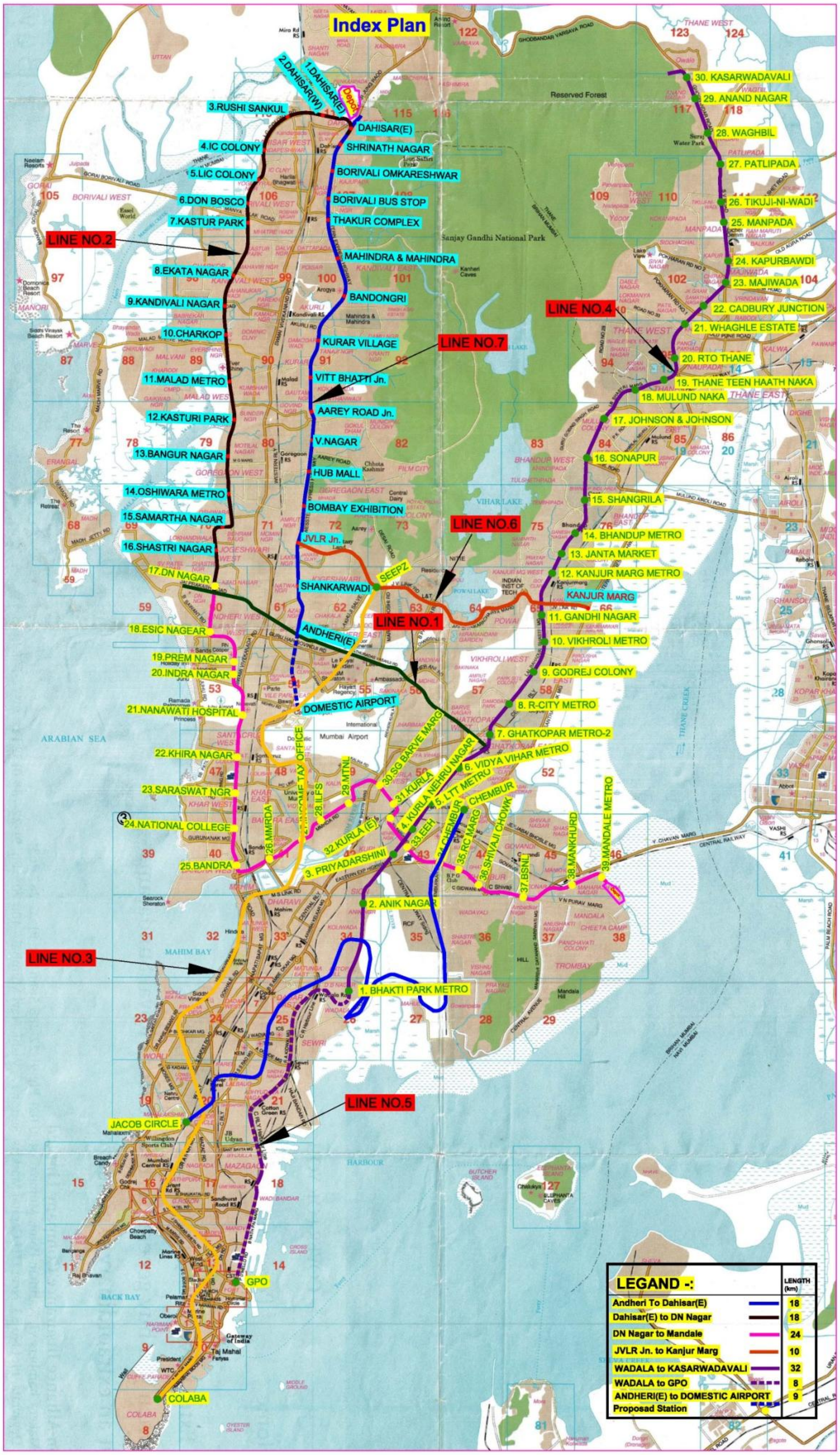
2.8.3 MMRDA is also taking help of DMRC for implementation of these corridors and they have awarded Dahisar (E) to D.N. Nagar Corridor on turnkey basis and for Andheri (E) to Dahisar (E) Corridor, DMRC has been appointed as Interim Consultant.

2.8.4 Draft updated DPR is for D.N. Nagar – MMRDA Office– Mankhurd – Mandala Corridor was submitted to MMRDA in the second week of December 2015. A presentation on the same was given by DMRC to MMRDA on 01.01.2016. MMRDA sent their final comments on Draft DPR on 28.01.2016. This DPR is being submitted after taking congisance of MMRDA’s comments.

Annexure 2.1


RECOMMENDED MUMBAI METRO MASTER PLAN
LENGTH (KM)
UNDERGROUND
ELEVATED
TOTAL
Phase - I 9.9 41.1 51.0
Phase - II 2.1 30.6 32.7
Phase - III 20.5 42.3 62.8
Total 32.5 111.2 146.5
LEGEND
Phase - I
Phase - II
Phase - III
Station
Underground
Elevated
Depots
Arabian Sea
KANDIVLI
BORIVALI
MALAD
GOREGAON
ANDHERI
VILE PARLE
JUHU
BANDRA
CHEMBUR
COLABA
BACK BAY
HARBOUR BAY
Elephanta Island
Butcher Island
Vehar Lake
AAREY MILK COLONY

Annexure 2.2


Index Plan
LINE NO.1
LINE NO.2
LINE NO.3
LINE NO.4
LINE NO.5
LINE NO.6
LINE NO.7
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 NAGAR
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
30.SG BARVE MARG
31.KURLA
32.KURLA (E)
33.EEH
35.RC MARG
36.SHIVAJI CHOWK
37.BSNL
38.MANKHURD
39.MANDALE METRO
DAHISAR(E)
SHRINATH NAGAR
BORIVALI OMKARESHWAR
BORIVALI BUS STOP
THAKUR COMPLEX
MAHINDRA & MAHINDRA
BANDONGRI
KURAR VILLAGE
VITT BHATTI Jn.
AAREY ROAD Jn.
V.NAGAR
HUB MALL
BOMBAY EXHIBITION
JVLR Jn.
SHANKARWADI
SEEPZ
ANDHERI(E)
DOMESTIC AIRPORT
KANJUR MARG
30. KASARWADAVALI
29. ANAND NAGAR
28. WAGHBIL
27. PATLIPADA
26. TIKUJI-NI-WADI
25. MANPADA
24. KAPURBAWDI
23. MAJIWADA
22. CADBURY JUNCTION
21. WHAGHLE ESTATE
20. RTO THANE
19. THANE TEEN HAATH NAKA
18. MULUND NAKA
17. JOHNSON & JOHNSON
16. SONAPUR
15. SHANGRILA
14. BHANDUP METRO
13. JANTA MARKET
12. KANJUR MARG METRO
11. GANDHI NAGAR
10. VIKHROLI METRO
9. GODREJ COLONY
8. R-CITY METRO
7. GHATKOPAR METRO-2
6. VIDYA VIHAR METRO
5. LTT METRO
4. KURLA NEHRU NAGAR
3. PRIYADARSHINI
2. ANIK NAGAR
1. BHAKTI PARK METRO
CHEMBUR
JACOB CIRCLE
GPO
COLABA
Sanjay Gandhi National Park
ARABIAN SEA
MAHIM BAY
BACK BAY
HARBOUR
Reserved Forest
LEGAND -:
LENGTH (km)
Andheri To Dahisar(E) 18
Dahisar(E) to DN Nagar 18
DN Nagar to Mandale 24
JVLR Jn. to Kanjur Marg 10
WADALA to KASARWADAVALI 32
WADALA to GPO 8
ANDHERI(E) to DOMESTIC AIRPORT 9
Proposed Station

Chapter 3- Traffic Forecast

Chapter - 3

TRAFFIC FORECAST

3.0 Based on the traffic modeling, MMRDA had initially given the traffic projections for four horizon years viz. 2016, 2021 and 2031. The traffic Projections for 2019 have been arrived at by interpolation.

3.1 PROPOSED METRO STATIONS ON DAHISAR – DN NAGAR - MANDALA CORRIDOR

It is proposed to have thirty nine stations on the Dahisar to Mandala Metro corridor (List is given in table 3.1 with chainage and inter station distance).

Table 3.1 Station Locations

Dahisar(E) to Mandala Metro Corridor (Mumbai)				
		CHAINAGE (M)	INTER STATION DISTANCE(M)	REMARKS
1	DAHISAR (E)	0.0	-	Elevated
2	DAHISAR (W)	711.0	711.0	Elevated
3	RUSHI SANKUL	2422.7	1711.7	Elevated
4	I C COLONY	3383.1	960.4	Elevated
5	LIC COLONY	4468.4	1085.3	Elevated
6	DON BOSCO	5537.5	1069.1	Elevated
7	KASTUR PARK	6465.9	928.4	Elevated
8	EKATA NAGAR	7571.8	1105.9	Elevated
9	KANDIVALI NAGAR	8200.3	628.5	Elevated
10	CHARKOP	9535.5	1335.2	Elevated
11	MALAD METRO	10846.0	1310.5	Elevated
12	KASTURI PARK	12243.4	1397.4	Elevated
13	BANGUR NAGAR	13183.1	939.7	Elevated
14	OSHIWARA METRO	14455.5	1272.4	Elevated
15	SAMARTHA NAGAR	15468.7	1013.2	Elevated
16	SHASTRI NAGAR	16433.0	964.3	Elevated
17	D N NAGAR	17578.6	1145.6	Elevated
18	ESIC NAGAR	18637.6	1059	Elevated
19	PREM NAGAR	20302.6	1665	Elevated
20	INDIRA NAGAR	20829.2	526.6	Elevated
21	NANAVATI HOSPITAL	21902.5	1073.3	Elevated
22	KHIRA NAGAR	23509.4	1606.9	Elevated
23	SARASWAT NAGAR	24466	956.6	Elevated
24	NATIONAL COLLEGE	25559	1093	Elevated
25	BANDRA METRO	26699.7	1140.7	Elevated

Dahisar(E) to Mandala Metro Corridor (Mumbai)				
		CHAINAGE (M)	INTER STATION DISTANCE(M)	REMARKS
26	MMRDA OFFICE	28292	1592.3	Elevated
27	INCOME TAX OFFICE	28913.9	621.9	Elevated
28	ILFS	30188	1274.1	Elevated
29	MTNL METRO	30982.8	794.8	Elevated
30	S G BARVE MARG	32720.2	1737.4	Elevated
31	KURLA TERMINAL	33194.7	474.5	Elevated
32	KURLA (E)	34349.2	1154.5	Elevated
33	EEH	35356.3	1007.1	Elevated
34	CHEMBUR	35996.7	640.4	Elevated
35	DIAMOND GARDEN	36959	962.3	Elevated
36	SHIVAJI CHOWK	37819	860	Elevated
37	B S N L METRO	38939.6	1120.6	Elevated
38	MANKHURD	40546.7	1607.1	Elevated
39	MANDALA METRO	41507.4	960.7	Elevated

3.2 TRAFFIC PROJECTIONS

MMRDA supplied station to station peak hour OD matrix for years 2016, 2021 and 2031 for the above corridor with the proposed stations as given in the table 3.1. A summary table of traffic projections is given in table 3.2.

Table 3.2 Summary of Daily Ridership

YEAR	TOTAL TRIP	PASS KM	AVERAGE LEAD (KM)	MAXIMUM PHPDT
2016	834640	79,57,122	9.53	21346
2021	1298260	1,43,91,377	11.09	35141
2031	1658950	1,61,05,386	9.71	38509

3.3 PEAK HOUR BOARDINGS / ALIGHTING AND SECTIONAL LOAD

Peak hour boarding / alighting and sectional load are derived for different horizon years are shown in Table No. 3.3, 3.4 and 3.5. “UP” indicates direction from Dahisar –Mandala, “DN” indicates direction from Mandala- Dahisar, “BR” –boarding, “AL”-alighting, “LOAD”-traffic volume. Trip length distribution frequency tables for different horizon years are shown in Table No. 3.3A, 3.4A and 3.5A.

Table 3.3: Peak Hr. Boarding and Alighting for Dahisar(E) to Mandala Metro Corridor(2016)

Station Name	UPBR	UPAL	DNBR	DNAL	ALLBR	ALLAL	UPLOAD	DNLOAD
DAHISAR (E)	1164	0	0	2102	1164	2102	1164	0
DAHISAR (W)	2141	0	0	4864	2141	4864	3305	2102
RUSHI SANKUL	7930	645	4430	712	12360	1357	10590	6966
I C COLONY	0	49	31	0	31	49	10541	3248
LIC COLONY	693	281	81	486	774	766	10954	3217

Station Name	UPBR	UPAL	DNBR	DNAL	ALLBR	ALLAL	UPLOAD	DNLOAD
DON BOSCO	493	305	222	286	715	592	11141	3622
KASTUR PARK	1055	422	289	400	1344	823	11774	3686
EKATA NAGAR	1757	483	270	1172	2028	1655	13048	3797
KANDIVALI NAGAR	4026	1208	807	2025	4833	3232	15866	4698
CHARKOP	2402	643	350	998	2753	1641	17625	5916
MALAD METRO	1302	2229	787	1793	2089	4022	16698	6564
KASTURI PARK	331	824	413	840	743	1665	16205	7570
BANGUR NAGAR	3571	384	131	1720	3702	2104	19391	7997
OSHIWARA METRO	2019	692	220	644	2239	1336	20719	9586
SAMARTHA NAGAR	942	888	255	1580	1198	2467	20774	10010
SHASTRI NAGAR	1001	429	245	622	1246	1050	21346	11334
D N NAGAR	1760	5248	3760	1143	5520	6391	17858	11711
ESIC NAGAR	1359	1015	458	1474	1817	2489	18202	9094
PREM NAGAR	1400	605	374	769	1773	1373	18997	10110
INDIRA NAGAR	435	819	335	566	769	1385	18613	10505
NANAVATI HOSPITAL	648	646	458	684	1106	1329	18615	10737
KHIRA NAGAR	571	1007	699	899	1270	1906	18179	10963
SARASWAT NAGAR	405	833	584	408	989	1241	17751	11163
NATIONAL COLLEGE	356	454	289	241	645	695	17653	10988
BANDRA METRO	3249	8488	5221	2577	8470	11065	12415	10940
MMRDA OFFICE	74	839	661	199	735	1038	11649	8296
INCOME TAX OFFICE	1627	745	499	1217	2126	1961	12531	7834
ILFS	115	1473	394	375	509	1848	11173	8552
MTNL METRO	31	84	64	35	95	119	11120	8533
S G BARVE MARG	888	5361	4067	922	4955	6283	6648	8504
KURLA TERMINAL	112	325	189	120	301	445	6434	5359
KURLA (E)	83	301	536	33	619	334	6215	5291
EEH	1930	1395	894	3504	2824	4899	6750	4788
CHEMBUR	82	1277	581	143	662	1420	5555	7398
DIAMOND GARDEN	150	2459	1086	282	1237	2740	3247	6961
SHIVAJI CHOWK	1167	1939	4174	362	5341	2300	2475	6156
B S N L METRO	0	919	1393	0	1393	919	1556	2344
MANKHURD	0	1305	621	0	621	1305	252	950
MANDALA METRO	0	252	329	0	329	252	0	329
	47268	47268	36196	36196	83464	83464		

Table 3.3A: Trip Length Distribution (2016)

from km	to km	trips	percent
0	2	5970	7.15%
2	4	13194	15.81%
4	6	11729	14.05%
6	9	16346	19.58%
9	12	11392	13.65%
12	15	7891	9.45%
15	18	7626	9.14%
18	21	2932	3.51%
21	24	3165	3.79%
24	27	1069	1.28%
27	31	1104	1.32%
31	35	780	0.93%
35	42	266	0.32%

Table 3.4: Peak Hr. Boarding and Alighting for Dahisar(E) to Mandala Metro Corridor(2021)

Station Name	UPBR	UPAL	DNBR	DNAL	ALLBR	ALLAL	UPLOAD	DNLOAD
DAHISAR (E)	4546	0	0	3439	4546	3439	4546	0
DAHISAR (W)	1163	0	0	1788	1163	1788	5709	3439
RUSHI SANKUL	12252	3053	2848	8667	15099	11720	14907	5228
I C COLONY	0	24	225	0	225	24	14883	11047
LIC COLONY	1457	341	271	1115	1728	1457	15999	10822
DON BOSCO	1133	272	340	655	1472	927	16859	11666
KASTUR PARK	2517	390	444	1092	2961	1482	18986	11981
EKATA NAGAR	3078	878	686	1483	3764	2361	21186	12629
KANDIVALI NAGAR	4917	1153	1141	2428	6059	3582	24950	13426
CHARKOP	3406	549	564	1449	3970	1998	27808	14713
MALAD METRO	4088	2313	1298	3373	5386	5686	29582	15598
KASTURI PARK	464	889	769	861	1233	1750	29156	17672
BANGUR NAGAR	4338	423	300	2356	4638	2778	33072	17763
OSHIWARA METRO	2814	744	454	854	3268	1598	35141	19819
SAMARTHA NAGAR	2085	8437	5690	2092	7775	10529	28789	20219
SHASTRI NAGAR	1271	445	338	814	1609	1259	29615	16620
D N NAGAR	2422	3115	2386	1399	4808	4515	28922	17096
ESIC NAGAR	2390	1517	905	1936	3295	3453	29795	16110
PREM NAGAR	1613	590	538	813	2151	1402	30818	17141
INDIRA NAGAR	831	891	549	858	1380	1749	30758	17415
NANAVATI HOSPITAL	891	774	647	756	1538	1530	30875	17724
KHIRA NAGAR	1242	1203	1028	1050	2270	2253	30914	17833
SARASWAT NAGAR	1065	892	841	638	1906	1530	31087	17855

Station Name	UPBR	UPAL	DNBR	DNAL	ALLBR	ALLAL	UPLOAD	DNLOAD
NATIONAL COLLEGE	706	467	395	309	1101	776	31326	17651
BANDRA METRO	6050	13622	6935	4131	12985	17753	23754	17565
MMRDA OFFICE	161	2371	1588	392	1749	2763	21544	14760
INCOME TAX OFFICE	1943	768	638	1000	2582	1768	22720	13564
ILFS	264	1817	616	562	879	2379	21167	13926
MTNL METRO	84	111	103	65	187	176	21140	13873
S G BARVE MARG	1280	7185	3857	1238	5137	8423	15234	13835
KURLA TERMINAL	223	781	365	232	589	1013	14676	11216
KURLA (E)	77	504	837	45	915	548	14250	11083
EEH	2200	2284	1397	3607	3597	5892	14166	10291
CHEMBUR	158	1212	623	428	781	1640	13112	12501
DIAMOND GARDEN	1266	2942	1600	1777	2866	4718	11436	12307
SHIVAJI CHOWK	1307	1927	4915	424	6222	2351	10816	12483
B S N L METRO	0	1648	1651	0	1651	1648	9169	7992
MANKHURD	0	8398	5456	0	5456	8398	771	6341
MANDALA METRO	0	771	885	0	885	771	0	885
	75701	75701	54126	54126	129826			

Table 3.4A: Trip Length Distribution (2021)

from km	to km	trips	percent
0	2	6496	5.00%
2	4	21223	16.35%
4	6	15904	12.25%
6	9	22746	17.52%
9	12	12887	9.93%
12	15	13653	10.52%
15	18	14002	10.78%
18	21	4907	3.78%
21	24	8167	6.29%
24	27	2564	1.98%
27	31	3199	2.46%
31	35	2433	1.87%
35	42	1646	1.27%

Table 3.5: Peak Hr. Boarding and Alighting for Dahisar(E) to Mandala Metro Corridor (2031)

Station Name	UPBR	UPAL	DNBR	DNAL	ALLBR	ALLAL	UPLOAD	DNLOAD
DAHISAR (E)	6300	0	0	4749	6300	4749	6300	0
DAHISAR (W)	2280	0	0	3209	2280	3209	8580	4749
RUSHI SANKUL	13002	4818	4749	10939	17751	15757	16764	7957
I C COLONY	0	43	580	0	580	43	16720	14147
LIC COLONY	2476	914	506	2448	2981	3361	18282	13567

Station Name	UPBR	UPAL	DNBR	DNAL	ALLBR	ALLAL	UPLOAD	DNLOAD
DON BOSCO	2831	861	794	1915	3626	2777	20252	15509
KASTUR PARK	4639	1132	839	2153	5478	3285	23759	16630
EKATA NAGAR	3177	1245	861	2061	4037	3306	25691	17944
KANDIVALI NAGAR	5877	1686	1804	3512	7681	5198	29881	19145
CHARKOP	3260	783	792	1658	4052	2441	32359	20853
MALAD METRO	3864	3163	1827	4599	5692	7762	33061	21719
KASTURI PARK	554	1164	1092	1014	1646	2178	32450	24491
BANGUR NAGAR	4793	560	410	3115	5204	3675	36684	24413
OSHIWARA METRO	2820	995	625	937	3445	1932	38509	27118
SAMARTHA NAGAR	1985	10515	9620	2426	11605	12941	29978	27431
SHASTRI NAGAR	1388	691	425	1262	1813	1953	30675	20236
D N NAGAR	2682	4137	3353	1841	6036	5977	29221	21072
ESIC NAGAR	2467	1951	1062	2512	3529	4463	29737	19560
PREM NAGAR	1634	688	636	910	2270	1599	30683	21010
INDIRA NAGAR	676	1150	747	798	1423	1948	30209	21284
NANAVATI HOSPITAL	940	872	770	924	1710	1797	30277	21336
KHIRA NAGAR	857	1504	1287	1372	2144	2876	29630	21490
SARASWAT NAGAR	880	1016	964	718	1844	1735	29494	21575
NATIONAL COLLEGE	632	499	473	414	1105	913	29626	21329
BANDRA METRO	4441	14438	9180	4226	13621	18663	19630	21270
MMRDA OFFICE	117	2196	1607	295	1724	2492	17550	16316
INCOME TAX OFFICE	2667	1108	847	4229	3514	5337	19109	15004
ILFS	296	1980	704	962	1000	2942	17425	18386
MTNL METRO	64	76	53	99	116	175	17413	18644
S G BARVE MARG	1300	6920	6598	1533	7898	8453	11794	18690
KURLA TERMINAL	142	454	307	209	449	663	11481	13625
KURLA (E)	1057	1717	2534	1311	3590	3028	10821	13528
EEH	3186	2991	1422	5503	4608	8494	11016	12305
CHEMBUR	139	1261	736	448	875	1710	9893	16386
DIAMOND GARDEN	945	1993	1653	1332	2598	3325	8845	16098
SHIVAJI CHOWK	1537	2393	5855	991	7392	3385	7988	15777
B S N L METRO	0	1694	2040	0	2040	1694	6294	10913
MANKHURD	1382	4233	6039	1985	7421	6217	3443	8873
MANDALA METRO	0	3443	4819	0	4819	3443	0	4819

Table 3.5A: Trip Length Distribution(2031)

from km	to km	trips	percent
0	2	11334	6.83%
2	4	28867	17.40%
4	6	23492	14.16%
6	9	31043	18.71%

from km	to km	trips	percent
9	12	18325	11.05%
12	15	16302	9.83%
15	18	14267	8.60%
18	21	8348	5.03%
21	24	6041	3.64%
24	27	2591	1.56%
27	31	2507	1.51%
31	35	1845	1.11%
35	42	933	0.56%

3.4. D. N. Nagar to Mandala corridor

The corridor will closely follow the construction of Dahisar (E) – D.N. Nagar Corridor. The summary of daily trips is given as under

Table 3.6 Summary of Daily Ridership

YEAR	TOTAL TRIP	PASS KM	AVERAGE LEAD (KM)	MAXIMUM PHPDT
2016	564430	63,29,422	11.21	21346
2021	890430	1,17,77,207	13.23	35141
2031	1049100	1,22,40,526	11.67	38509

Chapter 4- System Selection

Chapter - 4

SYSTEM SELECTION

4.0 INTRODUCTION

4.0.1 D. N. Nagar (excluding) to Mandala Corridor is extension of corridor from Dahisar (E) – D.N. Nagar. The alignment runs through ESIC Nagar, Prem Nagar, Indira Nagar, Nanavati Hospital, Khira Nagar, Saraswat Nagar, National College, Bandra Metro, MMRDA Office, Income Tax Office, ILFS, MTNL Metro, S.G. Barve Marg, Kurla Terminal, Kurla (E), EEH, Chembur, Diamond Garden, Shivaji Chowk, BSNL Metro, Mankhurd & Mandala Metro.

4.0.2 The entire corridor will be elevated and total length is 23.643 km. (dead end to dead end).

4.0.3 Twenty two stations have been proposed on the corridor. Efforts have been made to keep the inter station distance about a kilometer. However the closest inter- station distance is 474 metres and farthest 1737 metres.

4.0.4 All stations will be two level stations with the concourse and station facilities on the lower level and platforms on the higher level except ILFS station which has been proposed two tower stations.

4.0.5 Maintenance Depot has been proposed near Mandala station on Land identified by MMRDA.

4.1 PERMANENT WAY

4.1.1 CHOICE OF GAUGE

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

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

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

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

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

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

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

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

- Rolling Stock characteristics,
- Signaling Systems,
- Headways,
- Tariffs,
- Moving dimensions, and
- Loading standards.

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

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

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

4.1.2 TRACK STRUCTURE

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

General

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

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

Rail Section

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

Ballastless Track on Viaducts

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

Ballastless Track in Depot

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

- Discretely supported on concrete/steel 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.4.2**).

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

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

- The proposed specifications for turnouts are given below: -

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

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

- The switch rail should be with thick web 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.

4.1.3 RAIL STRUCTURE INTERACTION

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

Welding

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

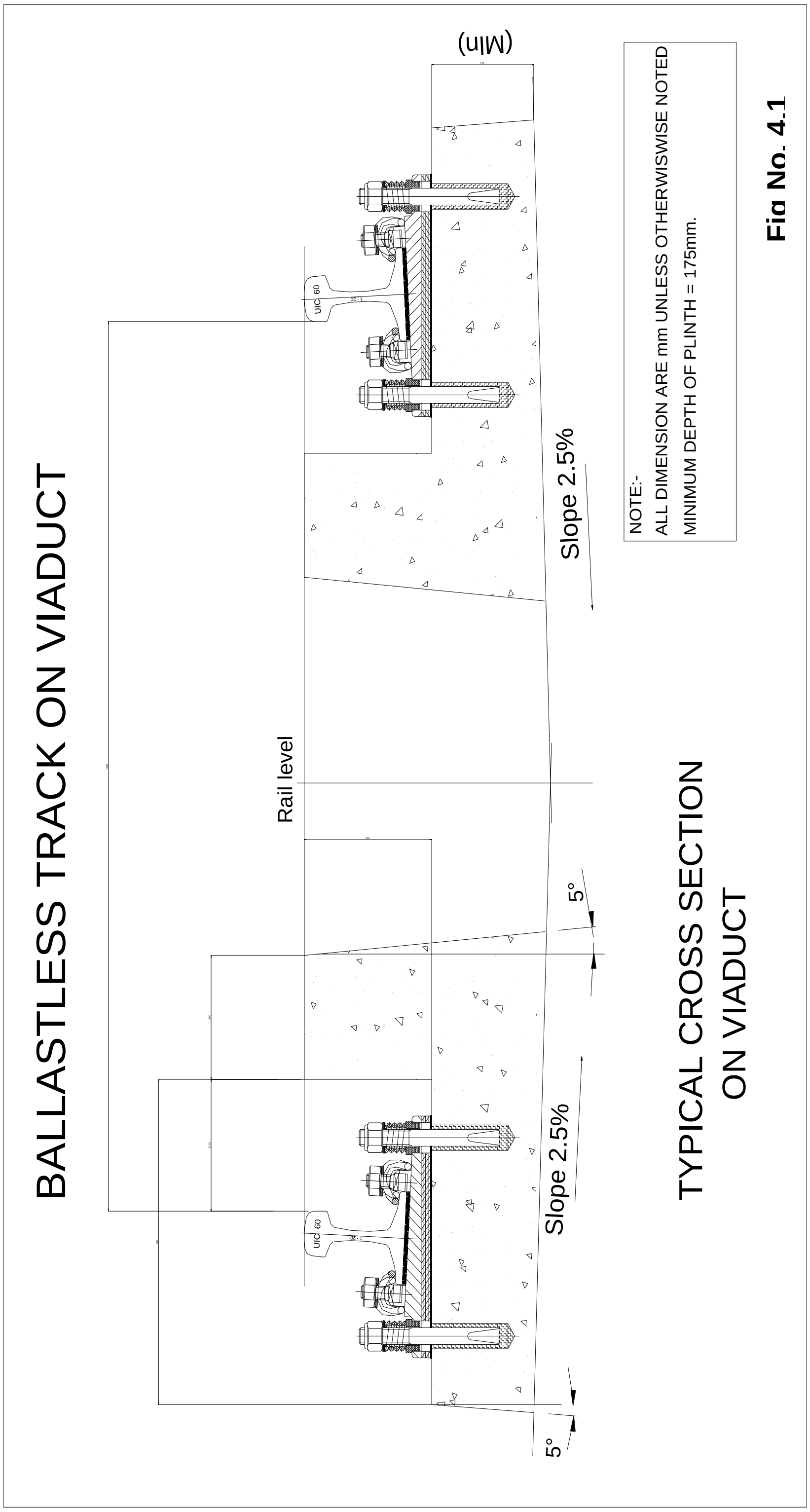
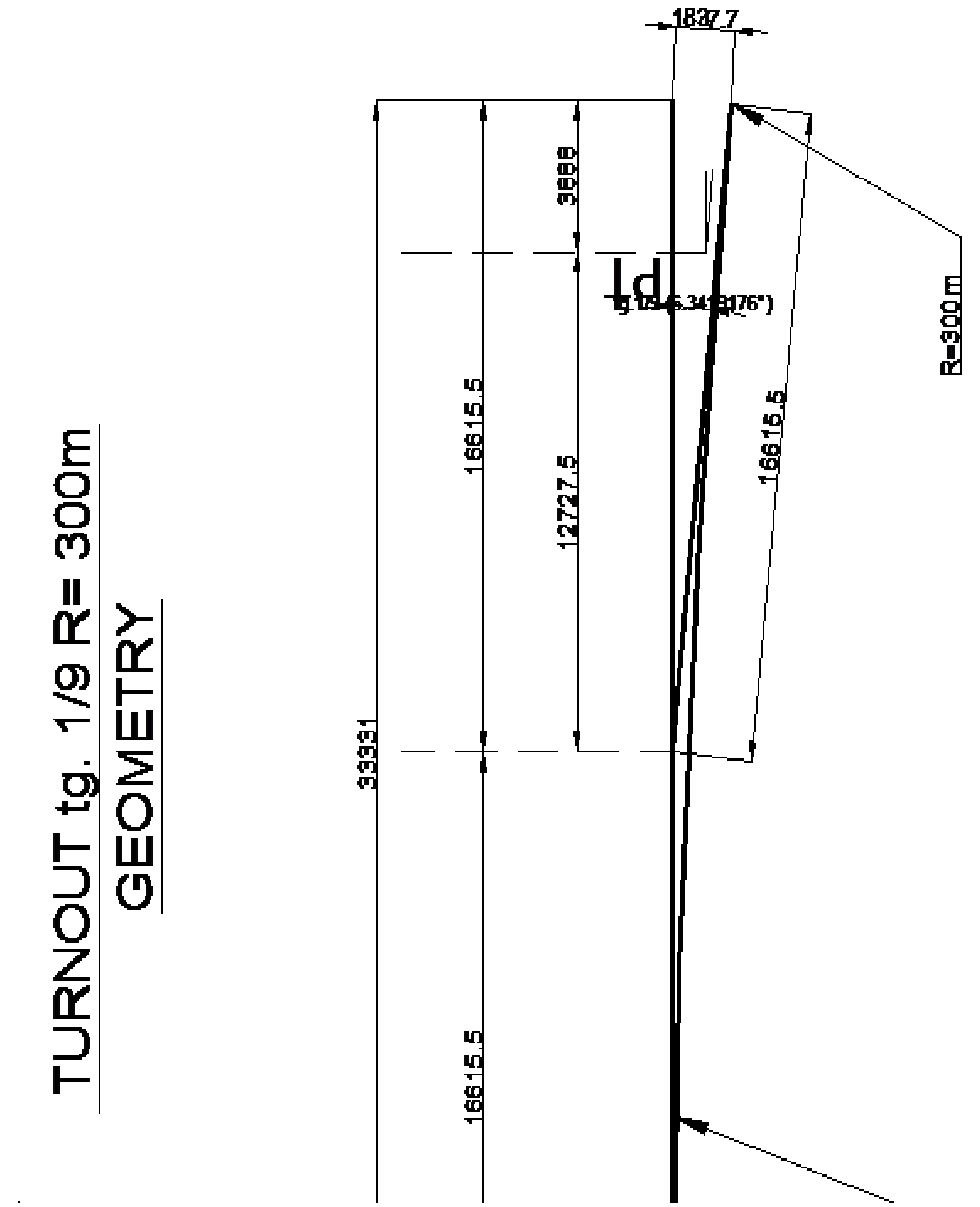


Fig No. 4.1

Fig No. 4.2


TURNOUT tg. 1/9 R= 300m
GEOMETRY
1827.7
3888
16615.5
12727.5
33331
16615.5
16615.5
R=300m
ld

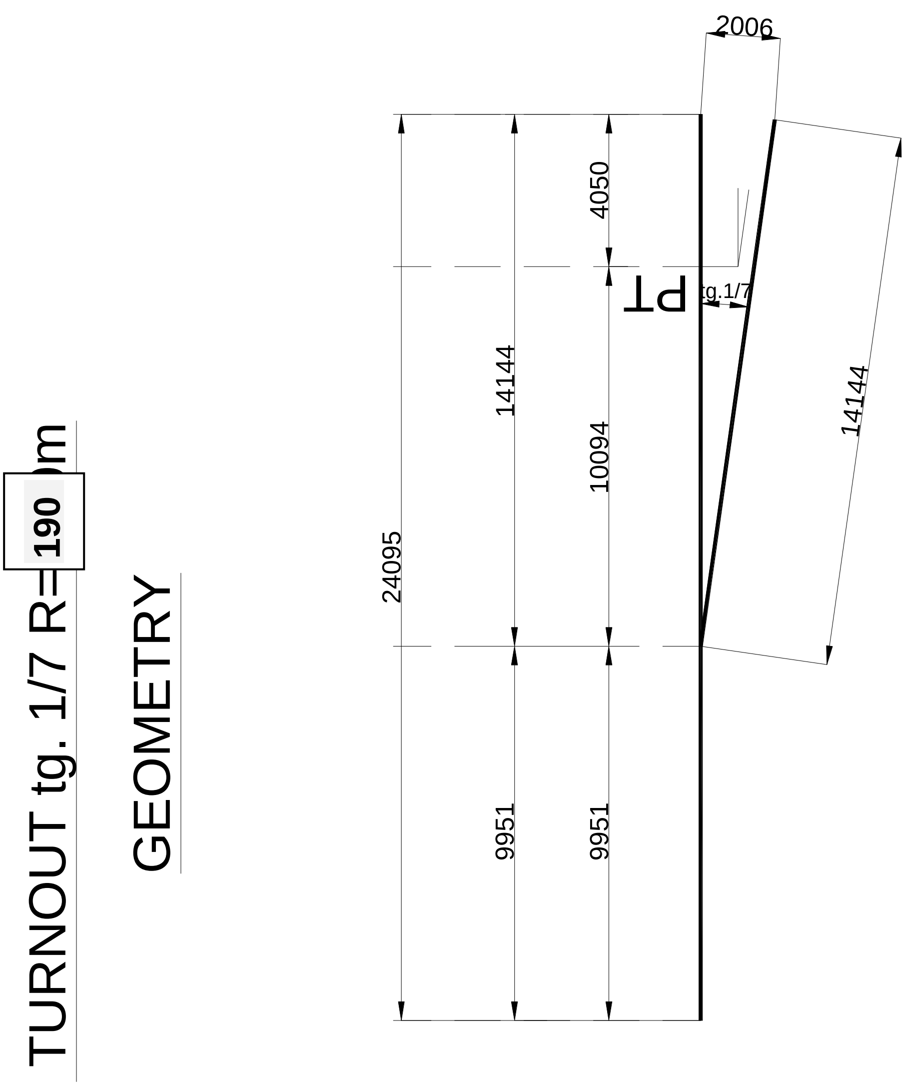

TURNOUT tg. 1/7 R=190m
GEOMETRY
2006
4050
14144
10094
24095
9951
9951
PT
tg.1/7
14144

Fig No. 4.3

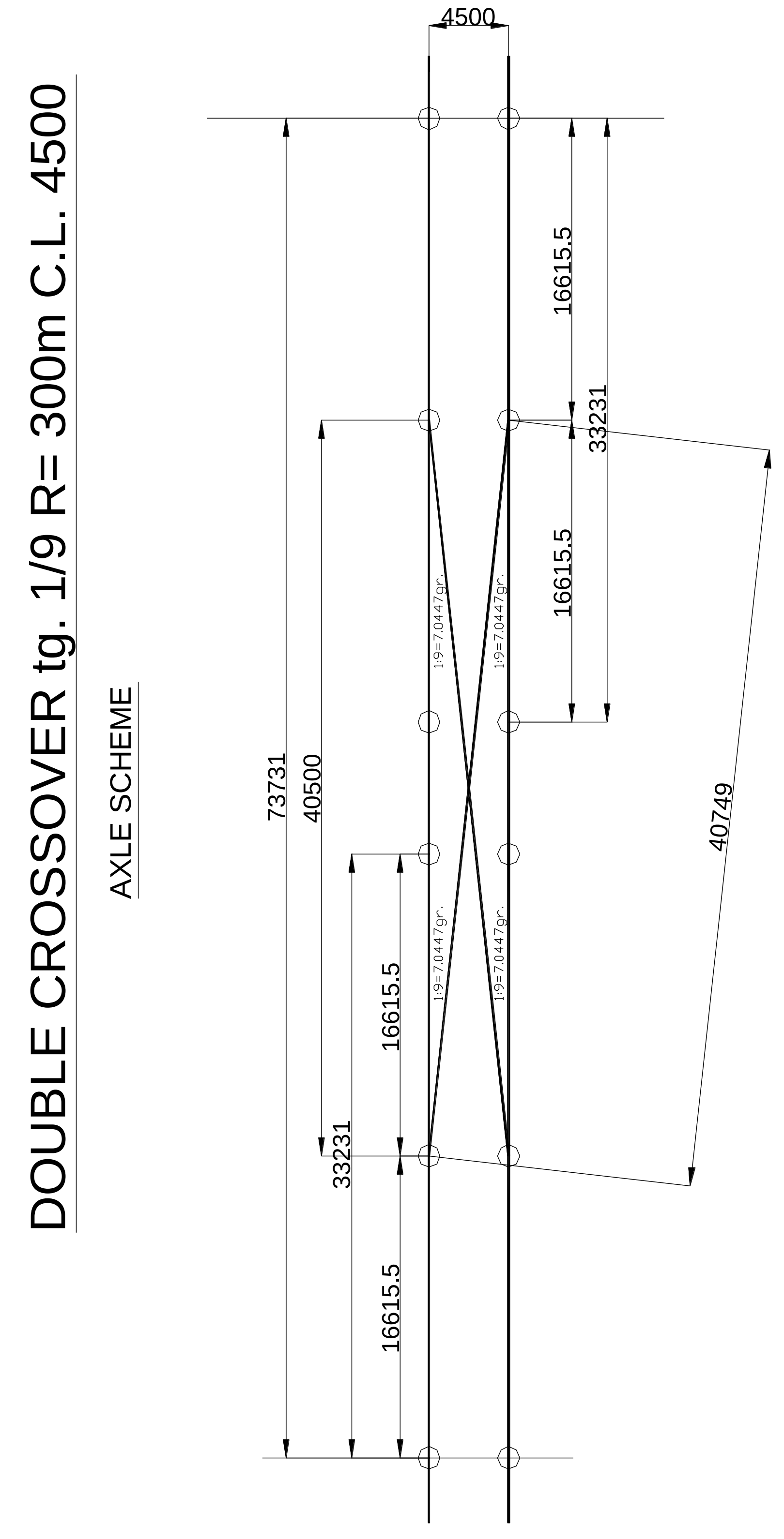

DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500
AXLE SCHEME
4500
16615.5
16615.5
33231
73731
40500
40749
16615.5
33231
16615.5
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.

Fig No. 4.4

4.2 TRACTION SYSTEM

4.2.1 INTRODUCTION

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

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

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

4.2.2 SALIENT FEATURES OF THE SYSTEM

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

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

4.2.2.3 Span of OHE Mast:

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

4.2.2.4 Height of Contact Wire:

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

4.2.3 EARTHING ARRANGEMENTS

4.2.3.1 Earthing of Over Line Structures:

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

4.2.3.2 Earthing of Exposed Metallic Parts:

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

4.2.3.3 Earthing Heel of Isolator Switch:

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

4.2.3.4 Provision of Overhead Protection Conductor:

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

4.2.4 OHE SECTIONING

4.2.4.1 Purpose

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

4.3 SIGNALLING AND TRAIN CONTROL

4.3.1 INTRODUCTION

4.3.2 OVERVIEW

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

This will:

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

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

4.3.3 SYSTEM DESCRIPTION AND SPECIFICATIONS

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

4.3.3.1 Continuous Automatic Train Control

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

4.3.3.1.1 Automatic Train Protection (ATP)

Automatic Train Protection is the primary function of the train control systems. This sub-system will be inherently capable of achieving the following objectives in a fail-safe manner. Line side signals will be provided at diverging routes (i.e. at points & crossings) as well as other required locations, which shall serve as backup signalling in case of failure of ATP system.

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

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

4.3.3.1.2 Automatic Train Operation (ATO)

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

4.3.3.1.3 Automatic Train Supervision (ATS)

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

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

- Automatic Route setting
- Automatic Train Regulation
- Continuous Tracking of train position
- Display Panel & Workstation interface
- Link to Passenger Information Display System for online information
- Computation of train schedules & Timetable.

4.3.3.2 Interlocking System

4.3.3.2.1 Computer Based Interlocking (CBI)

The entire line including turn back track, transfer track, sidings will be equipped with CBI system for operation of points and crossings and setting of routes.

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

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

The equipment will withstand tough environmental conditions encountered in a Mass Transit System. Suitable IS, IRS, BS standards or equivalent international standards will be followed in case wiring, installation, earthing, cabling, power supply and for material used in track circuits, axle counters, relays, point operating machines, power supply etc.

4.3.3.2.2 Track Vacancy Detection

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

4.3.3.2.3 Signals

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

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4.3.3.2.4 Point Machines

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

4.3.3.3Train 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.

4.3.3.4 Interface for PSD

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

4.3.4 STANDARDS

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

Table 4.1

Description	Standards
▪ Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for workshop lines, inspection shed lines etc.
▪ Block Working	Moving Block working concept may be followed.
▪ Operation of Points	Non-Trailable Electrical Point Machine capable of operating with 3-phase, 50 Hz. 380V AC will be used on main line and the depot point machine will be trailable/ non -trailable type electrical point machine capable of operating with either 3 phase, 50 Hz. 380V AC or 110V DC.
▪ Track Vacancy Detection System	Primary mode for track vacancy detection system on main line and test track in depot may be through radio and for depot and secondary detection it can be through Track circuit / Axle Counter.
▪ Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
▪ UPS (uninterrupted power at stations as well as for	For Signalling, Telecommunications and AFC.

Description	Standards
OCC)	
▪ Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide for redundancy. The system will conform to IEEE 1474 standards.
▪ Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC. The system architecture shall provide for redundancy.
▪ Cables	Outdoor cables will be steel armoured as far as possible.
▪ Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for Signal and Train Control System.
▪ Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables as per standard. CENELEC standards to be implemented for EMC.
▪ Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 Kmph.
▪ Environmental Conditions	Air-conditioners for all equipment rooms.
▪ Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.

4.3.5 SPACE REQUIREMENT FOR SIGNALING INSTALLATIONS

Adequate space for proper installations of all Signalling equipment and Platform screen doors at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment shall be generally 60 sqm. for UPS Room (common for signalling and telecom). For Signalling Equipment Room the area required 50 sqm. at depot and all the stations having crossovers and for remaining stations 20 sqm. These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC and the Depot, the areas required shall be as per the final configuration of the equipments and network configuration keeping space for further expansion.

4.3.6 MAINTENANCE PHILOSOPHY FOR SIGNALLING SYSTEMS

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

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

4.4 TELECOMMUNICATION

4.4.1 INTRODUCTION

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

4.4.2 OVERVIEW

The Telecommunication facilities proposed are helpful in meeting the requirements for :
1. Supplementing the Signalling system for efficient train operation.
2. Exchange of managerial information
3. Crisis management during emergencies
4. Passenger information system

The proposed Telecom system will cater to the following requirements:

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

4.4.3 TELECOMMUNICATION SYSTEM AND TRANSMISSION MEDIA

4.4.3.1 Fibre Optic System (FOTS) - Main Telecommunication Bearer

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

SDH (minimum STM-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.

4.4.3.2 Telephone Exchange

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

4.4.3.3 Mobile Radio Communication

Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. All the stations, depots and the OCC will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets. These persons will be able to communicate with each other as well as with central control.

The frequency band for operation of the system will be in 400/800 MHz band, depending on frequency availability. The system shall provide instant mobile radio communication between the motorman of the moving cars from any place and the Central Control. The motorman can also contact any station in the network through the central control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance.

To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 7 sites with rooftop towers with Base Stations shall be required along the proposed D. N. Nagar-Mandala Metro Corridor.

4.4.3.4 Passenger Announcement System

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

4.4.3.5 Passenger Information Display System

These shall be located at convenient locations at all stations to provide bilingual visual indication of the status of the running trains and will typically indicate information such as destination, arrival/departure time, and also special messages in emergencies. The boards shall be provided at all platforms and concourses of all stations. The System shall be integrated with the PA system and available from same MMI. For the Platform Area, high intensity LED Boards will be used in Evaluated Section. For all the concourses and Platform Area of underground Stations, HDLED Panels shall be used, which can also provide Audio/Visual Advertisements apart from Trains running status.

4.4.3.6 Centralized Clock System

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

4.4.3.7 Closed Circuit Television (CCTV) System

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

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

4.2.3.8 Access Control System

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

4.2.3.9 Network Monitoring and Management

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide an Integrated Network Control System, which will help in diagnosing faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance. The proposed NMS system will be covering Radio communication, Optical Fiber Transmission, Telephone Exchange and summary alarms of PA/PIDS, CCTV and Clock System. The Integrated NMS will collect and monitor status and alarms from the individual NMS of the respective sub-systems and display on a common Work Station.

4.4.4 TECHNOLOGY

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

Table 4.2 TECHNOGIES FOR TELECOMMUNICATION SYSTEMS

System	Standards
Transmission Media	Optical Fibre system as the main bearer for bulk of the Telecommunication network
Telephone Exchange	IP EPABX of minimum 30 ports is to be provided at all Stations, an Exchange of 60 Ports to be provided at Terminal Station
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel and central control.
Train Destination Indicator System	LED based boards with adequate visibility 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.

4.4.5 SPACE REQUIREMENT FOR TELECOM INSTALLATIONS

Adequate space for proper installations of all Telecommunication equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Telecom equipment shall be generally 30 sqm each for Telecom Room and 50 sqm. for UPS Room (common for signal, Telecom and AFC). These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC, the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion.

4.4.6 MAINTENANCE PHILOSOPHY FOR TELECOM SYSTEMS

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

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

4.5 AUTOMATIC FARE COLLECTION SYSTEM:

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

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

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

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

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

B. Automatic fare collection systems have the following advantages:

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

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

C. Choice of Control Gates

Retractable Flap type 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

4.5.2 AFC EQUIPMENT REQUIREMENT

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

4.5.3 STANDARDS

The standard proposed for AFC system are as under:

Table 4.3

Standards	Description
Fare media	a) **Contactless Smart Token** – For single journey. Token are captured at the exit gate. b) **Contactless Smart Card** – For multiple journeys. Contactless readers shall be as per ISO 14443 standards.
Gates	Computer controlled retractable flap / turnstile type automatic gates at entry and exit. There will be following types of gates : - **Entry** - **Exit** - **Reversible** - **Disabled** – Wide reversible gate for 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.

Standards	Description
Maintenance philosophy	Being fully Contactless system, manpower requirement for maintenance is much less compared to system with magnetic tickets. However, adequate facilities to be provided similar to that of S & T systems.

4.5.4 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 4.1 Entry/Exit Gates

Fig 4.2: Ticket Office Machine

Fig 4.3: Ticket vending machine

Fig. 4.4 Ticket Reader/Add Value Machine

Annexure 4.1

AFC Equipments for Metro line -2 for DN Nagar to Mandala Metro (via SCLR) (Projection for 2019)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Gate		Disabled Gate	TOM	EFO	TR	TVM	RCTM
						Entry	Exit						
1	D.N. Nagar	5093	5265	85	88	4	4	1	4	2	4	2	2
2	ESIC Nagar	2704	3067	45	51	2	3	1	2	2	4	2	2
3	Prem Nagar	2000	1390	33	23	2	2	1	2	2	4	2	2
4	Indira Nagar	1136	1603	19	27	2	2	1	2	2	4	2	2
5	Nanavati Hosp.	1365	1450	23	24	2	2	1	2	2	4	2	2
6	Khira Nagar	1870	2114	31	35	2	2	1	2	2	4	2	2
7	Saraswat Nagar	1539	1414	26	24	2	2	1	2	2	4	2	2
8	National College	919	744	15	12	2	2	1	2	2	4	2	2
9	Bandra Metro	11179	15078	186	251	8	10	1	10	2	4	2	2
10	MMRDA	1343	2073	22	35	2	2	1	2	2	4	2	2
11	Income Tax Office	2400	1845	40	31	2	2	1	2	2	4	2	2
12	ILFS	731	2167	12	36	2	2	1	2	2	4	2	2
13	MTNL Metro	150	153	3	3	2	2	1	2	2	4	2	2
14	S.G. Barve Marg	5064	7568	84	126	4	6	1	4	2	4	2	2
15	Kurla Railway	473	786	8	13	2	2	1	2	2	4	2	2
16	Kurla (E)	797	462	13	8	2	2	1	2	2	4	2	2
17	EEH	3287	5494	55	92	3	4	1	3	2	4	2	2
18	Chembur	733	1552	12	26	2	2	1	2	2	4	2	2
19	R.C. Marg	2214	3926	37	65	2	3	1	2	2	4	2	2
20	Shivaji Chowk	5870	2331	98	39	4	3	1	4	2	4	2	2
21	BSNL Metro	1548	1356	26	23	2	2	1	2	2	4	2	2
22	Mankhurd Metro	3522	5561	59	93	3	4	1	3	2	4	2	2
23	Mandala Metro	663	563	11	9	2	2	1	2	2	4	2	2
	TOTAL					**60**	**67**	**23**	**62**	**46**	**92**	**46**	**46**

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

4.6 ROLLING STOCK

4.6.1 INTRODUCTION

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

- **OPTIMIZATION OF COACH SIZE**

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

Table 4.4 - Size of the coach

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

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

Passenger Carrying Capacity

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

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

Following train composition is recommended:

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

Table 4.5 shows the carrying capacity of Medium Rail Vehicles.

Table 4.5 Carrying Capacity of Medium Rail Vehicles

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

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

- **WEIGHT**

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

Table 4.6 Weight of Light Rail Vehicles (TONNES)

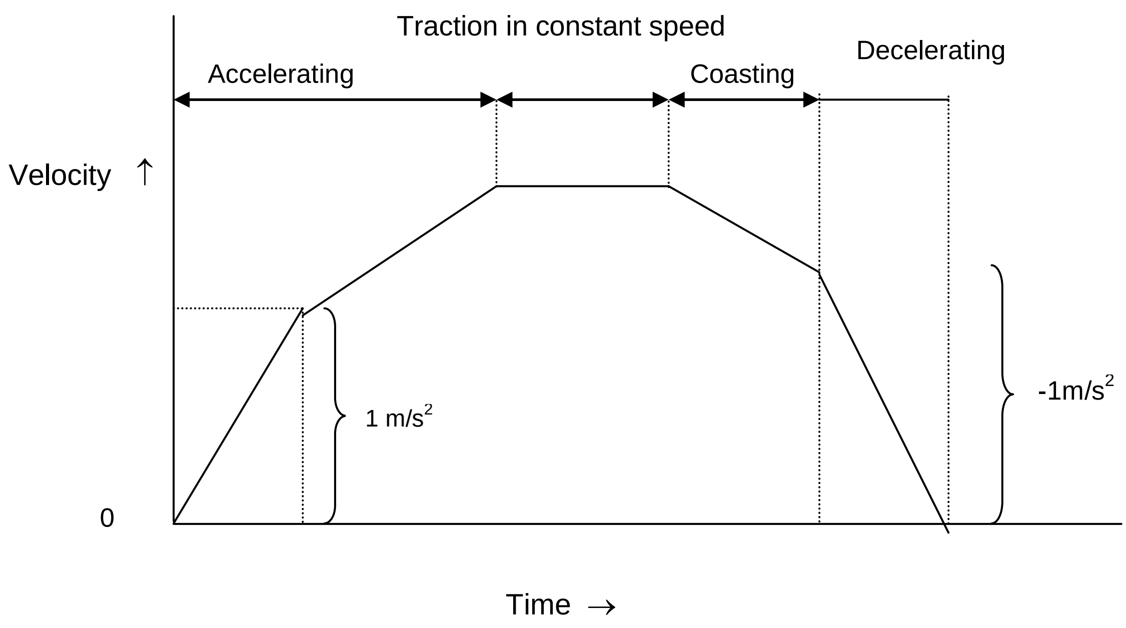
	DMC	TC/MC	6 Car train
TARE (maximum)	42.69	41.61/41.98	252.56
Passenger			
(Normal)	10.48	11.29/11.29	66.13
(Crush @6p/sqm)	18.33	19.37/19.37	114.14
(Crush @8p/sqm)	23.4	24.7/24.7	145.6
Gross			
(Normal)	53.17	52.90/53.27	318.69
(Crush @6p/sqm)	61.02	60.98/61.35	366.7
(Crush @8p/sqm)	66.09	66.31/66.68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

The axle load @ 6persons/sqm of standing area works out in the range of 15.25T to 15.33T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should, therefore, be designed for 17 T axle load.

4.6.2 PERFORMANCE PARAMETERS

The recommended performance parameters are:

Traction Power Supply:	25Kv ac
Motoring capacity:	67%
Maximum Design Speed:	90 kmph
Maximum Operating Speed:	80 kmph
Max. Acceleration:	1 m/s^2 $\pm$ 5%
Max. Deceleration:	1.0 m/s^2 (Normal brake)
	1.35m/s^2(Emergency Brake)



4.6.3 COACH DESIGN AND BASIC PARAMETERS

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

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

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

4.6.4 SELECTION OF TECHNOLOGY

- **Low life cycle cost**

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

- **Car body**

  In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs, which may have to be carried out up to 4-5 times during the service life of these coaches. It is now a standard practice to adopt stainless steel or aluminum for carbody.

  The car bodies with aluminum require long and complex extruded sections which are still not manufactured in India. Therefore aluminum car body has not been considered for use. Stainless steel sections are available in India and therefore stainless steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during their service life.

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

- **Bogies**

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

- **Braking System**

  The brake system shall consist of –

(i) An electro-pneumatic (EP) service friction brake
(ii) A fail safe, pneumatic friction emergency brake
(iii) A spring applied air-release parking brake
(iv) An electric regenerative service brake
(v) Provision of smooth and continuous blending of EP and regenerative braking

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

4.6.5 PROPULSION SYSTEM TECHNOLOGY

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

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

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

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

Recently advanced IGBT has been developed for inverter units. The advanced IGBT contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. The IGBT has internal protection from over current, short circuit, over temperature and low control voltage.

The inverter unit uses optical fiber cable to connect the control unit to the gate interface. This optical fiber cable transmits the gate signals to drive the advanced IGBT via the gate interface. This optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in Trains of MRTS.

4.6.6 INTERIOR AND GANGWAYS

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

Interior View

4.6.7 PASSENGER DOORS

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach have been considered. These doors shall be of such dimensions and location that all the passenger inside the train are able to evacuate within least possible time without conflicting movement .As the alignment passes through elevated section above ground, automatic door closing mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically by a switch in Driver cab. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

The door shall be of Bi-parting Sliding Type as in the existing coaches of DMRC.

Passenger Doors

4.6.8 AIR–CONDITIONING

With heavy passenger loading of 6 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

4.6.9 CAB LAYOUT AND EMERGENCY DETRAINMENT DOOR

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

Driving cab

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

4.6.10 COMMUNICATION

The driving cab of the cars are provided with continuous communication with base Operational Control Center and station control for easy monitoring of the individual train in all sections at all the time .

Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit conversation between passengers and the drivers in case of any emergency.

4.6.11 NOISE AND VIBRATION

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

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

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

4.6.12 PASSENGER SAFETY FEATURES

(i) ATP/ATO

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

(ii) Fire

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

(iii) Emergency door

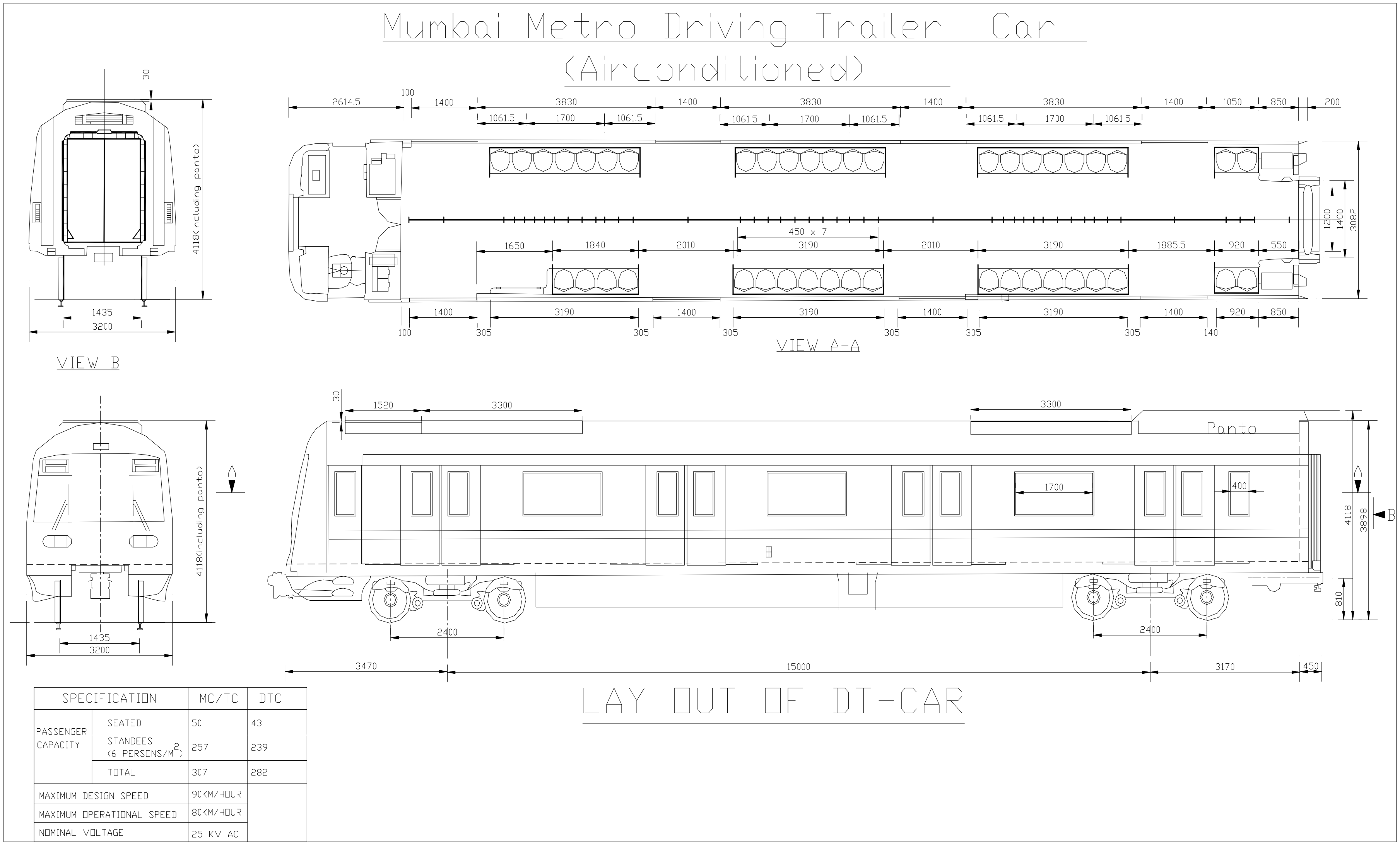
In Standard Gauge (3.2 m wide) Cars, the rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train.

(iv) Crash worthiness features

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

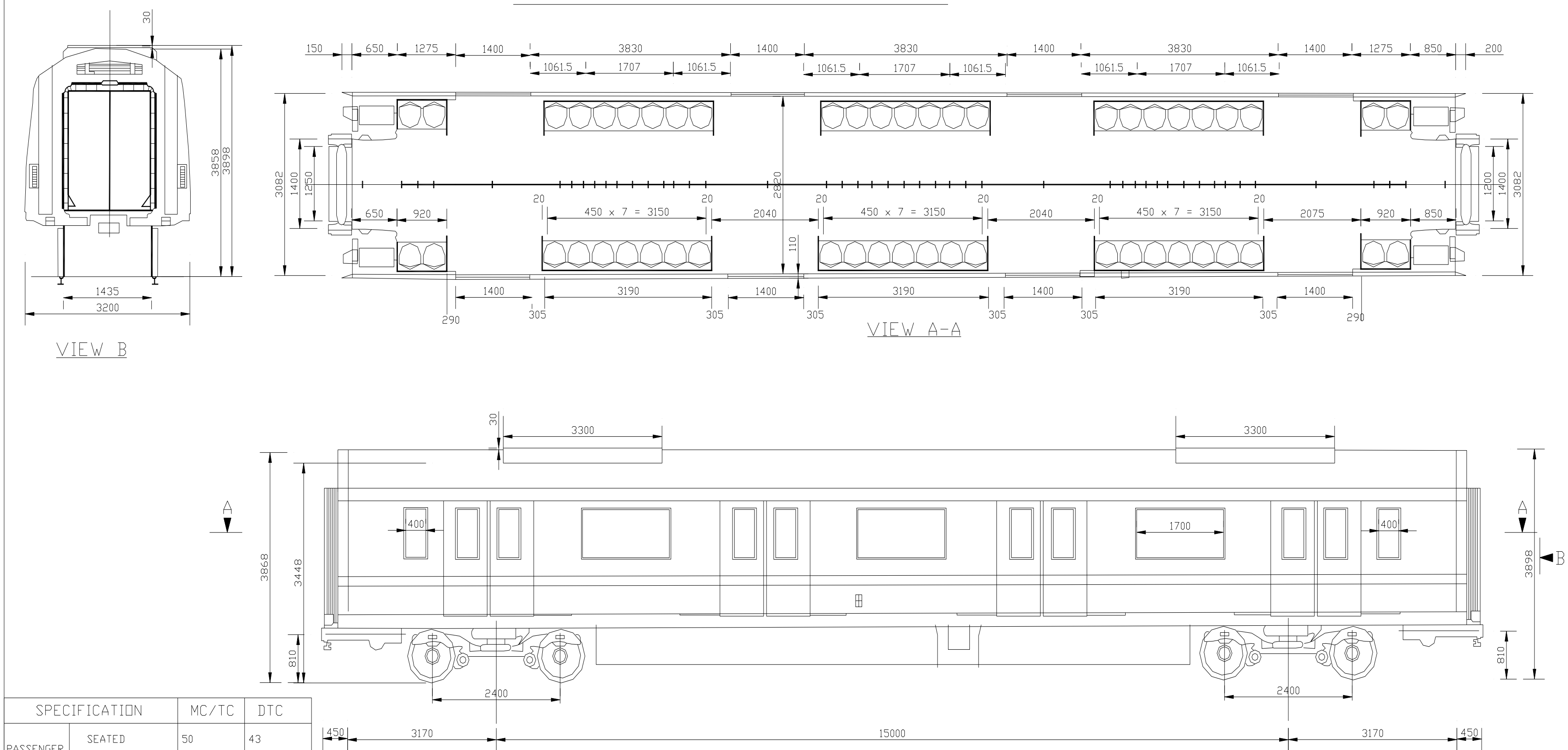
(v) Gangways

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



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

Mumbai Metro Motor Car
(Airconditioned)



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NOMINAL VOLTAGE		25KV AC	

LAY OUT OF M-CAR

Chapter 5 -Civil Engineering

Chapter - 5

CIVIL ENGINEERING

5.1 GEOMETRIC DESIGN NORMS

5.1.1 General:

The proposed corridors will consist of 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 about 1.08 km and trains will not be able to achieve higher speed.

The elevated tracks will be carried on segmental box 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- 5.1

5.1.2 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 210m has been used at one location having speed potential upto 55 km/h.

Horizontal Curves:

Table 5.1- Horizontal Curves

Description	Elevated Section
Desirable Minimum radius	200m
Absolute minimum radius	120m*

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

* not used on this corridor.

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

5.1.3 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 4.6 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 3.0 %. 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

5.1.4 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 5.2 - 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
300	110	70	3850
200	110	55	3950
150	110	45	4050
150*	0	30	4050
120	110	40	4150

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM TRACK CENTRE (ELEVATED & AT-GRADE)
m	mm	kmph	mm
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.

5.1.5 Codes and Standards

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

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

5.1.6 General technical requirements of the Rail System

The rail system shall be designed to:

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

The design of the Rail System shall also conform to:

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

5.2 ALIGNMENT

5.2.1 Introduction

5.2.1.1 D.N. Nagar (excluded) – Mandala corridor of Mumbai Metro Project is an extension of corridor from Dahisar (E) to D.N. Nagar. First station on this corridor is ESIC Nagar and last station is Mandala.

5.2.1.2 As this corridor is an extension therefore chainage of Dahisar (E) proposed station is taken as 0.0 for reference.

5.2.1.3 Total length of the corridor from dead end to dead end is 23.643 km. The entire corridor proposed is elevated.

5.2.1.4 Twenty-two stations have been proposed on the corridor. Names of stations are ESIC Nagar, Prem Nagar, Indra Nagar, Nanawati Hospital, Khira Nagar, Saraswat Nagar, National College, Bandra Metro, MMRDA Office, Income Tax Office, ILFS, MTNL Metro, S G Barve Marg, Kurla Terminal, Kurla (E), EEH, Chembur, Diamond Garden, Shivaji Chowk, BSNL Metro, Mankhurd and Mandala Metro. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one Km. distance apart. The maximum and minimum inter station distances are 1737.4 m and 474.5 m respectively. Depot for this extension has been planned at Mandala.

5.2.1.5 This corridor runs in North to South direction between DN Nagar to Bandra. Hereafter it takes turn and runs West to East direction. It connects heavily populated area of city, market places, Airport, Railway Stations and Central Business District (CBD) of Bandra Kurla Complex.

5.2.2 Station Locations

5.2.2.1 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. The average spacing of stations is close to one km.

5.2.2.2 All stations will be two level stations except ILFS station, which has been planned two tower station and Mandala Station has been planned at height of 10 m with ground concourse on the side of road to reduce length of ramp to enter in Depot. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level.

5.2.3 Terminals

As this corridor is an extension of Dahisar (E) to D.N. Nagar corridor, therefore there is only one terminal station for this corridor as mentioned below.

5.2.3.1 **Mandala Metro Terminal**

This Station is proposed on median of the road just before depot location. Scissors cross overs are proposed on both sides of the station but at little more distance due to geometry of alignment not allowing placement of X-overs in the vicinity of the platform.

5.2.4 Scissors Crossovers

Scissors Crossovers will be provided at the terminal station viz. Mandala Metro. In between, crossovers are proposed at one intermediate station i.e. Income Tax Office, for making one of the platform line as common loop for its use in emergencies.

5.2.5 Depot

It is proposed to provide depot at Mandala (low lying area) in the Government land identified by MMRDA. The land parcel available is of 22 Ha and of D-shaped. Detailed planning of depot in this area has been done.

5.2.6 Description of Alignment

5.2.6.1 **Horizontal Alignment**

The proposed alignment starts from CH: 18175.0 m and Station No. 1 named as ESIC Nagar is located at CH: 18637.6 m. Alignment starts on New Link Road.

The alignment from its start, runs along the centre of the Gurunanak Road (New Link road) till it reaches near S.N Maharaj Chowk. Before S.N. Maharaj Chowk at chainage 18890.947 m it turns towards east on Bhakti Vedanta Swami Marg using a left hand curve of 110 m. It moves along the central verge of the road and reaches Prem Nagar Station, located at chainage 20302.6 m on partly curved and partly straight alignment. It continues to run along the median of the Gulmohar Road.

The next station on the corridor comes Indra Nagar at chainage 20829.2 m. This station is on straight alignment and located at Chatrabhuj Narsee Chowk. Monaji Marg Road is joining Gulmohar Road on this station. Thereafter it turns left on Vaikunthlal Mehta Road using a left hand curve having radius of 125.0 m, after some distance it turns right from chainage 21218.283 m, towards Swami Vivekanand Road using a right hand curve of radius 125.0 m. Next station is Nanawati Hospital at chainage 21902.5 m, this station is on straight alignment and on east side of Juhu Airport. Thereafter, also it follows the road median. In this stretch, it crosses RK Singh Chowk. From there is the next station falls at chainage 23509.4 m, named as Khira Nagar. The station is located on partly curved alignment. The next station is located at chainage 24466.0 m, named as Saraswat Nagar. This station is also located on partly curved alignment. The next station is at chainage 25559.0 m with its name as National College. After this, it crosses Samant Chowk and remains on the road median. The next station located at chainage 26699.7 m, named as Bandra, is next to M Rafi Chowk. After this station, the alignment turns left with a curve of radius 125.0 m and goes off the road and crosses western railway line. It runs parallel to road over bridge (on the left of the bridge) at Ali Yavar Jung Marg. The next station on this corridor is MMRDA Office which is located at chainage 28292.0 m. From there the alignment follows median of the road. The next station is located at chainage 28913.9 m, named as Income Tax Office. This station is closely followed by a right hand curve of radius 350 m and the alignment goes off the road as there is a bridge on the road. It crosses Vakola Nala and thereafter it is followed by another curve of radius 125 m (left hand curve) so as to reach again on Bandra Kurla Complex Road. From chainage 29564.947 m, there is a straight length of 67.837 m, which is again followed by a right hand curve of 300 m radius. The corridor is on the median of the road. The next station is ILFS at chainage 30188 m which is located on straight alignment. The alignment continues along road median and there is a right hand curve of radius 10010 m from chainage 30390.146 m to 30458.865 m. Therafter, there is a straight length of 136.853 m and then there is a left hand curve of radius 5010 m. This curve is closely followed by another right hand curve of radius 5010 m. The alignment crosses a road junction, followed by MTNL Metro at chainage 30982.8 m. Thereafter, it turns left and goes off the road with a left hand curve of radius 125 m, closely followed by a right hand curve of radius 255.0 m and reaches road, heading towards Kurla Terminal Station/ S G Barve Marg. Subsequently followed by curve of radius 560 m, 570 m and 157 m, the alignment runs along the right side of the bridge. Thereafter, there is a left hand curve of radius 1650.0 m followed by S.G. Barve Marg Station at chainage 32720.2 m. This station is closely followed by Kurla Terminal at chainage 33194.7 m. It is located on a curve of radius 1010.0 m on the right side of the bridge/flyover. Here it is off the road because of the bridge/ flyover. It remains off the road and it crosses above the railway lines/ tracks. From chainage 33699.231 m, alignment turns right towards Nehru Nagar with a right hand curve of radius 125.0 m and crosses bridge/flyover. The alignment runs on left side of the bridge/ flyover and crosses railway line to Panvel. There is a straight length of 197.058 m and a curve of 230 m radius follows. It is followed by Kurla (E) station at chainage 34349.2 m. After this station, it turns left from chainage 34445.757 m with a curve of 125.0 m and corridor aligns along S G Barve Marg (CST Road). Before reaching EEH station at chainage 35356.3 m, the corridor crosses flyover bridge on Eastern Express Highway. This station is closely followed by a left hand curve at chainage 35517.12 m and alignment turns left towards V.N. Purav Marg (Sion Trombay Road). The corridor aligns with median of the road. The next station on this corridor is Chembur at chainage 35996.7 m on a curve of 1010 m. After this station, corridor crosses junction of V.N. Purav Marg and Diamond Garden on a curve of 560 m. Thereafter also the corridor runs along the median of the road. Next station is Diamond Garden at chainage 36959.0 m. This station is proposed after road junction. The alignment is running along the road and next station is Shivaji Chowk at chainage 37819.0 m. This station is partly on curved alignment having radius 2510.0 m and 10010.0 m and is closely followed by Shivaji Chowk. The alignment negotiates Shivaji Chowk with radius 150 m (left hand curve). Subsequently, followed by curves of radius 680 m, 810 m and 510 m, having small straight lengths in between. Next station is at chainage 38939.6 m, named as BSNL Metro. This station is also partly on curved alignment having radius 1010.0 m. After this station, it goes off the road, along the drain to the left side of the Fly Over Bridge. In this section, there are curves of 500 m, 200 m and 410 m along with straight lengths in between. Thereafter it comes along Sion-Panvel Highway with a curve of 410 m. Before reaching Mankhurd Station, alignment goes off the road. Mankhurd station is on straight alignment at chainage 40546.7 m and to the right of fly over bridge. Hereafter it continues on the right side of the fly over bridge and after some distance it turns right with a curve of 192.1 m. The last station is Mandala at chainage 41507.4 m. Depot is located after this station.

5.2.6.2 **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 9.8 m other than station locations. Efforts have been made to maintain minimum radius of vertical curves of 2500 m. However it is not possible to maintain this at certain locations due to space constraints 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 is not steeper than 2.846%. Detailed description of vertical alignment is as follows:

The proposed rail levels are given in **Table 5.3** and abstracts of gradients are given in **Table 5.4.**

Table 5.3: Proposed Gradients of Rail Track (Vertical Curve Details)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	17483.427	17726.133	242.7	26	26	0.000%	Level
2	17726.133	18447	720.9	26	17.3	-1.207%	Fall
3	18447	18850	403.0	17.3	17.3	0.000%	Level
4	18850	19233.5	383.5	17.3	13.5	-0.991%	Fall
5	19233.5	19583.5	350.0	13.5	13.7	0.057%	Rise
6	19583.5	19863.5	280.0	13.7	13.5	-0.071%	Fall
7	19863.5	20153.5	290.0	13.5	16.7	1.103%	Rise
8	20153.5	20433.5	280.0	16.7	16.7	0.000%	Level
9	20433.5	20663.5	230.0	16.7	17.1	0.174%	Rise
10	20663.5	21033.5	370.0	17.1	17.1	0.000%	Level
11	21033.5	21323.5	290.0	17.1	13.9	-1.103%	Fall
12	21323.5	21663.5	340.0	13.9	17.7	1.118%	Rise
13	21663.5	22033.5	370.0	17.7	17.7	0.000%	Level
14	22033.5	22323.5	290.0	17.7	13.6	-1.414%	Fall
15	22323.5	22663.5	340.0	13.6	14.4	0.235%	Rise
16	22663.5	23003.5	340.0	14.4	13.9	-0.147%	Fall
17	23003.5	23363.5	360.0	13.9	17.3	0.944%	Rise
18	23363.5	23653.5	290.0	17.3	17.3	0.000%	Level
19	23653.5	23983.5	330.0	17.3	14.7	-0.788%	Fall
20	23983.5	24323.5	340.0	14.7	19.6	1.441%	Rise
21	24323.5	24613.5	290.0	19.6	19.6	0.000%	Level
22	24613.5	25033.5	420.0	19.6	15.9	-0.881%	Fall
23	25033.5	25403.5	370.0	15.9	17.7	0.486%	Rise
24	25403.5	25683.5	280.0	17.7	17.7	0.000%	Level
25	25683.5	26083.5	400.0	17.7	17.5	-0.050%	Fall
26	26083.5	26563.5	480.0	17.5	19.6	0.438%	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
27	26563.5	26933.5	370.0	19.6	19.6	0.000%	Level
28	26933.5	27240	306.5	19.6	18.8	-0.261%	Fall
29	27240	27365	125.0	18.8	18.8	0.000%	Level
30	27365	27909	544.0	18.8	31	2.243%	Rise
31	27909	28080	171.0	31	26.5	-2.632%	Fall
32	28080	28455.645	375.6	26.5	26.5	0.000%	Level
33	28455.645	28792	336.4	26.5	18	-2.527%	Fall
34	28792	29100	308.0	18	18	0.000%	Level
35	29100	29473.5	373.5	18	14	-1.071%	Fall
36	29473.5	29813.5	340.0	14	14.1	0.029%	Rise
37	29813.5	30053.5	240.0	14.1	18.1	1.667%	Rise
38	30053.5	30343.5	290.0	18.1	18.1	0.000%	Level
39	30343.5	30563.5	220.0	18.1	14.7	-1.545%	Fall
40	30563.5	30793.5	230.0	14.7	18.1	1.478%	Rise
41	30793.5	31113.5	320.0	18.1	18.1	0.000%	Level
42	31113.5	31523.5	410.0	18.1	15.7	-0.585%	Fall
43	31523.5	31803.5	280.0	15.7	16.3	0.214%	Rise
44	31803.5	32123.5	320.0	16.3	22.9	2.063%	Rise
45	32123.5	32583.5	460.0	22.9	21.2	-0.370%	Fall
46	32583.5	32943.5	360.0	21.2	21.2	0.000%	Level
47	32943.5	33073.5	130.0	21.2	19	-1.692%	Fall
48	33073.5	33363.5	290.0	19	19	0.000%	Level
49	33363.5	33793.7	430.2	19	24.8	1.348%	Rise
50	33793.7	34184.29	390.6	24.8	18.4	-1.639%	Fall
51	34184.29	34543.5	359.2	18.4	18.4	0.000%	Level
52	34543.5	34943.5	400.0	18.4	14.6	-0.950%	Fall
53	34943.5	35203.5	260.0	14.6	22	2.846%	Rise
54	35203.5	35483.5	280.0	22	22	0.000%	Level
55	35483.5	35843.5	360.0	22	27	1.389%	Rise
56	35843.5	36163.5	320.0	27	27	0.000%	Level
57	36163.5	36360	196.5	27	24.8	-1.120%	Fall
58	36360	36755.473	395.5	24.8	31	1.568%	Rise
59	36755.473	37143.5	388.0	31	31	0.000%	Level
60	37143.5	37680	536.5	31	33.9	0.541%	Rise
61	37680	38023.5	343.5	33.9	33.9	0.000%	Level
62	38023.5	38360	336.5	33.9	31.6	-0.684%	Fall
63	38360	38754	394.0	31.6	29.4	-0.558%	Fall
64	38754	39109	355.0	29.4	29.4	0.000%	Level
65	39109	39463.5	354.5	29.4	20.1	-2.623%	Fall
66	39463.5	40043.5	580.0	20.1	16.9	-0.552%	Fall

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
67	40043.5	40433.5	390.0	16.9	17.5	0.154%	Rise
68	40433.5	40723.5	290.0	17.5	17.5	0.000%	Level
69	40723.5	41173.5	450.0	17.5	14.2	-0.733%	Fall
70	41173.5	41632.728	459.2	14.2	14.2	0.000%	Level

Table 5.4: Abstract of Gradients

S. No.	Descripton	Nos. Occurrences	Length (m)	% w. r. t. Total Alignment length
1	Level	24	7759.3145 36	32.13%
2	> 0% to = 1%	24	9167.000	37.96%
3	> 1% to = 2%	16	5237.131	21.69%
4	> 2% to = 3%	6	1985.856	8.22%
5	> 3% to = 4%	0	0.000	0.00%
	Total	**70**	**24149.301**	**100.00%**

5.2.7 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 110 m to reduce the property acquisition. Total 82 Nos. of curves have been provided in the entire length of D. N. Nagar (excluding D.N. Nagar Station) to Mandala Corridor. The details of curves and abstracts of horizontal curves are indicated in Table 5.5 and 5.6 respectively.

Table 5.5 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		188.696
1	Left	290	28.019	40	40	05 32 08	14.02	104.796
2	Right	200	43.556	40	40	12 28 40	21.864	0
3	Left	410	27.742	35	35	03 52 36	13.876	110.17
4	Left	2510	26.655	25	25	00 36 30	13.328	84.994
5	Left	390	28.72	55	55	04 13 09	14.366	374.172
6	Left	110	114.809	55	55	59 48 01	63.253	152.246
7	Right	481	750.98	55	55	89 27 19	476.449	213.885
8	Left	1010	103.121	25	25	05 50 59	51.605	438.659
9	Left	125	87.8	55	55	40 14 39	45.798	85.837
10	Right	125	84.765	55	55	38 51 12	44.085	301.442
11	Right	8010	30.812	15	15	00 13 13	15.406	298.888
12	Right	310	92.458	55	55	17 05 19	46.575	103.204
13	Left	280	59.701	55	55	12 12 59	29.964	420.214
14	Left	2010	50.249	25	25	01 25 56	25.126	44.575
15	Right	1010	25.379	25	25	01 26 23	12.69	66.566
16	Left	1210	30.724	25	25	01 27 17	15.363	74.054
17	Right	1510	30.172	25	25	01 08 41	15.086	140.766
18	Left	6010	41.093	15	15	00 23 30	20.547	536.412

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		188.696
19	Right	3010	29.601	20	20	00 33 48	14.801	45.953
20	Left	3010	30.024	20	20	00 34 17	15.012	478.093
21	Left	11010	44.652	10	10	00 13 56	22.326	26.618
22	Left	1010	54.174	25	25	03 04 23	27.094	0
23	Right	1010	34.687	25	25	01 58 03	17.345	81.281
24	Left	2010	33.64	25	25	00 57 32	16.821	268.356
25	Right	1010	83.731	25	25	04 44 59	41.889	93.948
26	Right	460	25.97	40	40	03 14 04	12.988	0
27	Left	550	25.323	35	35	02 38 16	12.664	103.271
28	Left	278	140.934	50	50	29 02 47	72.016	25.353
29	Right	205	26.76	50	50	07 28 45	13.399	311.405
30	Left	125	170.869	55	55	78 19 14	101.804	388.443
31	Right	1010	271.744	25	25	15 24 56	136.698	111.881
32	Left	204	104.212	50	50	29 16 08	53.269	25.195
33	Right	1010	175.699	25	25	09 58 01	88.072	499.876
34	Left	910	48.135	30	30	03 01 50	24.073	129.913
35	Right	350	126.242	55	55	20 39 57	63.814	67.837
36	Left	125	79.205	55	55	36 18 17	40.983	519.457
37	Right	300	167.439	55	55	31 58 42	85.963	136.853
38	Right	10010	28.718	20	20	00 09 51	14.359	137.491
39	Left	5010	43.214	10	10	00 29 39	21.607	248.945
40	Right	5010	42.232	10	10	00 28 58	21.116	37.202
41	Left	125	97.594	55	55	44 44 00	51.437	247.339
42	Right	230	259.59	55	55	64 40 01	145.588	102.747
43	Right	170	118.145	55	55	39 49 08	61.571	0
44	Left	1650	476.064	25	25	16 31 52	239.697	141.371
45	Right	210	52.902	50	55	14 26 00	26.592	405.816
46	Right	1010	78.327	25	25	04 26 36	39.183	197.058
47	Right	125	101.346	55	55	46 27 13	53.644	0
48	Right	230	32.393	55	55	08 04 09	16.223	60.666
49	Left	1010	85.063	25	25	04 49 31	42.557	0
50	Left	125	133.406	55	55	61 08 55	73.849	37.006
51	Right	1020	25.06	25	25	01 24 27	12.531	203.41
52	Right	3810	29.618	20	20	00 26 43	14.809	84.207
53	Left	3010	34.335	20	20	00 39 12	17.168	198.52
54	Right	1010	35.802	25	25	02 01 51	17.903	60.069
55	Left	125	80.287	55	55	36 48 03	41.583	0
56	Right	1010	111.891	25	25	06 20 50	56.003	67.299
57	Left	1010	43.794	25	25	02 29 03	21.9	82.087
58	Right	560	153.273	35	35	15 40 54	77.118	141.292
59	Right	2010	34.814	20	20	00 59 32	17.408	79.758
60	Left	3010	34.296	10	10	00 39 10	17.148	146.087
61	Right	3010	39.206	10	10	00 44 46	19.603	45.696
62	Left	2510	26.041	15	15	00 35 39	13.021	0
63	Right	410	130.761	55	55	18 16 24	65.941	66.09
64	Right	2310	49.286	15	15	01 13 20	24.644	93.271

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		188.696
65	Left	2010	96.282	15	15	02 44 40	48.15	36.401
66	Right	2510	25.691	15	15	00 35 11	12.846	61.024
67	Right	10010	27.919	10	10	00 09 35	13.96	67.333
68	Left	150	75.264	55	55	28 44 55	38.442	30.219
69	Right	680	94.659	35	35	07 58 33	47.406	0
70	Left	810	39.868	30	30	02 49 12	19.938	35.692
71	Right	510	38.145	40	40	04 17 07	19.082	133.384
72	Right	510	40.527	40	40	04 33 10	20.274	104.869
73	Left	1010	26.273	25	25	01 29 25	13.137	47.497
74	Left	500	52.007	40	40	05 57 34	26.027	0
75	Right	500	55.652	40	40	06 22 38	27.855	26.175
76	Left	200	142.912	55	55	40 56 28	74.66	188.301
77	Right	410	32.179	55	55	04 29 48	16.098	34.756
78	Left	410	50.613	55	55	07 04 22	25.339	98.843
79	Right	260	44.245	55	55	09 45 00	22.176	476.258
80	Right	18010	32.735	20	20	00 06 14	16.367	138.372
81	Right	192.1	140.543	55	55	41 55 06	73.583	136.272
82	Left	1002.25	78.257	25	25	04 28 25	39.149	61.143

Table 5.6 Abstract of Horizontal Curves

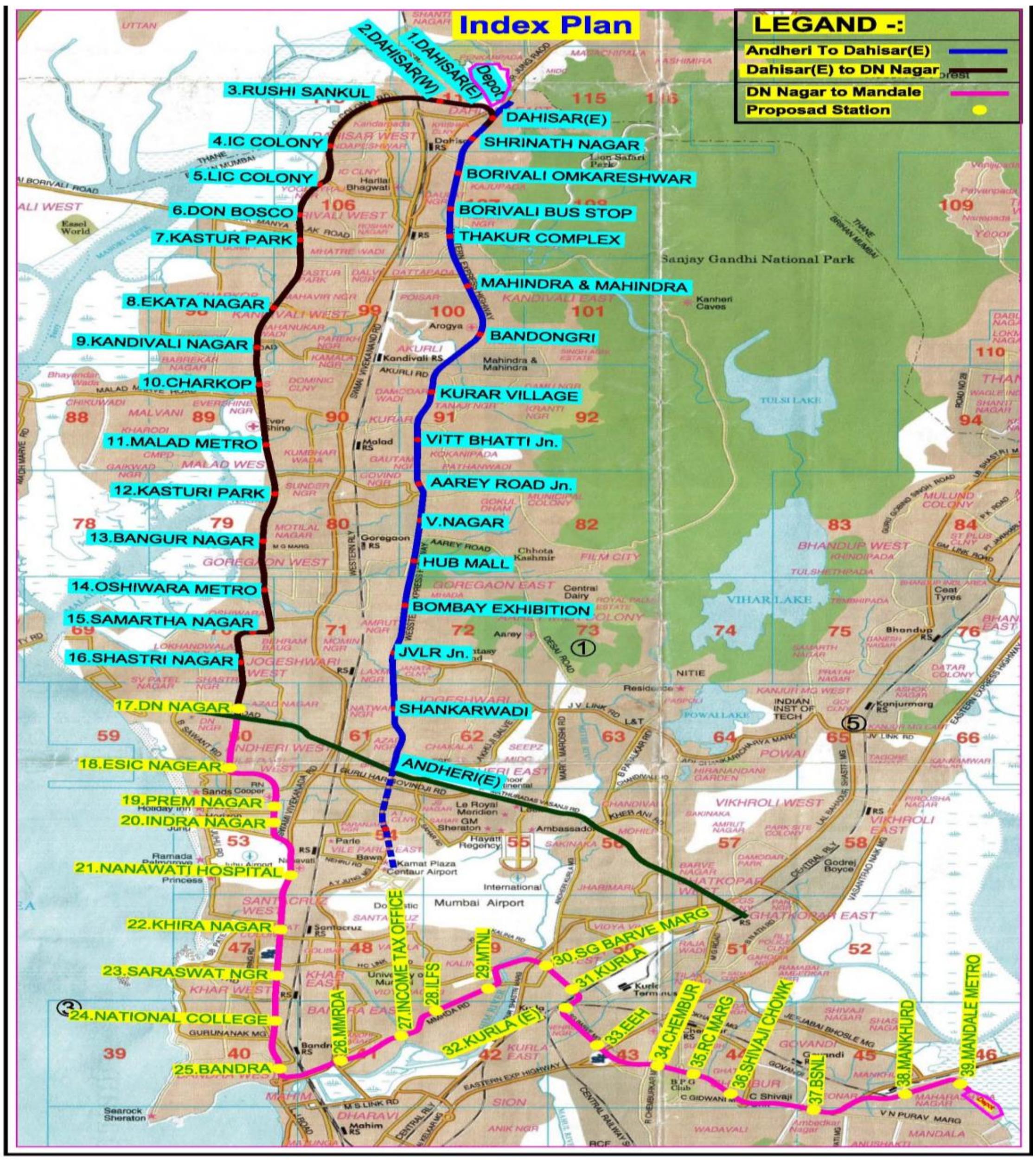
S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL(m)	% w. r. t. total curved length
1	110m - 510m	37	7623.692	60.77%
2	>510m - 1010m	19	2599.2	20.72%
3	>1010m - 1510m	3	235.956	1.88%
4	>1510m - 2010m	5	911.049	7.26%
5	>2010m - 5010m	12	790.199	6.30%
6	>5010m	6	385.929	3.08%
	Total	**82**	**12546.025**	**100.00%**

5.3 STATION PLANNING

5.3.1 General

The proposed corridor runs from Dahisar (E) to Mandala.This chapter deals with the section of the corridor from ESIC Nagar to Mandala.

The length of the proposed corridor from ESIC Nagar to Mandala is approximately 24km. Along this section of the proposed corridor, 22 stations have been planned and are all elevated. The locations of the station have been identified taking into consideration the constraints in land acquisition and congestion issues. Stations are proposed in such a way so as to attract maximum demand from the traffic nodal points.



5.3.2 Station Types

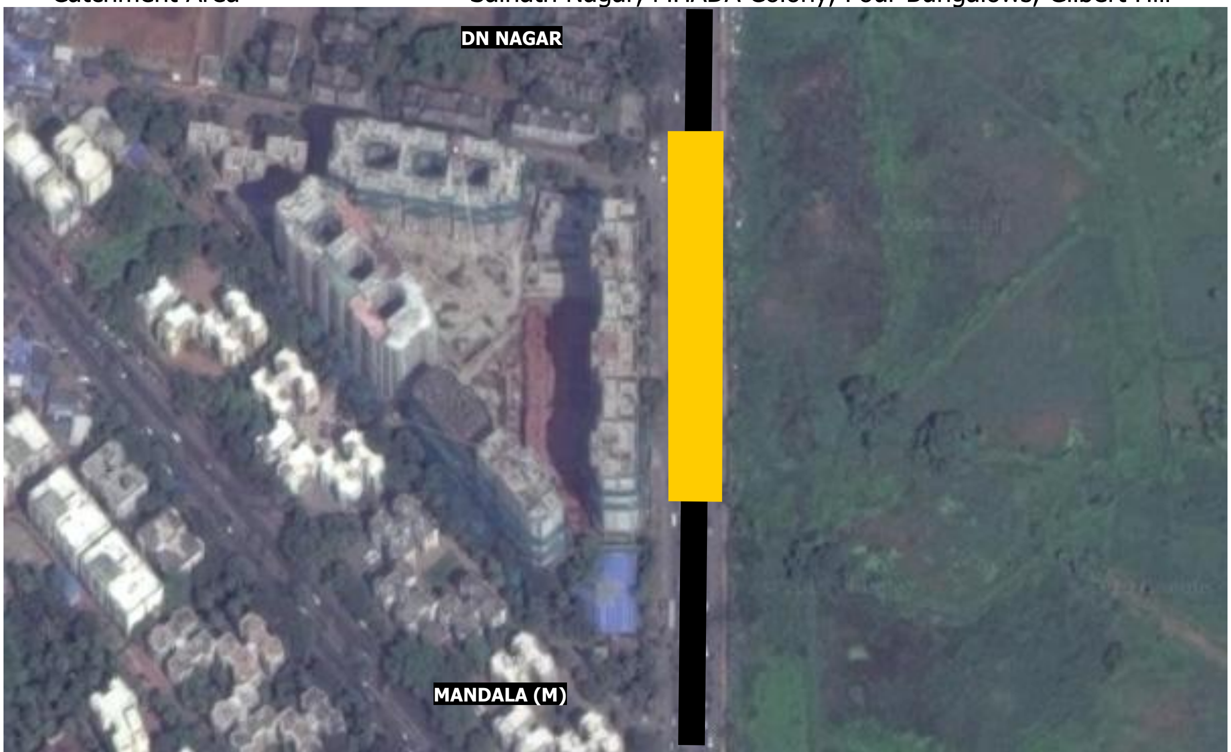
All twenty-two stations planned in this section are elevated and have side platforms. Average inter-station distance is approximately 1.08 km varying from 474.5m to 1737.4m depending upon the site, operational and traffic constraints. The sequence of stations with their respective chainages and locational and platform characteristics is presented in **Table 5.7**.

Table 5.7

Corridor DN Nagar – Mandala (M)								
SN	Name	Chainage	Interstation Distance	Platform	Ground Lvl	Rail Lvl	Rail to Ground	Plat to Ground
18	ESIC Nagar	18637.6		Side	3.842	17.300	13.458	14.548
19	Prem Nagar	20302.6	1665	Side	3.577	16.700	13.123	14.213
20	Indira Nagar	20829.2	526.6	Side	3.236	17.100	13.864	14.954
21	Nanavati Hospital	21902.5	1073.3	Side	4.042	17.700	13.658	14.748
22	Khira Nagar	23509.4	1606.9	Side	3.653	17.300	13.647	14.737
23	Saraswat Nagar	24466	956.6	Side	5.792	19.600	13.808	14.898
24	National College	25559	1093	Side	4.122	17.700	13.578	14.668
25	Bandra Metro	26699.7	1140.7	Side	5.887	19.600	13.713	14.803
26	MMRDA Office	28292	1592.3	Side	4.431	18.000	13.569	14.659
27	Income Tax Office	28913.9	621.9	Side	4.087	17.700	13.613	14.703
28	ILFS	30188	1274.1	Side	4.625	18.100	13.475	14.565
29	MTNL Metro	30982.8	794.8	Side	4.419	18.100	13.681	14.771
30	SG Barve Marg	32720.2	1737.4	Side	7.624	21.200	13.576	14.666
31	Kurla Terminal	33194.7	474.5	Side	4.801	19.000	14.199	15.289
32	Kurla (E)	34349.2	1154.5	Side	4.884	18.400	13.516	14.606
33	EEH	35356.3	1007.1	Side	3.973	22.000	18.027	19.117
34	Chembur	35996.7	640.4	Side	8.772	27.000	18.228	19.318
35	Diamond Garden	36959	962.3	Side	9.396	31.000	21.604	22.694
36	Shivaji Chowk	37819	860	Side	20.517	33.900	13.383	14.473
37	BSNL Metro	38939.6	1120.6	Side	16.231	29.400	13.169	14.259
38	Mankhurd Metro	40546.7	1607.1	Side	4.249	17.500	13.251	14.341
39	Mandala Metro	41507.4	960.7	Side	3.7	14.200	10.5	11.590

1. ESIC Nagar

Chainage	18637.6m
Inter-station Distance	-
Rail Level	17.3m
Location	Located on Cosmopolitan Education Society Marg.
Entry / Exit Stairs	On three sides the entry exit structures are located flanking the station.
Catchment Area	Sainath Nagar, MHADA Colony, Four Bungalows, Gilbert Hill



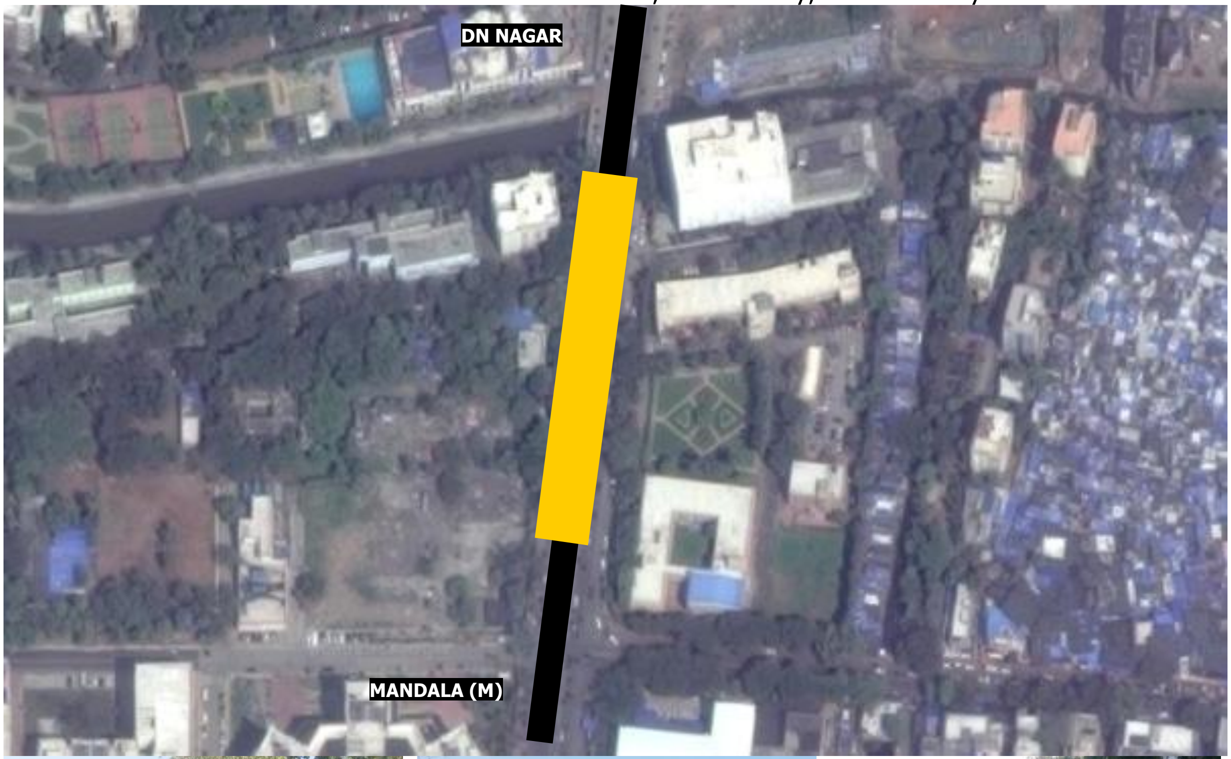
Club to the East of the station

Development to the West

Cosmopolitan Edu. Society Rd.

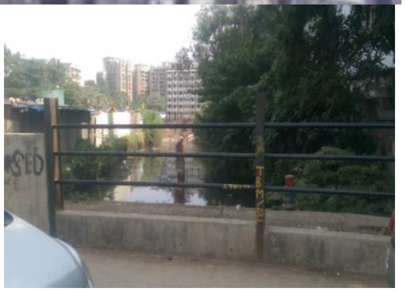
2. Prem Nagar

Chainage	20302.6m
Inter-station Distance	1665.0m
Rail Level	16.7m
Location	Located on Gulmohar Road opposite CMPH Medical College.
Entry / Exit Stairs	The naala to the north is covered and developed into an entrance plaza. On the South land is acquired from the two hospitals.
Catchment Area	Ville Parle West, Tata Colony, ONGC Colony



MPH Medical College to the East of the station

Dr. RN Cooper Hospital to the West



Naala on the northern end

3. Indira Nagar

Chainage	20829.2m
Inter-station Distance	526.6m
Rail Level	17.1m
Location	Located on the junction of Gulmohar Road & Vaikunthlal Marg
Entry / Exit Stairs	Land is acquired from Bhaidas Hall & UPG College of Management on the east & Mithhibhai College is the west. Additional stairs are provided on perpendicular roads.
Catchment Area	Azad Nagar, Swastik Society, Nehru Nagar


Bhaidas Hall


Road off Chattarbhuj Narsee Chowk for Entry Stair


Narsee Monjee Institute

4. Nanawati Hospital

Chainage	21902.5m
Inter-station Distance	1073.3m
Rail Level	17.7m
Location	Located on SV Road between Juhu Airport & Nanavati Hospital
Entry / Exit Stairs	Two are placed on land to be acquired from the Airport, One from the hospital & one from private owners
Catchment Area	Ville Parle Station, Suresh Colony, Labh Sidhhi Society

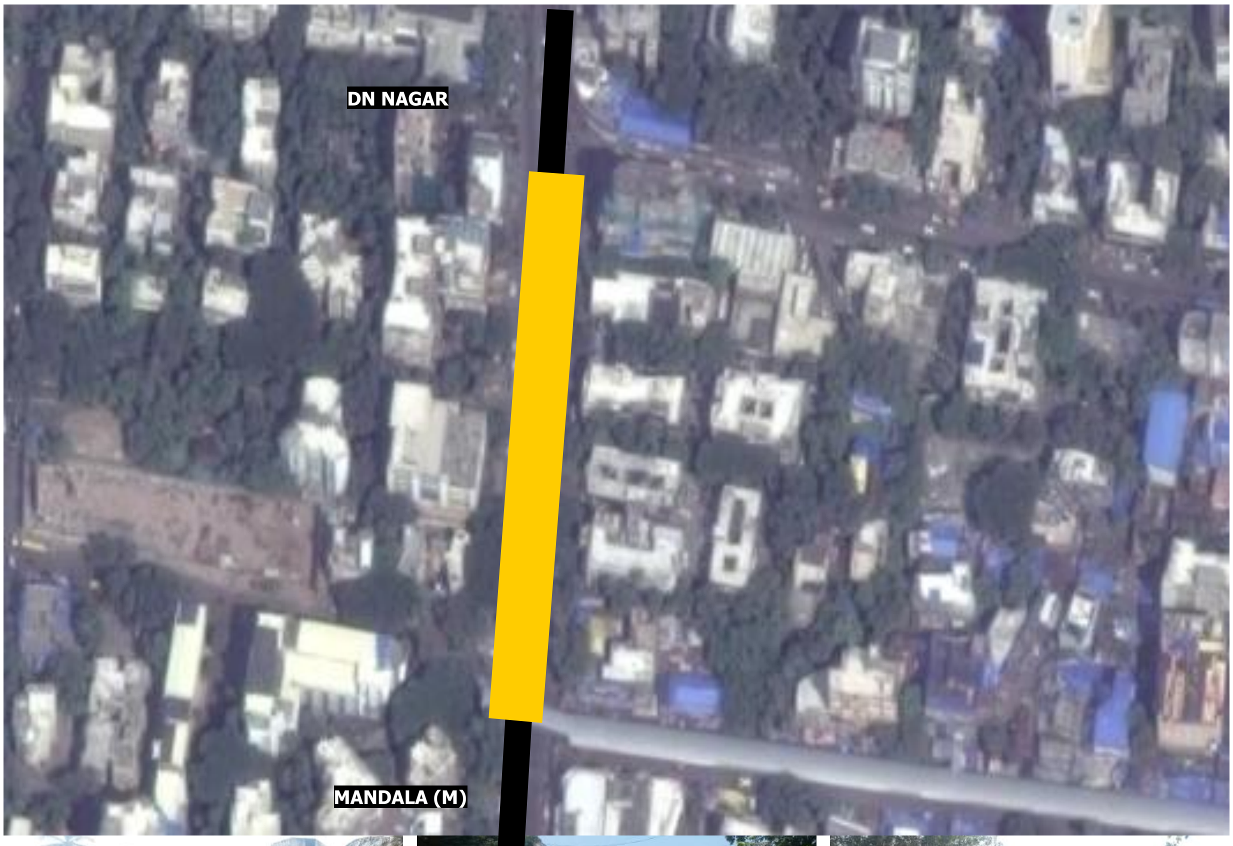
Nanavati Hospital Entrance

Juhu Airport Boundary Wall

Boundary Wall of Private Residence next to Nanavati Hospital

5. Khira Nagar

Chainage	23509.4m
Inter-station Distance	1606.9m
Rail Level	17.3m
Location	On SV Road between Tilak Road & Santa Cruz Railway FOB
Entry / Exit Stairs	One Entry connects with the FOB and One is on Tilak Road while land is planned on land of LV Podda SS High School
Catchment Area	Santa Cruz railway Station, Navyug Colony, Hasmukh Nagar, Khira Nagar



Existing Stairs to FOB

SV Road at the station location

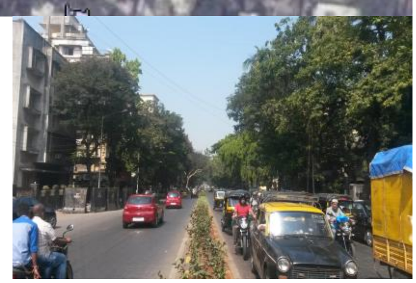
FOB crossing SV Road

6. Saraswat Nagar

Chainage	24466m
Inter-station Distance	956.6m
Rail Level	19.6m
Location	On SV Road between 9th Road & Khar Education Society
Entry / Exit Stairs	One structure is planned each on V Kadam Park & Khar Education Society and two on private land across the road
Catchment Area	Khar West, Ram Krishna Nagar,

Grounds of Khar Education Society

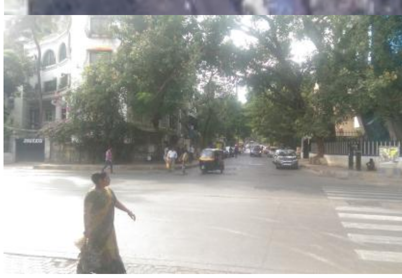
V Kadam Park



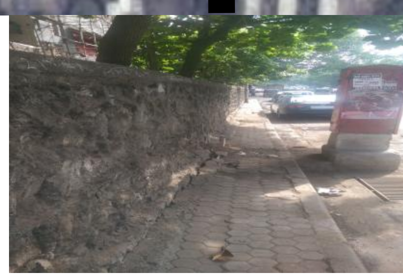
SV Road at the station location

7. National College

Chainage	25559m
Inter-station Distance	1093.0m
Rail Level	17.7m
Location	On SV Road between Khar Jama Masjid & 30th Cross Road
Entry / Exit Stairs	Two on private land & two near Railway Quarters
Catchment Area	Chinaiwadi, Bandra West



Barrister Gopaldas Advani Marg



Stretch of SV Road with small pavements

Railway Quarters next to station location

8. Bandra Metro

Chainage	26699.7m
Inter-station Distance	1140.7m
Rail Level	19.6m
Location	On SV Road between GR Varasakar Marg & Jama Masjid
Entry / Exit Stairs	BEST depot, Police Station & private land areas are earmarked for four entry structures
Catchment Area	Bandra Railway Station, BEST depot, Santosh Nagar


Station Entrance Location


Station Location

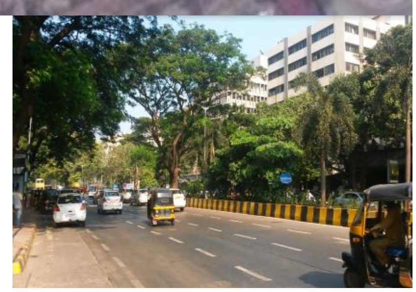

FOB at junction near station end

9. MMRDA Office

Chainage	28252m
Inter-station Distance	1592.3m
Rail Level	24.2m
Location	On Bandra Kurla Complex Road to the west of the turning for MMRDA Office
Entry / Exit Stairs	Four structures, one at either corner of the station on the sidewalks
Catchment Area	MMRDA Office, MIG Colony, Office Complexes in the vicinity (Google, SBI, Maruti Udyog)

Large Existing Pavements

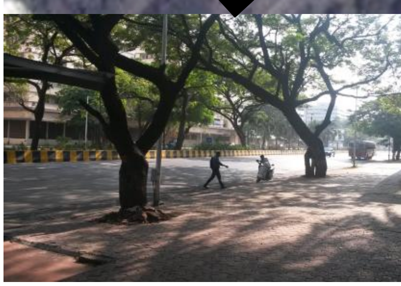
Google Offices



Existing 14m Carriageway

10. Income Tax Office

Chainage	28913.9m
Inter-station Distance	621.9m
Rail Level	15.9m
Location	On Bandra Kurla Complex Road opposite the ITO
Entry / Exit Stairs	Four structures, one at either corner of the station on the sidewalks
Catchment Area	ITO, RBI, FDA Maharashtra & E Block of BKC



Large Existing Pavements

ITO at Station Location

Large Existing Pavements

11. ILFS

Chainage	30188m
Inter-station Distance	1274.1m
Rail Level	18.1m
Location	On Bandra Kurla Complex Road opposite Padma Gems
Entry / Exit Stairs	Four structures, one at either corner of the station on the sidewalks
Catchment Area	G Block of BKC (ICICI, Padma Gems, Asian Heart Institute, NABARD etc), Bharam Nagar

NABARD Building

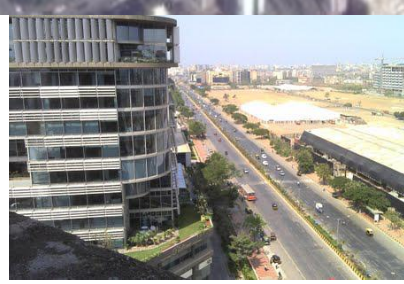
Large Existing Pavements

Existing 14.0m carriageway

12. MTNL Metro

Chainage	30982.8m
Inter-station Distance	794.8m
Rail Level	18.1m
Location	On Bandra Kurla Complex Road opposite Citi Bank
Entry / Exit Stairs	Four structures, one at either corner of the station on the sidewalks
Catchment Area	Several hotels & offices in the BKS

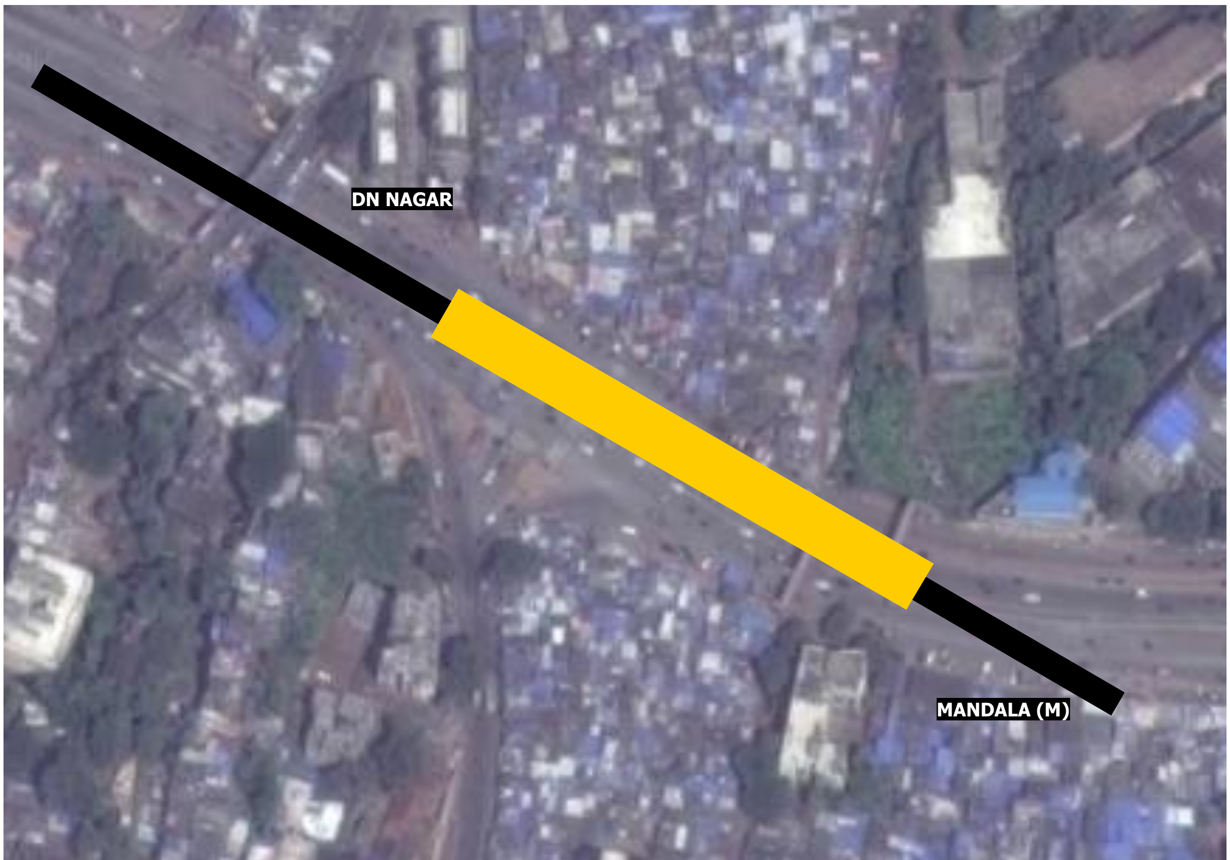

Large Existing Pavements


Platina Building


CITI Bank Building at Station Location

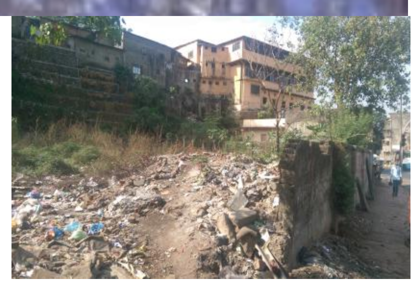
13. SG Barve Marg

Chainage	32720.2m
Inter-station Distance	1737.4m
Rail Level	21.2m
Location	On Santa Cruz Chembur Link Road opposite Moreshwar Patankar Marg
Entry / Exit Stairs	One on pavement of SG Barve Marg, One near Hanuman Mandir, One on Masrani Estate & One to the south near the existing FOB
Catchment Area	Makadwala Chowk, Ambedkar Nagar, Netaji Nagar, Shanti Nagar




Existing FOB at Station Location


View from SG Barve Marg


Empty lot on SG Barve Marg near entrance location

14. Kurla Terminal

Chainage	33194.7m
Inter-station Distance	474.5m
Rail Level	19.0m
Location	To the South West of the Flyover on Santa Cruz Chembur Link Road
Entry / Exit Stairs	Only two structures are planned as the station runs parallel to the flyover
Catchment Area	Bhartiya Nagar, Vinobha Bhave Nagar, LIG Colony, Achanak Nagar

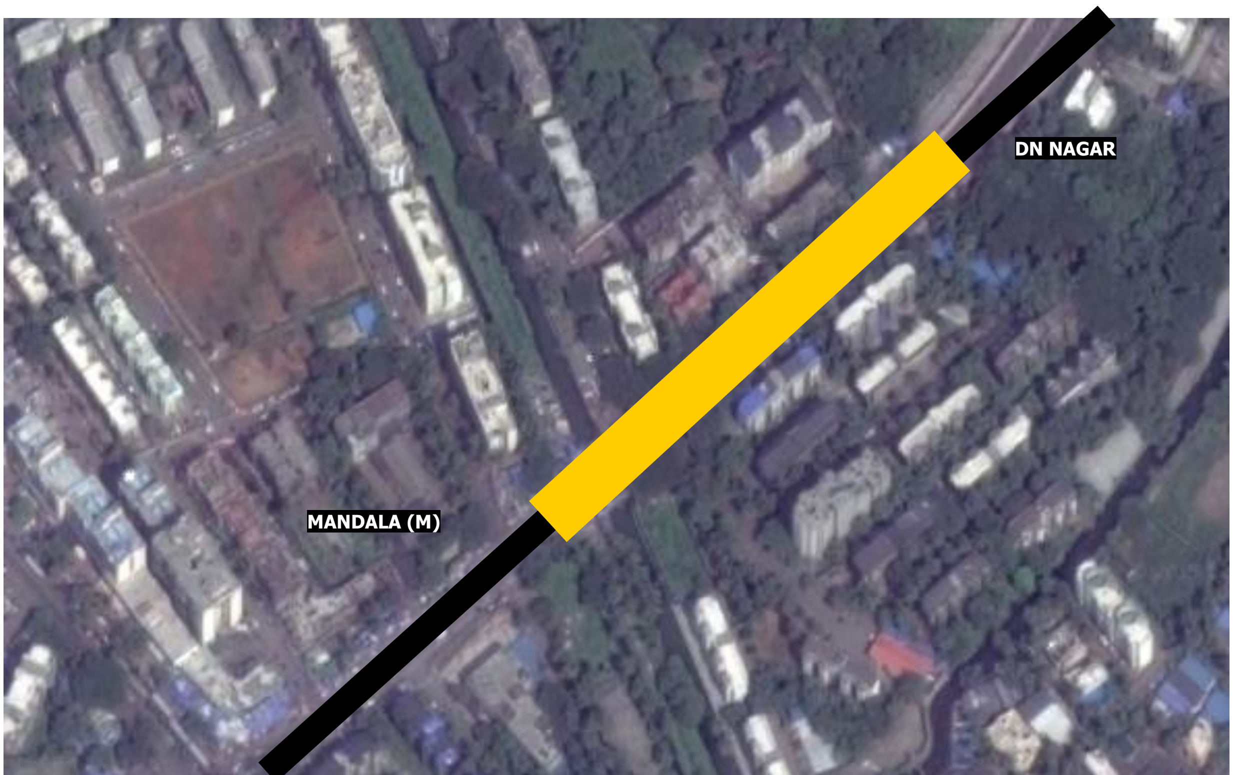

Railway Tracks before Station Location

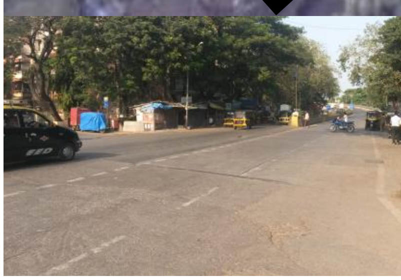

Station Location


Flyover next to Station Building

15. Kurla (E)

Chainage	34349.2m
Inter-station Distance	1154.5m
Rail Level	18.4m
Location	Mother Dairy Road (Exit ramp of Santa Cruz Chembur Link Road)
Entry / Exit Stairs	Two on the Naala running perpendicular to the station & two on the sides at the foot of the ramp
Catchment Area	Nehru Nagar, Kurla East, Kamgaar Nagar, Mahda Colony





From Exit Ramp

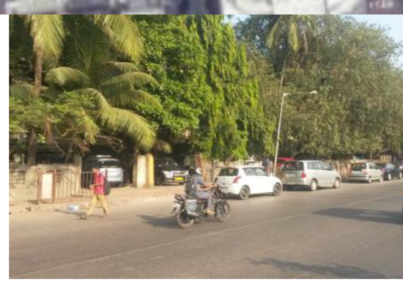
View of Naala to be covered

View of Naala to be covered

16. EEH

Chainage	35356.3m
Inter-station Distance	1007.1m
Rail Level	22.0m
Location	On SG Barve Marg, to the south of the Eastern Express Highway
Entry / Exit Stairs	Four structures, one at either corner of the station
Catchment Area	Swastik Park, Vatsalabai Naik Nagar, Lal Dongar

EEH with Empty lot in the foreground

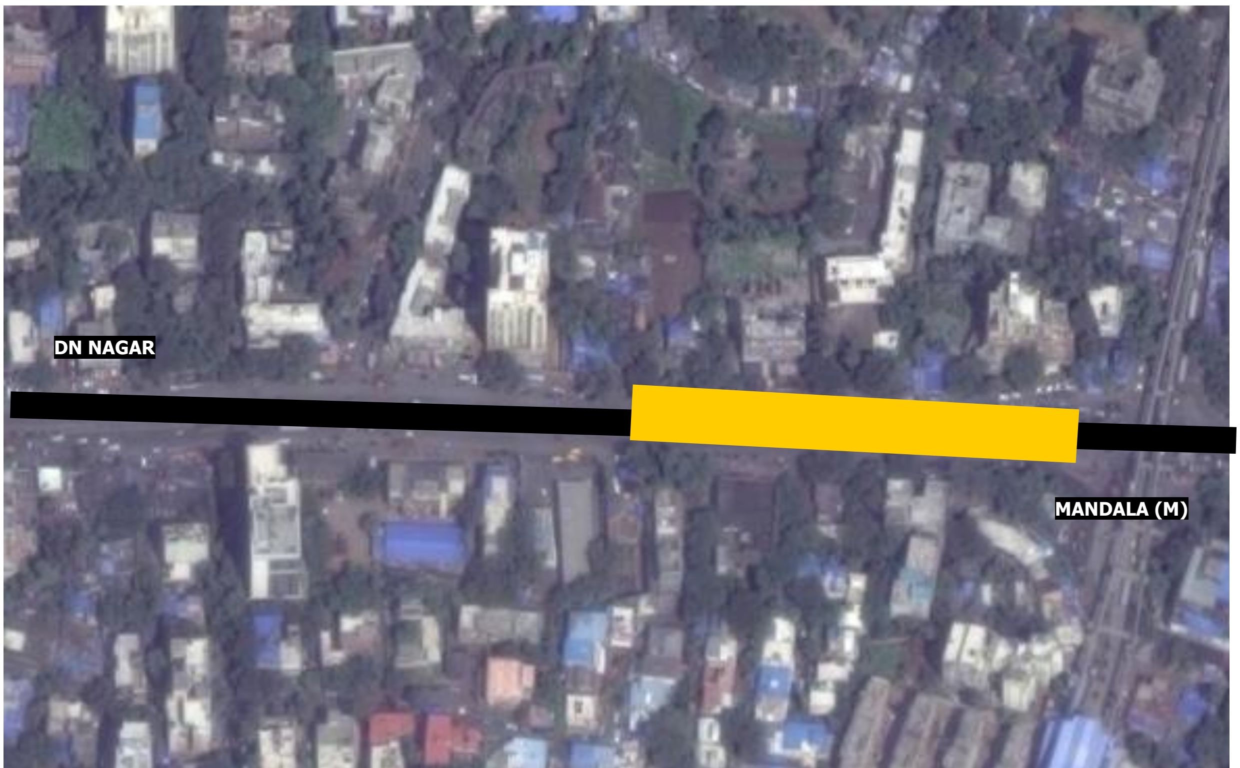


Location for Entry Structure

Location for Entry Structure

17. Chembur

Chainage	35996.7m
Inter-station Distance	640.4m
Rail Level	27.0m
Location	On VN Purav Marg to the west of Mono Rail Track
Entry / Exit Stairs	Four structures, one at either corner of the station
Catchment Area	RC Marg Monorail Station, Ganesh Nagar, Runwal Park, Jai Ambe Nagar



Petrol Pump near Station Entry

VN Purav Marg

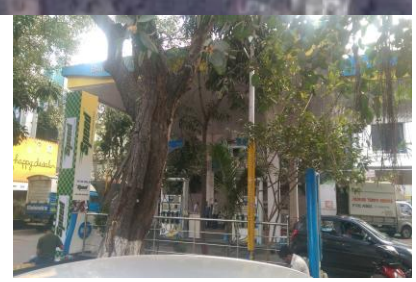
Bus Stop near Station Entry

18. Diamond Garden

Chainage	36959m
Inter-station Distance	962.3m
Rail Level	31.0m
Location	On VN Purav Marg near Narayan Gajanan Acharya Garden
Entry / Exit Stairs	Four structures, one at either corner of the station
Catchment Area	Jai Ambe Nagar, Mahadeo Wadi

Existing Pavement

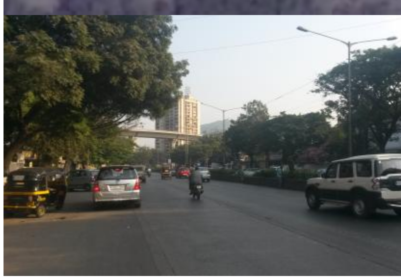
Mall near Station Entry



Petrol Pump near Station Entry

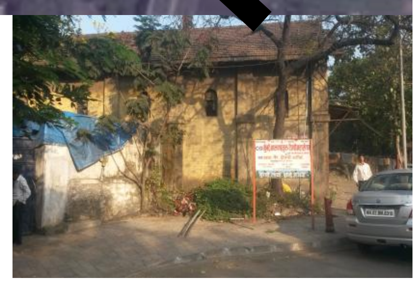
19. Shivaji Chowk

Chainage	37819m
Inter-station Distance	860m
Rail Level	33.9m
Location	On VN Purav Marg just to the west of Shivaji Chowk
Entry / Exit Stairs	Four structures, one at either corner of the station on the sidewalks
Catchment Area	Amar Nagar, Basant Garden, MBPT Colony, Gulab Park Colony



Eastern Freeway in the Distance

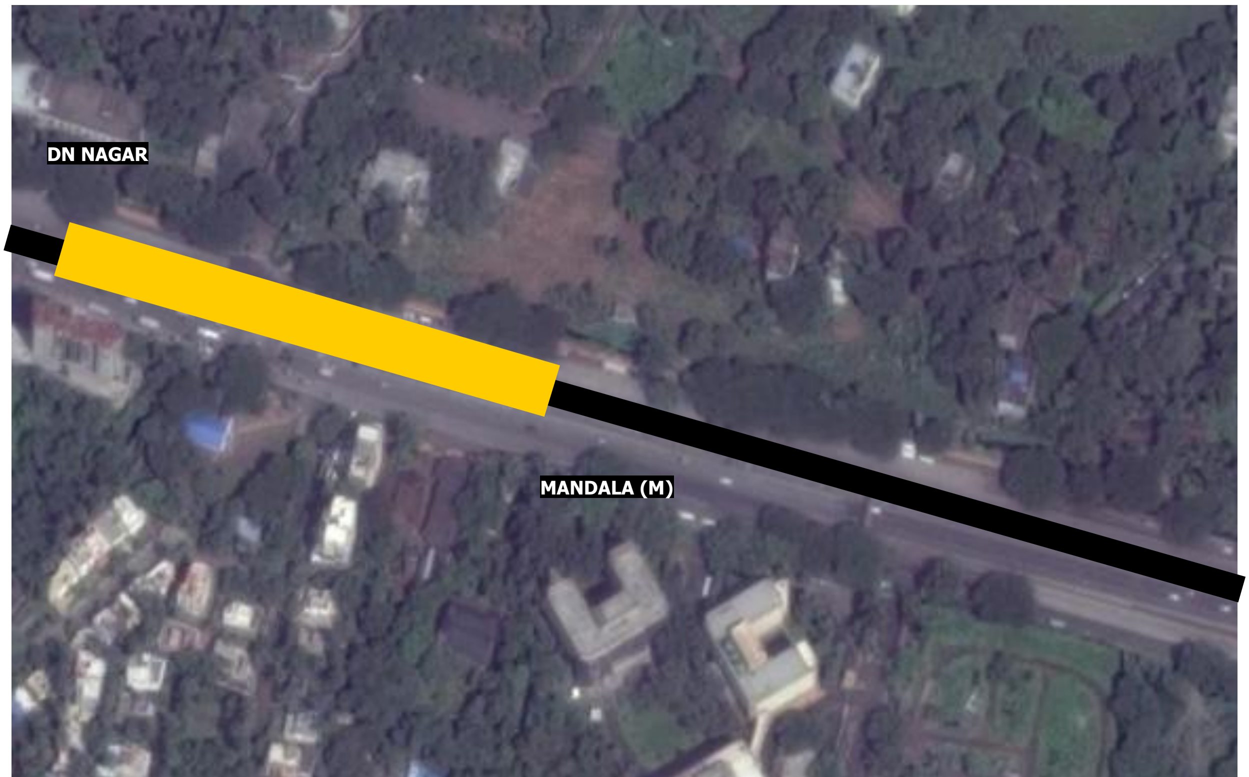
VN Purav Marg at Station Location



Station Entry Location

20. BSNL Station

Chainage	38939.6m
Inter-station Distance	1120.6m
Rail Level	29.4m
Location	On VN Purav Marg just before flyover on Yashwant Roa Chavan Marg
Entry / Exit Stairs	Four structures, one at either corner of the station on the sidewalks
Catchment Area	Anushakti Colony, Udaygiri CHS, Saras Baug, Dattaguru Colony



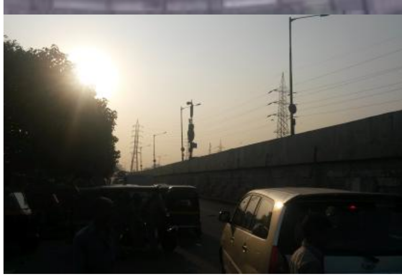

VN Purav Marg


Station Entry Location


Station Entry Location

21. Mankhurd (M)

Chainage	40546.7m
Inter-station Distance	1607.1m
Rail Level	17.5m
Location	On Sion Panvel Expressway (Yashwant Roa Chavan Marg) adjoining the flyover near Mankhurd Station
Entry / Exit Stairs	One entry from station forecourt, one connection to station FOB and two on either end of the station
Catchment Area	Mankhurd Station, Agarwadi, Phule Nagar, Jyotirling Nagar



Station Location

Station Entry Location

Station Entry Location

22. Mandala Metro

Chainage	41507.4m
Inter-station Distance	960.7m
Rail Level	14.2m
Location	On road leading to Ghatkopar perpendicular & south of Sion Panvel Expressway (Yashwant Roa Chavan Marg)
Entry / Exit Stairs	....
Catchment Area	Chikuwadi, Ekta Nagar, Jai Maharashtra Nagar & Commuters from Navi Mumbai


Flats at Jai Maharashtra Nagar


Flats at Jai Maharashtra Nagar

5.3.3 Planning and Design Criteria for Stations

Salient features of a typical station are as follows:

1. The stations can be divided into public and non-public areas (those areas where access is restricted). The public areas can be further subdivided into paid and unpaid areas.

2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.

3. The platform level is determined by a critical clearance of 5.50-m under the concourse above the road intersection, allowing 3.00-m for the concourse height, about 2-m for concourse floor and 2.00-m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the platforms in an elevated situation around 14.0-m above ground.

4. 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.

5. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.

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

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

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station.

9. The DG set, bore well pump houses and ground tank would be located generally in one area on ground under an entrance structure.

10. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:

- Minimum distance of travel to and from the platform.
- Adequate capacity for passenger movements.
- Convenience, including good signage relating to circulation and orientation.
- Safety and security, including a high level of protection against accidents.

12. Following requirements have been taken into account:
    - Minimum capital cost is incurred consistent with maximizing passenger attraction.
    - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    - Flexibility of operation including the ability to adapt to different traffic conditions, changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.
    - Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
    - Provision of display of passenger information and advertising.

13. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions.

14. 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.

15. Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

    A list of accommodation required in the non-public area at each station is given below:

Non Public Area – Station Accommodation	
Station Control Room	Ticket Operators Room
Excess Fare Collection (Passenger Office)	Staff Mess Room
Station Master’s Room	Staff Locker Rooms
Auxiliary Substation	Staff Toilets
Switch Room / UPS Room	Security Room
Telecom Equipment Room	Fire Tank & Pump room

Non Public Area – Station Accommodation	
UPS & Battery Room	DG Room
Signaling Equipment Room	

5.3.4 TYPICAL ELEVATED STATION

The station is generally located on the road median, is~185m long and is a three level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master's Room, UPS & Battery Room, Signaling Room, Telecom Room, ASS, Staff Mess & Toilets, etc. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid zone, after accommodating passenger movement and other station facilities is earmarked for commercial utilization.

The advantages of having the concourse spread throughout the length of the station are:

a. Station can be made as narrow as 19.4 m, as equipment rooms can be placed along the length of concourse. This station prototype therefore is suitable for narrow streets.

b. Since the station is narrow, it is possible to make it a cantilever structure supported on a single column, leaving the road underneath more flexible for present use as well as future expansion.

c. Construction is easier, less barricading and infringement with utilities

d. More opportunities for locating entrances as the station has al ong surface area for articulating with surroundings, even at the ends, where skywalks can connect the station to street or adjoining properties

e. Long concourse provides opportunities for locating retail outlets along the movement path within the station

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5-m has been provided under the concourse. Concourse floor level is about 7.5-m above the road. Consequently, platforms are at a level of about 14.0-m from the road. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides.

With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer as compared to an *At-grade* station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and are light looking have been envisaged. A slim and ultra-modern concrete form is proposed, as they would look both modern and compatible with the lesser-built, low-rise developments along most parts of the corridor.

Platform roofs that can invariably make a structure look heavy; have been proposed to be of steel frame with aluminium cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. In order to allow unhindered traffic movement below the stations, cantilevers across the road have been proposed in the concourse part, over which the station structure would rest. The station structure is supported on a single column, which lies unobtrusively on the central verge.

5.3.4.1 Passenger Amenities

Passenger amenities such as ticketing counters / automatic ticket vending machines, ticketing gate, etc. are provided in the concourse. Uniform numbers of these facilities have been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase / escalators. Maximum capacity required at any station by the year 2031 for normal operation has been adopted for all stations. For this purpose, *peak minute traffic* is assumed to be 2% of the *peak hour traffic*.

5.3.4.2 Concourse

Concourse forms the interface between street and platforms. This is where all the passenger amenities are provided. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct *paid* and *unpaid* areas. The *'unpaid area'* is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the *'paid area', which* includes access to the platforms. The concourse is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the ticketing gates.

5.3.4.3 Ticketing Gates

Ticketing gates' requirement has been calculated taking the gate capacity as 25 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.

5.3.4.4 Ticket Counters and Ticket Vending Machines (TVMs)

It is proposed to deploy manual ticket issuing in the beginning of the operation of the line. At a later stage, automatic TVMs would be used for which space provision has been made in the concourse. At present, ticket counters would be provided, which would be replaced with TVMs 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. The rest are expected to buy season tickets or prepaid card, etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

5.3.4.5 Platforms

A uniform platform width of 6m wide (elevated stations) including staircases and escalators in the central section is proposed for the elevated stations. All platform widths have been checked for holding capacity of the platform for worst-case scenario (two missed headways) in the design year i.e. 2031.

5.3.4.6 Stairs, Escalators and Lifts for Normal and Emergency Operations

Provision has been made for escalators in the paid as well as entrance on both sides i.e. from ground to concourse and concourse to platforms. On each platform, two escalators have been proposed. In addition, three staircases with a combined width of 9.0 m are provided on each side platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate passengers in emergency from platforms to concourse in 5.5 minutes in most stations. Wherever, this is inadequate, additional emergency exit staircases are proposed. (see table xxx) While calculating the waiting passengers on the platform in emergency, 2 missed headways are assumed and the train arriving is assumed to be carrying full capacity load. Lifts have been provided one each on either platform, to provide access for elderly and disabled. Since the rise from road to concourse is about 7.5-m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from street to concourse.

5.3.4.7 Passenger Information Kiosks and Commercial Kiosks

Passenger Information Kiosks and Commercial Kiosks are provided in the unpaid and paid areas of the concourse respectively.

Summary of passenger amenities required and proposed at stations based on projected traffic for the year 2031 is given in Table 5.8.

Table 5.8 PASSENGER AMENITY REQUIREMENT IN STATIONS (Projections for Year 2031)

Corridor DN Nagar – Mandala (M) - Figures for 2031									
No.	**Name of the Station**	**Ticketing Counters (#'s)**	**AFC's (#'s)**	**Max Required Platform Width (m)**	**Additional Emergency Stair (m)**	**Lift Ground to Conc**	**Lift Conc to Plat**	**Esc Ground to Conc**	**Esc Conc to Plat**
18	ESIC Nagar	3	4	4.38	N/A	3	2	3	2
19	Prem Nagar	2	3	4.24	N/A	4	2	4	2
20	Indira Nagar	1	2	4.08	N/A	3	2	3	2
21	Nanavati Hospital	2	2	4.11	N/A	3	2	2	2
22	Khira Nagar	2	3	4.17	N/A	2	2	2	2
23	Saraswat Nagar	2	2	4.12	N/A	3	2	2	2
24	National College	1	2	4.06	N/A	3	2	3	2
25	Bandra Metro	10	17	5.58	N/A	4	2	4	2
26	MMRDA Office	2	4	4.23	N/A	3	2	3	2
27	Income Tax Office	3	5	4.90	N/A	4	2	4	2
28	ILFS	1	3	4.20	N/A	4	2	4	2
29	MTNL Metro	1	2	3.97	N/A	4	2	4	2
30	SG Barve Marg	6	10	6.30	2.4m	3	2	2	2
31	Kurla Terminal	1	2	4.05	N/A	2	2	2	2
32	Kurla (E)	3	4	4.85	N/A	2	2	2	2
33	EEH	4	7	5.08	N/A	2	2	2	2
34	Chembur	1	2	4.21	N/A	2	2	2	2
35	Diamond Garden	2	4	4.53	N/A	2	2	2	2
36	Shivaji Marg	5	6	6.03	N/A	3	2	3	2
37	BSNL	2	4	4.67	N/A	4	2	4	2
38	Mankhurd (M)	5	8	5.92	N/A	3	2	2	2
39	Mandala (M)	4	7	4.47	N/A	2	2	2	2

5.3.4.8 Traffic Integration

Concept of Traffic Integration - The objective of an integrated transport system and traffic movement is to offer maximum advantage to commuters and society from traffic and planning consideration. Various modes of transport need to be integrated in a way that each mode supplements the other. A large proportion of MRTS users will come to and depart from various stations by public, hired and private modes, for which integration facilities need to be provided at stations to ensure quick and convenient transfers.

In order to ensure that entire MRTS function as an integrated network and provides efficient service to the commuter, the following steps have been identified:

- Suitable linkages are proposed so that various corridors of MRTS are integrated within themselves, with existing rail services and with road based modes.
- Facilities needed at various stations are planned in conformity with the type of linkages planned there.

Traffic and transport integration facilities are provided for two different types of linkages:

- Feeder links to provide integration between various MRTS corridors and road based transport modes i.e. public, hired, and private vehicles.
- Walk links to provide access to the pedestrians.

5.3.4.9 Approach Adopted in Planning Traffic Integration Facilities

Integration facilities at MRTS stations include approach roads to the stations, circulation facilities, pedestrian ways and adequate circulation areas for various modes likely to come to important stations including feeder bus/mini-buses. Parking for private vehicles has not been proposed.

5.3.4.10 Operational Integration

Integration at operational level will be required to synchronize the timings of the MRTS services and the feeder service. For an efficient interchange, walking and waiting time at these stations will need to be minimized. Introduction of common ticketing and their availability at convenient locations will be necessary to ensure forecast patronage of the system. Last but not the least will be the need for an integrated passenger information system covering all the modes through the publication of common route guides, time tables and information boards at terminals and in the train coaches for providing updated information for users of the system.

5.4 CIVIL STRUCTURE AND CONSTRUCTION METHODOLOGY

5.4.1 Viaduct – Elevated Structure

5.4.1.1 Choice of Superstructure

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

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

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

5.4.2 Types of Superstructure for Elevated Section

Normally in metro elevated section, following three types of superstructure construction are adopted;

(A) Pre-cast segmental box girder using external unbounded tendon.
(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.
(C) Precast prestressed Twin U girders

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

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

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

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

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

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

i) Parapets are to provided separately after launching of box guider is completed. This takes some extra time in the construction.
ii) Rail level is about 1 m higher as compared to U-girder.

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

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

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

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

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

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

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

Considering ''pros and cons'' of the three type of superstructures as described above, the segmental box girder is recommended for this corridor.

5.4.3 Structural System of Viaduct

5.4.3.1 Superstructure

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

Normally the Box Girder having a soffit width of about 4.0 m (approx) accommodates the two tracks situated at 4.2m center to center (c/c). The Box Girder superstructure for almost all the simply supported standard spans will be constructed by precast pre-stressed segmental construction with epoxy bonded joints.

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

The pier segment will be finalized based on simply supported span of 31.0m and the same will be also kept for all simply supported standard span.

For major crossing having spans greater than 31.0m, 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.

5.4.3.2 Substructure

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

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0 m height above existing road level has been provided all around the pier. A gap of 25 mm has also been provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that a required clearance of 5.5 m is always available on road side beyond vertical plane drawn on outer face of crash barrier. In such case, the minimum height of rail above the existing road is 9.8 m.

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

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

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

5.4.4 Construction of Stations

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

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

5.4.5 Grade of Concrete

It is proposed to carry out construction work with 'Design mix concrete' through computerized automatic Batching Plants with following grades of concretefor 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.

5.4.6 Reinforcement and pre-stressed Steel

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

5.4.7 Road width required during construction

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

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

i) Preliminary action for diversion of utility and preparation of estimates thereof.
ii) Reservation of land along the corridor, identification and survey for acquisition.

5.5 GEOTECHNICAL INVESTIGATIONS

Geological site investigation data and Geotechnical Investigation data for the portion of the proposed Corridor from D. N. Nagar to Mankhurd has been extracted from DPR forCharkop-Bandra-Mankhurd corridor submitted by DMRC in 2006. No fresh Geotechnical Investigation is done and the data given below has been taken from DPR for Charkop-Bandra-Mankhurd corridor. Chainageshave been correlated with the chainages of Charkop-Bandra-Mankhurd DPR for corresponding alignment. There is no geotechnical data provided in this report for the stretches of the corridor detoured from the previous route.

5.5.1 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

5.5.2 Seismicity-Mumbai lies in seismic zone III. Suitable seismic coefficient may be adopted in the design of structures to commensurate with the Indian Standard seismic zoning of the country IS.1893-1984 which is under revision after the occurrence of Gujarat Earthquake in January' 2001.

5.5.3 Field Investigations

This proposed corridor of the Mumbai MRTS is from D. N. Nagar(excluding D.N. Nagar Station) to Mandala. The details of boreholes along the corridor are shown in Table 5.9. Geotechnical Investigation is not done again and the data given below have chainages correlated with the chainages of previous DPR for corresponding alignment.

Table 5.9
DETAILS OF BOREHOLES

BOREHOLE NUMBER	CHAINAGE (in m)	Ground R.L. (m)	GROUND WATER TABLE DEPTH (in m)	DEPTH OF INVESTIGATION (in m)		
				In SOIL	In ROCK (soft/hard)	TOTAL
BH 49	17642.1	3.44	7	7.3	16.2	23.5
BH 48	17974.1	4.19	7.4	7.3	6.9	14.2
BH 47	18439.9	3.89	7.1	7.5	10.7	18.2
BH 46	18931.4	3.12	7.4	6	7.7	13.7
BH 45	19487	3.01	-	6	10.8	16.8
BH 44	19950.8	3	6.2	8.1	10.9	19
BH 43	20373.6	3.21	3.7	2.1	11.5	13.6
BH 42	20872	2.92	-	3.6	12.8	16.4
BH 41	21468.2	4.12	3	1.5	11.9	13.4
BH 40	21919.2	3.68	-	7.4	6.25	13.7
BH 39	22428.8	3.48	2.8	6	6.4	12.4
BH 38	22896.5	3.89	1.2	4	5.05	9.05
BH 2	28233.9		0.3	10.5	5.35	15.9
BH 3	28733.9		0.6	9.2	10.5	19.7
BH 4	29233.9		1.2	6.5	8.5	15

BOREHOLE NUMBER	CHAINAGE (in m)	Ground R.L. (m)	GROUND WATER TABLE DEPTH (in m)	DEPTH OF INVESTIGATION (in m)		
				In SOIL	In ROCK (soft/hard)	TOTAL
BH 5	29733.9		1.7	6.9	5	11.9
BH 6	30283.9		2	3.4	8.8	12.2
BH 7	30733.9		2.7	8.8	5.6	14.4
BH 13	34957.3		1.5	5	6	11
BH 14	35631.3		3	5	7	12
BH 15	36106.3		2.3	5	8	13
BH 16	36614.3		3	5.5	10	15.5
BH 17	37106.3		2	3	10	13
BH 18	37606.3		2.6	5	5	10
BH 19	38106.3		3.5	5	6	11
BH 20	38606.3		3	4	6	10
BH 21	39106.3		2.5	3	10	13
BH 22	39606.3		2	4	6	10
BH 23	40106.3		2	3	7	10

Note: Borehole No. 49 to 38 belongs to D.N Nagar to Nanawati Hospital portion of Coloba-Bandra-Charkop Corridor and Borehole No. 2 to 23 belongs to MMRDA to Mankhurd portion from Bandra-Kurla-Mankhurd Corridor.

5.5.4 Construction Methodology

Type of Foundation- Considering the nature of soil, type of proposed structures (Elevated Rail Corridor) and expected loads on foundations, 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 should be 10 to 30m 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 mm or 1500 mm diameter are proposed to 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 5.10** and the minimum pile lengths (bore hole wise) are indicated in **Table 5.11.**

Table 5.10Pile Capacity (in T)

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

Table 5.11Borehole wise pile Lengths B.G.L (in m.)

Bore Hole No	Minimum Pile Length Required BGL (in m.)	Pile termination depth BGL (in m.)		
		For 1m. □	For 1.20m. □	For 1.50m. □
D.N. Nagar - Nanawati Hospital Section				
BH-49	19.0+3D	22.00	22.60	23.50
BH-48	8.0+3D	11.00	11.60	12.50
BH-47	12.70+3D	15.70	16.30	17.20
BH-46	11.0+3D	14.00	14.60	15.50
BH-45	8.0+3D	11.00	11.60	12.50
BH-44	13.50+3D	16.50	17.10	18.00
BH-43	9.0+3D	12.00	12.60	13.50
BH-42	10.50+3D	13.50	14.10	15.00
BH-41	9.50+3D	12.50	13.10	14.00
BH-40	7.0+3D	10.00	10.60	11.50
BH-39	7.0+3D	10.00	10.60	11.50
MMRDA-Mankhurd Section				
BH 2	10.50+3D	13.50	14.10	15.00
BH 3	10.20+3D	13.20	13.80	14.70
BH 4	8.80+3D	11.80	12.40	13.30
BH 5	7.90+3D	10.90	11.50	12.40
BH 7	9.40+3D	12.40	13.00	13.90
BH 13	6.00+3D	9.00	9.60	10.50
BH 14	7.00+3D	10.00	10.60	11.50
BH 15	8.00+3D	11.00	11.60	12.50
BH 16	8.50+3D	11.50	12.10	13.00
BH 17	7.50+3D	10.00	10.60	11.50
BH 21	8.00+3D	11.00	11.60	12.50
BH 23	6.00+3D	9.00	9.60	10.50

Open Foundation- Keeping in view the type of the proposed structure and the subsoil strata, open foundations are recommended at ten locations. Net safe bearing capacity of 100 T/m^2 is recommended in such boreholes. Founding depths from existing ground level are tabulated in **Table 5.12**.

Table 5.12 Borehole Wise Founding Depths for Footing Foundation

BOREHOLE NUMBER	GROUND WATER TABLE DEPTH (in m)	ROCK DEPTH (in m)	MINIMUM FOUNDING DEPTH FOR SBC=100 T/m2 (in m)
BH 6	2.00	3.40	6.00
BH 18	2.55	5.00	6.00
BH 19	3.50	5.00	7.50
BH 20	3.00	4.00	7.00
BH 22	2.00	4.00	7.00

5.5.5 Engineering Design Parameters- Based upon investigation done and the analysis made thereafter, following design parameters have been finalized as discussed in the subsequent paras.

5.5.6 Design Parameters - The sub-soil strata at the proposed site comprise of following types of layers (based on field tests & laboratory test result data). Description of each layer along with various engineering parameters is as shown in **Table 5.13**

Table 5.13 Layer Type and Description

Layer	Description	Classification as per IS : 1498-1970	Relative Density/ Consistency	Observed in Bore Hole Nos.
D.N Nagar–Nanawati Hospital				
VII	Highly to moderately weathered SANDSTONE/ BRECCIA/ BASALT	-	-	BH 38 to BH 49
VI	Completely weathered rock	CI, CH, GM	-	BH 49
V	Silty Sandy Clay with gravel	CH, CI	Very stiff to hard	BH 40, BH 47 , BH 48
IV	Silty Clay	CH	Medium stiff to stiff	BH 40, BH 42 to BH 49
III	Sandy Clay/ Silty Clay	-	Soft	BH 42, BH 47
II	Silty Sand	SM-SC, SP-SC, SM, SC	Medium dense to dense	BH 38 to BH 41, BH 45, BH 49.
I	Road material & Backfill	-	-	BH 38 to BH 49 Except in BH 40, BH 41
MMRDA - Mankhurd				
I	Road Material & Backfill	---	---	BH 2, BH 3, BH 4, BH 5, BH 6, BH 7, BH 13, BH 14, BH 15, BH 16, BH 17, BH 18, BH 19,BH 20, BH 21, BH 22 & BH 23
II	Backfill Soil With Boulders	---	Loose	BH 7
III	Grey Soft To Medium Stiff Marine Clay	CH	Soft to Medium Stiff	BH 2, BH 3, BH 4, BH 5, BH 6
IV	Yellow Stiff Silty Clay	CH	Stiff	BH 2, BH 3, BH 4, BH 5, BH 7, BH 13, BH 14, BH 15, BH 16, BH 17, BH 18, BH 19, BH 20, BH 21 & BH 22

Layer	Description	Classification as per IS : 1498-1970	Relative Density/ Consistency	Observed in Bore Hole Nos.
V	Completely Weathered Rock	GM-GC	Dense	BH 18
VI	Highly Weathered Volcanic Breccia	Rock		BH 2, BH 3, BH 4, BH 6, BH 7 , BH 13, BH 14, BH 15, BH 16, BH 17, BH 19, BH 20, BH 21, BH 22 & BH 23
VII	Moderately Weathered Volcanic Breccia	Rock		BH 2, BH 3, BH 4, BH 5, BH 6, BH 7, BH 13, BH 14, BH 15, BH 16, BH 17, BH 18, BH 19, BH 20, BH 21, BH 22, BH 23
VIII	Slightly Weathered Volcanic Breccia	Rock		BH 18, BH 19, BH 21, BH 22 & BH 23

5.5.7 The proposed foundation levels for both stretches combined in this DPR have been taken as arrived in the DPRs earlier prepared. It is however recommended that detailed soil investigations will have to be done and sub structure designed at the time of implementing the corridor.

5.6 UTILITY DIVERSIONS

5.6.1 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 below:

5.6.2 Utility and Services

The proposed corridor starts at D. N. Nagar and terminates at Mandala. The details of existing utilities for D.N Nagar to Mankhurd stretch have been extracted from the DPR previously prepared by DMRC.

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.

Organizations/Departments with concerned utility services in Mumbai are mentioned in **Table 5.14.**

Table 5.14 Utility Responsibility Departments

Sr. No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	Municipal Corporation of Greater Mumbai (MCGM)	Roads, surface water drains, nallahs, Sewerage and drainage conduits, sewerage treatment plants, pumping stations, Water mains and their service lines, including hydrants, water treatment plants, pumping stations, Gardens etc.
2.	Public Works Deptt. (PWD)	Road construction & maintenance of State highways and Expressways.
3.	Irrigation and Flood Department, MCGM	Nallahs/flood water drains etc.
4.	BEST (Brihanmumbai Electric Supply & Transportation)	Power cables and their appurtenances H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc.
5.	Mahanagar Telephone Nigam Ltd. (MTNL)	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
6.	Mumbai Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
7.	Mahanagar Gas Ltd.	Gas lines
8.	BSES(Bombay Sub-urban Electric Supply) /Reliance Energy	Power cables and their appurtenances H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc
9.	TATA Power	Power cables and their appurtenances H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc
10.	MMRDA & MHADA	Land development & Housing etc.
11.	TATA Tele Services	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
12.	Reliance Info. Ltd	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
13.	Western & Central Railway	Railway crossings, signals, railway bridges, etc.

5.6.3 Diversion of Underground Utilities

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

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

- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.

- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout of piles in the foundation may be suitably adjusted to ensure that no foundation needs be constructed at the location, where utility is crossing the proposed alignment. The utility service can also be encased within the foundation piles.

5.6.4 Sewer Lines, Strom Water Drains And Water Lines

The sewer/drainage lines generally exist in the service lanes i.e. away frommain 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 service lines. Details of sewer lines & storm water drains and water pipe lines affected along with their diversion proposals are indicated in Table 5.15 and Table 5.16

Table 5.15 Details of Sewer Lines

S. No.	Chainage	Affected length(m)	Dia. (mm)	Position wrt alignment	Diversion proposal
1	17617.5-17517.5	100	75	Along	A
2	17617.5-17517.5	100	1200	Along	A
3	17617.5-17517.5	100	1400	Along	A
4	17617.5-17517.5	100	1600	Along	A
5	18117.5-17617.5	500	1200	Along	A
6	18117.5-17617.5	500	1400	Along	A
7	18177.5	30	500	Across	B
8	18537.5	40	350	Across	B
9	18617.5-18117.5	500	1200	Along	A
10	18617.5-18117.5	500	1400	Along	A
11	18867.5	40	350	Across	B
12	21214.4	30	300	Across	B
13	21214.4-21139.4	75	1050	Along	A
14	21239.4	30	300	Across	B
15	21289.4	30	300	Across	B
16	21289.4-21214.4	75	300	Along	A
17	21339.4	30	90	Across	B
18	21339.4	30	300	Across	B
19	21339.4-21289.4	50	300	Along	A
20	21589.4	30	230	Across	B
21	21639.4	60	300	Across	B
22	21639.4-20389.4	250	300	Along	A
23	21669.4	30	230	Across	B
24	21689.4-21339.4	350	300	Along	A
25	22049.4-21689.4	360	230	Along	A
26	22979.4-22609.4	370	230	Along	A
27	28234	40	600	Across	B
28	29966	10	600	Across	B

S. No.	Chainage	Affected length(m)	Dia. (mm)	Position wrt alignment	Diversion proposal
29	30369	10	600	Across	B
30	34723-34888	65	600	Along	A
31	34983-35164	187	600	Along	A
32	35185-35195	10	600	Across	B
33	35201	8	600	Across	B
34	35201-35247	46	600	Along	A
35	35449-35523	74	600	Along	A
36	35475-35659	184	600	Along	A
37	35596-36106	510	300	Along	A
38	36106	10	230	Across	B
39	36106-36266	160	230	Along	A
40	36636-36820	184	300	Along	A
41	36829-37458	629	230	Along	A
42	37458	10	230	Across	B
43	37458-37874	432	230	Along	A
44	37917	13	230	Across	B
45	38436	10	300	Across	B
46	39001-39185	184	600	Along	A
47	39106	52	600	Across	B
48	39284-39376	92	300	Along	A

Note:1. The depth of sewer lines was reported between 2 to 3m (app.) below ground.
2. “A” – To be shifted away from station location.
3. “B” – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.16: Details of Affected Water Pipeline

S. No.	Chainage	Affected Length (in m.)	Dia (mm)	Position W.R.T Alignment	Proposal for Diversion
1	28333.3-28388.3	55	600	Across diagonally	B
2	28333.3-29004.3	671	250	Along	A
3	28443.3-28658.3	215	250	Along	A
4	28983.3-29003.3	20	600	Across diagonally	B
5	29120.3	10	250	Across	B
6	29478.3-29508.3	30	600	Across diagonally	B
7	29506.3-29690.3	184	600	Along	A
8	30069.3	10	300	Across	B
9	30078.3	10	300	Across	B
10	30888.3	10	300	Across	B
11	34676.1	10	150	Across	B
12	34689.1	10	150	Across	B
13	34695.1	10	150	Across	B
14	34144.1	10	800	Across	B
15	35150.1	10	1200	Across	B
16	35154.1	10	1200	Across	B
17	35156.1-35291.1	135	250	Along	A
18	35362.1	10	1200	Across	B
19	35364.1	10	1200	Across	B
20	35366.1	10	1200	Across	B
21	35434.1-35748.1	314	250	Along	A

S. No.	Chainage	Affected Length (in m.)	Dia (mm)	Position W.R.T Alignment	Proposal for Diversion
22	35469.1-35653.1	184	250	Along	A
23	35748.1-35780.1	143	250	Along	A
24	35780.1	23	300	Across	B
25	35781.1-36437.1	656	250	Along	B
26	35800.1-38133.1	2333	525	Along	A
27	36635.1-36819.1	184	300	Along	A
28	36635.1-36819.1	184	150	Along	A
29	36635.1-36819.1	184	200	Along	A
30	36965.1	10	1800	Across	B
31	36967.1	10	750	Across	B
32	37878.1-38062.1	184	1200	Along	A
33	37878.1-38062.1	184	200	Along	A
34	38656.1-38705.1	122	450	Along	A
35	38178.1	5	250	Across	B
36	38174.1	5	150	Across	B
37	38305.1-38417.1	112	450	Along	A
38	38656.1	10	150	Across	B
39	38705.1-38887.1	182	450	Along	A
40	38998.1-39182.1	184	200	Along	A
41	39131.1	10	900	Across	B
42	39131.1-39240.1	109	900	Along	A
43	39305.1-39365.1	60	450	Across diagonally	B
44	39330.1-39532.1	202	450	Along	A
45	39365.1-39545.1	180	150	Along	A
46	39965.1	12	250	Across	B
47	39965.1-40044.1	79	100	Across diagonally	B
48	40347.1-40367.1	20	100	Across diagonally	B

Note:1)The depthofwater lines was reported between1to2m. (app.) below ground.
2)“A”–Tobeshifted/diverted.
3)“B”–Suitablylocatethepier/changethepilelayouttoavoiddiversion.

5.6.4.1 **Gas Pipe Lines**

Few gas pipe lines with varying diameters belonging to Mahanagar gas Limited, Mumbai are running along and across the roads along which the metro alignment is proposed. Though, the alignment is planned almost along the center of the road en-route, few pipelines runningacross & along the alignment are likely to be affected by the alignment are detailed in **Table 5.17**. All these pipelines are placed at a depth of about 1 m below the ground.

The alignment being elevated, to avoid diversion of pipelines running across the alignment, necessary span adjustments are to be made. The pipelines running along the proposed alignment needs to be diverted at few stretches. At the time of project execution, the pipe line authorities should be contacted for necessary diversions and sufficient care should be taken to ensure their safety.

Table 5.17: Details of Affected Gas (Mahanagar) Pipeline

S. No.	Chainage (m)	Affected length (m)	Approx. depth (m)	Position w.r.t. alignment	Diversion Proposals
1	21276.2-21691.2	415	1.00	Along	A
2	22391.2-22591.2	200	1.00	Along	A
3	22591.2	30	1.50	Across	B
4	23154.2-23176.2	30	1.00	Along	A
5	28443.1-28627.1	184	Steel line	Along	A
6	31358.1	10	Steel line	Across	B
7	31723.1	20	Steel line	Across	B
8	32678.1	10	63 PE/PL	Across	B
9	32842.1-33246.1	404	90 PE/PL	Along	A
10	33352.1-33568.1	216	Steel line	Along	A
11	33847.1	10	Steel line	Across	B
12	34478.1	10	Steel line	Across	B
13	35065.1-35249.1	184	125 PE/PL	Along	A
14	35408.1	10	125 PE/PL	Across	B
15	36306.1-36490.1	184	125 PE/PL	Along	A
16	36397.1	10	Steel line	Across	B
17	36528.1	10	125 PE/PL	Across	B
18	37255.1	10	Steel line	Across	B
19	37427.1-37611.1	184	125 PE/PL	Along	A

Note: 1)"A"–Tobeshifted/diverted.
2)"B"–Suitablylocatethepier/changethepilelayouttoavoiddiversion.

Details of underground utilities are notional and extracted from the DPR prepared by DMRC in 2006. Fresh investigation of underground utilities are strongly recommended before implementing the project.

5.6.5 Aboveground Utilities

Above ground utilities namely street light, poles, traffic signal posts, telecommunication posts, junction boxes, etc. are also required to be shifted and relocated suitably during construction. Since these will be interfering with the proposed alignment. Approximate numbers of such aboveground utilities are indicated in **Table 5.18** below:

Table5.18DetailsofAffectedAboveGroundServices

Service Description	Approximate Numbers
Light Post	202
Man Hole	215
Signal Pole	45
High Tension Power Line	6

5.6.6 HT-Electric cables Along the Corridor (Underground position)

At several places, 11kV/22kV/33kV/66kv power cables belonging to Reliance Energy and TATA Power are running along & across the proposed alignment in underground position and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are indicated in Table 5.19& Table 5.20. These lines need to be modified/shifted or cabled well in advance of construction along this route.

Table 5.19 Details of Affected Reliance Power Cables

S. No.	Chainage (m)	Affected Length (in m)	Type	Position W.R.T Alignment	Diversion Proposals
1	28442.9-28626.9	13	11 kv	Along	A
2	28442.9 -28626.9	184	11kv	Along	A
3	28987.9	9	11kv	Across	B
4	28987.9- 29019.9	32	11kv	Along	A
5	29657.9	20(2nos)	11kv	Across	B
6	30014.9	9(3nos)	11kv	Across	B
7	30365.9	9	11kv	Across	B
8	30953.9	9	11kv	Across	B
9	31350.9	9	11kv	Across	B
10	31687.9	9	11kv	Across	B
11	31702.9	20(2nos)	11kv	Across	B
12	31959.9	9	11kv	Across	B
13	32032.9	22	11kv	Across	B
14	32225.9	42	11kv	Across	B
15	32812.9	10	11kv	Across	B
16	33362.9	10	11kv	Across	B
17	33432.9 – 33800.9	368	11kv	Along	A
18	33573.9	10	11kv	Across	B
19	33894.9 – 34078.9	184	11kv	Along	A
20	33922.9	10	11kv	Across	B
21	34022.9	19	11kv	Across	B
22	34532.9	2*10	22kv	Across	B
23	34585.9	10	11kv	Across	B
24	35483.9	10	11kv	Across	B
25	35545.9	10	11kv	Across	B
26	36332.9 – 36430.9	2*98	11kv	Along	A
27	36430.9 – 36520.9	90	11kv	Along	A
28	36520.9	2*10	11kv	Across	B
29	37287.9	10	11kv	Across	B
30	37588.9 – 37727.9	139	11kv	Across	B
31	37727.9	10	11kv	Across	B
32	38165.9	2*12	11kv	Across	B
33	38415.9	13	11kv	Across	B
34	38550.9	2*10	11kv	Across	B
35	38632.9	13	11kv	Across	B
36	39014.9	15	11kv	Across	B
37	39025.9	15	11kv	Across	B
38	39205.9	25	11kv	Across	B
39	39212.9	25	11kv	Across	B

Note: 1. The depth of Power cables was reported upto 1 m.(app.) below ground.
2. "A" – To be shifted away from station location.
3. "B" – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.20 Details of Affected Tata Power Cables

S. No.	Chainage (in m.)	Affected Length (in m.)	Type	Position w.r.t Alignment	Diversion Proposals
1.	30071.4	4*10m	22/11kv	Across	B
2.	30171.4	40*10m	22/11kv	Across	B
3.	30699.4	4*10m	22/11kv	Across	B
4.	31368.4	6*10m	22/11kv	Across	B
5.	31706.4	4*10m	22kv	Across	B
6.	31864.4	2*10m	22kv	Across	B

Note: 1. The depth of Power cables was reported upto 1 m(app.) below ground.
2. "A" – To be shifted away from station location.
3. "B" – Suitably locate the pier/change the pile layout to avoid diversion.

5.6.7 Telecom Cables

At several places, telecom cables of MTNL are also running along & across the proposed alignment in underground position and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are indicated in **Table 5.21**givenbelow. Detailed proposals for tackling these lines need to be prepared in consultation with the concerned agencies. However, Tentative provision has been made in cost estimates.

Table 5.21Details of Affected MTNL Telecom Cables

S.No.	Chainage	Affected Length(m)	Approx. Depth Below Ground	Type	Position w.r.t Alignment	Diversion Proposals
1	18117.3-17887.3	230	1	Cableduct	Along	A
2	21189.3	44	1	Cableduct	Across	B
3	21889.3-21289.3	600	1	Cableduct	Along	A
4	21935.3-21889.3	46	1	Cableduct	Along	A
5	22853.3-22614.3	240	1	Cableduct	Along	A
6	28874.3	10		Cable duct	Across	B
7	29426.3	10		Cable duct	Across	B
8	30474.3	20		Cable duct	Across	B
9	31229.3	10		Cable duct	Across	B
10	31571.3	20		Cable duct	Across	B
11	32600.3	10		Cable duct	Across	B
12	33807.3	10		Cable duct	Across	B
13	33974.3	24		Cable duct	Across	B
14	33998.3	20		Cable duct	Across	B
15	34548.3	11		Cable duct	Across	B
16	36611.3	10		Cable duct	Across	B
17	36876.3	10		Cable duct	Across	B
18	37308.3	20		Cable duct	Across	B
19	33897.3-34081.3	184		Cable duct	Along	A

S.No.	Chainage	Affected Length(m)	Approx. Depth Below Ground	Type	Position w.r.t Alignment	Diversion Proposals
20	34013.3-34080.3	67		Cable duct	Along	A
21	35065.3-35249.3	184		Cable duct	Along	A
22	37584.3-38134.3	450		Cable duct	Along	A

Note: 1. The depth of MTNL cables was reported upto 1 m.(app.) below ground.
2. "A" – To be shifted away from station location.
3. "B" – Suitably locate the pier/change the pile layout to avoid diversion.

Table 5.22 Details of Affected Tata Tele Services (OFC) Telecom Cables

S.No.	Chainage	Affected Length(m)	Type	Position w.r.t Alignment	Diversion Proposals
1	22642.8	30	Tata Ofc	Across	B
2	23102.8-23425.8	323	Tata Ofc	Along	A
3	23217.8	30	Tata Ofc	Across	B
4	23231.8	30	Tata Ofc	Across	B
5	23401.8-23425.8	24	Tata Ofc	Along	A
6	23510.8-23537.8	27	Tata Ofc	Along	A
7	24236.8	30	Tata Ofc	Across	B

Note: 1. The depth of Telephone cables was reported upto 1 m.(app.) below ground.
2. "A" – To be shifted away from station location.
3. "B" – Suitably locate the pier/change the pile layout to avoid diversion.

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

5.7 LAND ACQUISITION

5.7.1 Land

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)

5.7.2 Land Requirement for Elevated Streches:

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 is about 8.7 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 20.4 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.

5.7.3 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.

5.7.4 Land for Depot

Depot for D. N. Nagar – Mandala Corridor has been proposed in land identified by MMRDA at Mandala. Hence an area of 22 ha govt. land has been earmarked.

5.7.5 Land for Traction and Receiving Substation and Radio Towers

Two RSS near MMRDA station and Mandala depot are proposed to be located for this Corridor. Hence, an area of 11,200m^2 (Government) has been earmarked. Exact location will be decided at the time of implementation of the project. No additional land proposed for locating radio towers. These will be accommodated in the land already acquired.

5.7.6 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.

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 and running sections are indicated in Table 5.23 and 5.24.

Table 5.23 RUNNING SECTION

S.No.	PLOT NO	AREA PROPOSED TO BE ACQUIRED(Sqm.)	OWNERSHIP
1	RS-1	0	---
2	RS-2	21	Pvt.
3	RS-3	1963	Pvt.
4	RS-4	1263	GOVT.
5	RS-5	2034	GOVT.
6	RS-6	2622	GOVT.
7	RS-7	1878	Pvt.
8	RS-8	1600	GOVT.
9	RS-9	66	Pvt.
10	RS-10	168	Pvt.
11	RS-11	609	Pvt.
12	RS-12	600	Pvt.
13	RS-13	6024	Pvt.
14	RS-14	1422	Pvt.
15	RS-15	84	Pvt.
16	RS-16	395	Pvt.
17	RS-17	196	Pvt.
18	RS-18	41	Pvt.
19	RS-19	321	Pvt.
20	RS-20	69	Pvt.
21	RS-21	1158	GOVT.
22	RS-22	895	GOVT.
TOTAL =23430Sqm.			
GOVT. =9573Sqm.			
PVT. =13857Sqm.			

Table 5.24 LAND REQUIRED FOR STATIONS

S.NO.	PLOT NO.	AREA(m^2)	TYPE OF PROPERTY	OWNERSHIP
1	EN-1	466	Exit/Entry	Pvt.
2	EN-2	447	Exit/Entry	Pvt.
3	EN-3	403	Exit/Entry	Pvt.
7	PN-1	530	Exit/Entry	Govt.
8	PN-2	552	Exit/Entry	Govt.
9	PN-3	440	Exit/Entry	Pvt.
10	PN-4	447	Exit/Entry	Pvt.
13	IN-1	266	Exit/Entry	Pvt.
14	IN-2	423	Exit/Entry	Pvt.
15	IN-3	55	Exit/Entry	Pvt.
16	IN-4	347	Exit/Entry	Pvt.
17	IN-5	230	Exit/Entry	Pvt.
23	NH-1	240	Exit/Entry	Pvt.
24	NH-2	292	Exit/Entry	Pvt.
25	NH-3	454	Exit/Entry	Pvt.
26	NH-4	454	Exit/Entry	Pvt.
31	KN-1	354	Exit/Entry	Govt.
32	KN-2	744	Exit/Entry	Govt.
33	KN-3	245	Exit/Entry	Pvt.
34	KN-4	234	Exit/Entry	Pvt.
37	SN-1	442	Exit/Entry	Pvt.
38	SN-2	430	Exit/Entry	Pvt.
39	SN-3	319	Exit/Entry	Pvt.
40	SN-4	248	Exit/Entry	Pvt.
44	NC-1	490	Exit/Entry	Pvt.
45	NC-2	525	Exit/Entry	Pvt.
46	NC-3	187	Exit/Entry	Pvt.
47	NC-4	245	Exit/Entry	Pvt.
52	B-1	425	Exit/Entry	Govt.
53	B-2	566	Exit/Entry	Pvt.
54	B-3	430	Exit/Entry	Pvt.
55	B-4	481	Exit/Entry	Pvt.
58	M-1	525	Exit/Entry	Govt.

S.NO.	PLOT NO.	AREA(m^2)	TYPE OF PROPERTY	OWNERSHIP
59	M-2	528	Exit/Entry	Govt.
60	M-3	401	Exit/Entry	Govt.
61	M-4	550	Exit/Entry	Govt.
66	I-1	220	Exit/Entry	Pvt.
67	I-2	85	Exit/Entry	Pvt.
68	I-3	421	Exit/Entry	Govt.
69	I-4	440	Exit/Entry	Govt.
72	IL-1	465	Exit/Entry	Pvt.
73	IL-2	463	Exit/Entry	Pvt.
74	IL-3	330	Exit/Entry	Govt.
75	IL-4	122	Exit/Entry	Pvt.
76	IL-5	310	Exit/Entry	Govt.
77	IL-6	182	Exit/Entry	Pvt.
78	MM-1	393	Exit/Entry	Pvt.
79	MM-2	401	Exit/Entry	Pvt.
80	MM-3	414	Exit/Entry	Govt.
81	MM-4	100	Exit/Entry	Pvt.
86	S.G.B-1	549	Exit/Entry	Pvt.
87	S.G.B-2	387	Exit/Entry	Pvt.
88	S.G.B-3	95	Exit/Entry	Govt.
89	S.G.B-4	49	Exit/Entry	Pvt.
90	S.G.B-5	264	Exit/Entry	Govt.
91	S.G.B-6	4	Exit/Entry	Pvt.
92	S.G.B-7	4	Exit/Entry	Pvt.
93	S.G.B-8	22	Exit/Entry	Pvt.
95	KR-1	551	Exit/Entry	Govt.
96	KR-2	551	Exit/Entry	Govt.
97	K-1	551	Exit/Entry	Govt.
98	K-2	14	Exit/Entry	Pvt.
99	K-3	533	Exit/Entry	Govt.
100	K-4	29	Exit/Entry	Pvt.
101	K-5	11	Exit/Entry	Pvt.
102	K-6	354	Exit/Entry	Pvt.
103	K-7	365	Exit/Entry	Pvt.

S.NO.	PLOT NO.	AREA(m^2)	TYPE OF PROPERTY	OWNERSHIP
104	E-1	407	Exit/Entry	Pvt.
105	E-2	195	Exit/Entry	Pvt.
106	E-3	161	Exit/Entry	Pvt.
107	E-4	294	Exit/Entry	Pvt.
108	C-1	53	Exit/Entry	Pvt.
109	C-2	362	Exit/Entry	Govt.
110	C-3	340	Exit/Entry	Govt.
111	C-4	77	Exit/Entry	Pvt.
112	C-5	168	Exit/Entry	Pvt.
113	C-6	162	Exit/Entry	Pvt.
114	R C M -1	659	Exit/Entry	Pvt.
115	R C M -2	304	Exit/Entry	Govt.
116	R C M -3	146	Exit/Entry	Pvt.
117	R C M -4	326	Exit/Entry	Pvt.
118	S-1	422	Exit/Entry	Pvt.
119	S-2	255	Exit/Entry	Pvt.
120	S-3	290	Exit/Entry	Pvt.
121	S-4	148	Exit/Entry	Pvt.
122	BSNL-1	529	Exit/Entry	Govt.
123	BSNL-2	440	Exit/Entry	Govt.
124	BSNL-3	534	Exit/Entry	Govt.
125	BSNL-4	17	Exit/Entry	Pvt.
126	BSNL-5	494	Exit/Entry	Govt.
127	MH-1	306	Exit/Entry	Govt.
128	MH-2	565	Exit/Entry	Govt.
129	MH-3	87	Exit/Entry	Pvt.
130	MH-4	326	Exit/Entry	Govt.
131	MN-1	551	Exit/Entry	Govt.
132	MN-2	551	Exit/Entry	Govt.
133	MN-3	551	Exit/Entry	Govt.
134	MN-4	551	Exit/Entry	Govt.
Total Land Area = 33365 m^2				
Govt. Land Area = 15473 m^2				
Pvt. Land Area= 17892 m^2				

5.7.7 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. Office and OCC proposed for Metro Corridor for Dahisar (E) to D.N. Nagarwill be used for this corridor also (extension of Dahisar (E) to D.N. Nagar). It is proposed to keep the provision of **1.5 ha** of government land for the purpose of staff quarters. Exact location of land has not been identified at this stage. It may be decided at the time of project implementation.

5.7.8 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 the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose has been considered throughout the corridor @ 2000 m^2 at every 5 km. These sites will be obtained on lease temporarily for the construction period. After completion of construction, these will be handed over back to the land owning agency.

Table 5.25 Details of Temporary Land office accommodation

S. No.	Corridor	AREA (m^2)	OWNER-SHIP
1	D.N. Nagar to Mandala	10000	Government
	Total	**10000**	

5.7.9 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. Considering the various factors, it is proposed to setup five casting yards for the proposed corridor. Accordingly a provision of **10 ha** land has been proposed on temporary basis considering 2.0 ha of land for each casting yard for a period of four years.

5.7.10 Summary of Land Requirements

Abstract of land requirements for different components of this corridor is given in **Table 5.26**.

Table 5.26 Summary of Permanent Land Requirement (All figures in Sq. m)

S. No.	Description	Govt.	Pvt.
1	Stations	15473	17892
2	Running Section	9573	13857
3	Depot	220000	0
4	Staff Quarter	15000	0
5	Office Complex and OCC	0	0
6	RSS	11200	0
	Total (Area in sq m)	**271246**	**31749**

Total Permanent Land = 30.2995ha
Permanent Land (Govt.) = 27.1246 ha
Permanent Land (Pvt.) = 3.1749 ha

Note: Permanent land requirement has been reduced by 2971 sqm and 210 sqm due to change in align at JVPD and relocation of exit/entry structure location at National College respectively. This reduction in land requirement has not been taken in account in the cost estimate calculation as it will not have significant effect.

Table 5.27 - Summary of Temporary Land Requirement

S. No.	Description	AREA (m^2)	OWNER-SHIP
1	Temporary Office/ Site Office	10000	Government
2	Segment Casting Yard	100000	Government
	Total	**110000**	

Total land required for temporary acquisition is **11ha,** which is assumed that it will be government land.

5.8 SAFETY & SECURITY SYSTEMS

5.8.1 General

5.8.1.1This 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.

5.8.1.2 **Requirements:**

i. The System shall protect the passengers against the fire in train services and at the premises of Metro Railway.
ii. The system shall protect vulnerable premises from fire.
iii. The system shall be able to detect the unauthorized entry and exit at nominated places.
iv. The system shall include
- Fire alarm system.
- Fire Hydrant and Sprinkler System.
- Fire Extinguishers.

- Closed circuit television with video analytics.
- Security Gates – Metal Detector.
- Baggage Scanner.

5.8.2 Fire Alarm System:

5.8.2.1 General

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

i. At Station Control Room (SCR).
ii. Station security services centre.
iii. At Operational Control Centre.
iv. At Depot, in depot controller room.
v. Escalator landing and inside elevators.
vi. Evacuation routes.
vii. Cash transfer routes on the station.
viii. Equipment room.
ix. Store room.
x. Any other place required.

5.8.2.2 Scope

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

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

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

5.8.2.3 System Components

Fire Alarm Control Panel

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

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

i. Addressable pull stations – Manual Call Point.
ii. Intelligent photo electric smoke, thermal detector.

iii. Addressable control model.
iv. Isolated modules.

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

Anaddressable 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 firealarm control panel. After operation, fire alarm pull station must be restored to the ready position using a special tool or key in order to de-activate the alarm sequence and return the system to normal.

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

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

5.8.2.6 **Addressable Control Module:**

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

5.8.2.7 **Isolator Module:**

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

5.8.3 Fire Hydrant System:

5.8.3.1 **General**

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

5.8.3.2 **Scope**

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

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

Fire Hydrant System comprises of the following:

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

Hydrant System is proposed to be installed at following Places

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

5.8.3.3 **System Component**

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

5.8.3.4 **Landing Valve**

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

5.8.3.5**Hoses**

Hose is a flexible tube used to carry water

5.8.3.6**Hose Reel**

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

5.8.3.7**Coupling**

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

5.8.3.8**Fire Brigade Connector:**

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

5.8.4 Sprinkler System:

5.8.4.1 **A fire sprinkler system** is an active fire protection measure, consisting of a water supply system, with adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected.

Each closed-head sprinkler is held by either a heat-sensitive glass bulb or a two-part metal link held together with fusible alloy. The glass bulb or link, applies pressure to a pipe cap which acts as a plug. This prevents water from flowing, until the ambient temperature around the sprinkler reaches the designed activation temperature of the individual sprinkler head. Each sprinkler activates independently, when the predetermined heat level is reached. The number of sprinklers that operate are limited to only those near the fire, thereby 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.

5.8.5 Fire Extinguishers:

5.8.5.1 **General**

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

5.8.5.2 **Scope**

Types of Extinguishers:

i. Carbon-di-oxide of 4.5 kg.
ii. ABC Type 5Kg.
iii. Water Container 9 ltr. capacity.

These extinguishers shall be installed in the entire public, as well as service areas where the security is necessary. These appliances should be distributed, over the entire area, so that its users do not have to travel more than 15 m to reach the appliance. These appliances can be mounted or hanged on the wall at desired location.

5.8.5.3 **Description:**

Carbon Di Oxide (CO2) Fire Extinguishers

The cylinder filled with carbon dioxide (CO2), when operated extinguishes fire without any residue. Carbon-di-oxide Extinguishers are recommended, as these have inert gas with no residue, which is electrically non-conductive and ideal to be used over electronics and electric appliances.

5.8.5.4 **ABC Dry Powder - Fire Extinguishers**

ABC Extinguishers are proposed for Class ‘A’ fire. These extinguishers are portable & can be handled by anyone / common person. These when operated, protect against the fire to flammable material, such as wooden articles, curtains etc.

- Type ‘A’ extinguisher shall be used for ordinary combustible articles such as cloth, wood, paper.
- Type ‘B’ extinguisher shall be used for flammable liquid fires, such as oil, gasoline, paints, lacquers, grease, and solvents.
- Type ‘C’ extinguisher shall be used for electrical fires, such as wiring, fuse boxes, energized electrical equipments and other electrical sources.
- Type ‘D’ extinguisher shall be used for metal fires such as magnesium, titanium and sodium.

5.8.5.5 **Water Type Fire Extinguishers**

Water Type Fire Extinguishers are recommended for all Class “A” type of Fires where unskilled staff / personnel exist and can operate these without much difficulty.

5.8.5.6 **Glow Signs**

Different types of signs like Exit, Fire and Emergency shall be provided to ensure passengers guidance and safety. The signs can glow in the dark specially. Exit Fire and Emergency Signs help passengers to find exit and help fire fighters to locate emergency equipment.

5.8.6 Closed Circuit Television

5.8.6.1 **General**

The objective of CCTV System is to provide High degree of Electronic surveillance system to the entire premises. It is essential to have recorded images to be stored at least for 30 days of all critical area’s to facilitate investigations of reported cases. CCTV provision facilitates effective management.

Strategically placed video surveillance cameras help to enhance security by providing motion based / continuous monitoring of all corners / areas of premises.

CCTV monitoring shall cover the following areas:

i. Station Control Room (SCR)
ii. Station security services
iii. Platform Supervisor Booth
iv. Operational Control Centre and Traffic Controller (TC)
v. Depot controller (DC) in Depot.
vi. Escalator landing and inside elevators
vii. Evacuation routes
viii. Cash transfer routes at the station

5.8.6.2 **Description:**

CCTV comprises of the following components:

i. Integrated Port Camera (IP Cameras)
ii. Computer
iii. Software

5.8.6.3 **Integrated Port Cameras:**

For operation of IP Cameras, no external supply connection is needed. However, Power Over Ethernet (PoE) shall be attached to an Uninterruptible Power Supply (UPS) and sized to maintain camera operations. 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.

5.8.6.4 **Computer**

Images, when recorded by cameras, are transmitted to computer. When computer is on, images are displayed on its monitor instantly. These images are also stored in memory device.

Storing of images occurs automatically, even when computer is in off position.

5.8.6.5 **Software**

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

5.8.6.6 **Server Software:**

Software covers MS-SQL 2005, or better based Main Archive Server for audio and video, Main directory, Failover directory, Failover recording, Digital Virtual Matrix, Incident Reports, Alarm Management, Network Management System and Watchdog modules.

Server maintains a catalog of settings for all clients. It also encodes & decodes of stored information through I P cameras.

Software enables the client to dynamically create connections between Cameras and workstations and view live or recorded video on the digital monitors (Audio, video, serial ports and digital I/Os)

5.8.6.7 **Client Software:**

Client software includes of Administrator Tool application, Monitoring application, Archive Player application, Sync archive player application, Map creation application etc. All the relevant software licenses work on concurrent basis and no restriction of its use for specific work station is classified.

Client software performs the following applications simultaneously without interfering with any of the Archive Server operations (Recording, Alarms, etc.):

- Live display of cameras and audio
- Live display of camera sequences, panoramic camera views.
- Playback of archived video
- Instant replays of Video and Audio
- Display and control of Maps
- Audio announcements
- Alarm management

Client application provides, management and control over the system, using a standard PC mouse, keyboard or CCTV keyboard. Standard scroll mouse moves the camera by merely clicking on the extremes of the picture, in all directions and zoom function by scroll button, to avoid the use of joystick keyboard while maintaining easiness of the control.

Client application is to control pan-tilt-zoom, iris, focus, presets and dome patterns of the PTZ camera for correct functioning of the system.

Software provides utility to play multiple exported clips simultaneously. It also provides the ability to play multiple clips in time sync with each other to understand the sequence of events occurred during an emergency.

5.8.6.8 Security in general has gained great importance during the last few years. It is a prime concern at the stations due to the large number of commuters who congregate there daily. Any short coming or lapse at the stations can cause a disaster. Security arrangement has been catered for at the stations and in the coaches. Cost of the same is included in the estimate.

The estimate for security may, however, need revision after level and quantum of security to be provided are known in greater detail.

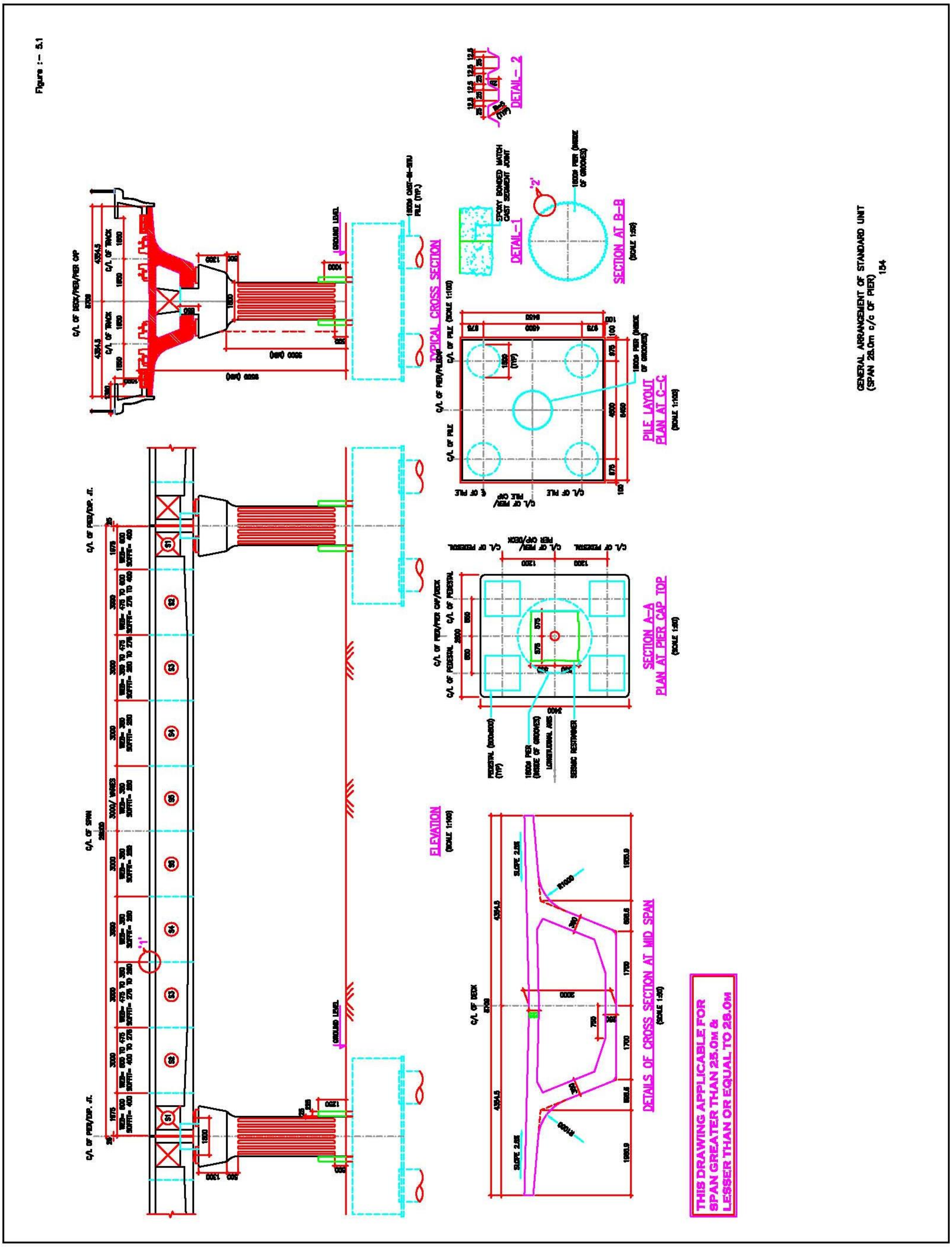
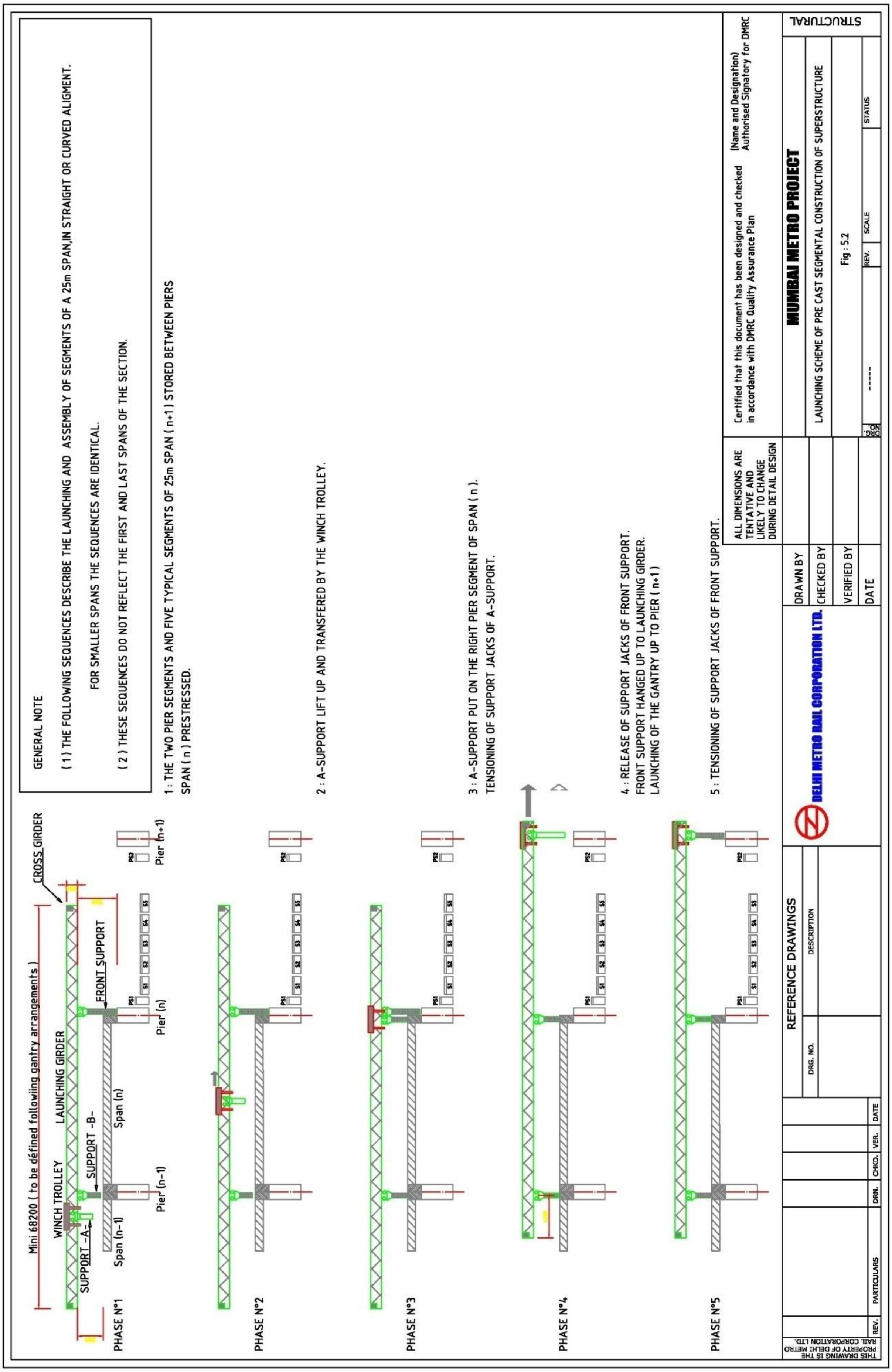


Figure :- 5.1
TYPICAL CROSS SECTION
ELEVATION
DETAIL-1
DETAIL-2
SECTION AT B-B
PILE LAYOUT PLAN AT C-C
SECTION A-A PLAN AT PIER CAP TOP
DETAILS OF CROSS SECTION AT MID SPAN
THIS DRAWING APPLICABLE FOR SPAN GREATER THAN 25.0M & LESSER THAN OR EQUAL TO 28.0M
GENERAL ARRANGEMENT OF STANDARD UNIT (SPAN 28.0m c/c OF PIER)


GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
1 : THE TWO PIER SEGMENTS AND FIVE TYPICAL SEGMENTS OF 25m SPAN (n+1) STORED BETWEEN PIERS
SPAN (n) PRESTRESSED.
2 : A-SUPPORT LIFT UP AND TRANSFERED BY THE WINCH TROLLEY.
3 : A-SUPPORT PUT ON THE RIGHT PIER SEGMENT OF SPAN (n).
TENSIONING OF SUPPORT JACKS OF A-SUPPORT.
4 : RELEASE OF SUPPORT JACKS OF FRONT SUPPORT.
FRONT SUPPORT HANGED UP TO LAUNCHING GIRDER.
LAUNCHING OF THE GANTRY UP TO PIER (n+1)
5 : TENSIONING OF SUPPORT JACKS OF FRONT SUPPORT.
Mini 68200 (to be defined followiing gantry arrangements)
CROSS GIRDER
WINCH TROLLEY
LAUNCHING GIRDER
FRONT SUPPORT
SUPPORT -B-
SUPPORT -A-
Span (n-1)
Span (n)
Pier (n-1)
Pier (n)
Pier (n+1)
PS1
PS2
S1
S2
S3
S4
S5
PHASE N°1
PHASE N°2
PHASE N°3
PHASE N°4
PHASE N°5
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MUMBAI METRO PROJECT
LAUNCHING SCHEME OF PRE CAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE
Fig : 5.2
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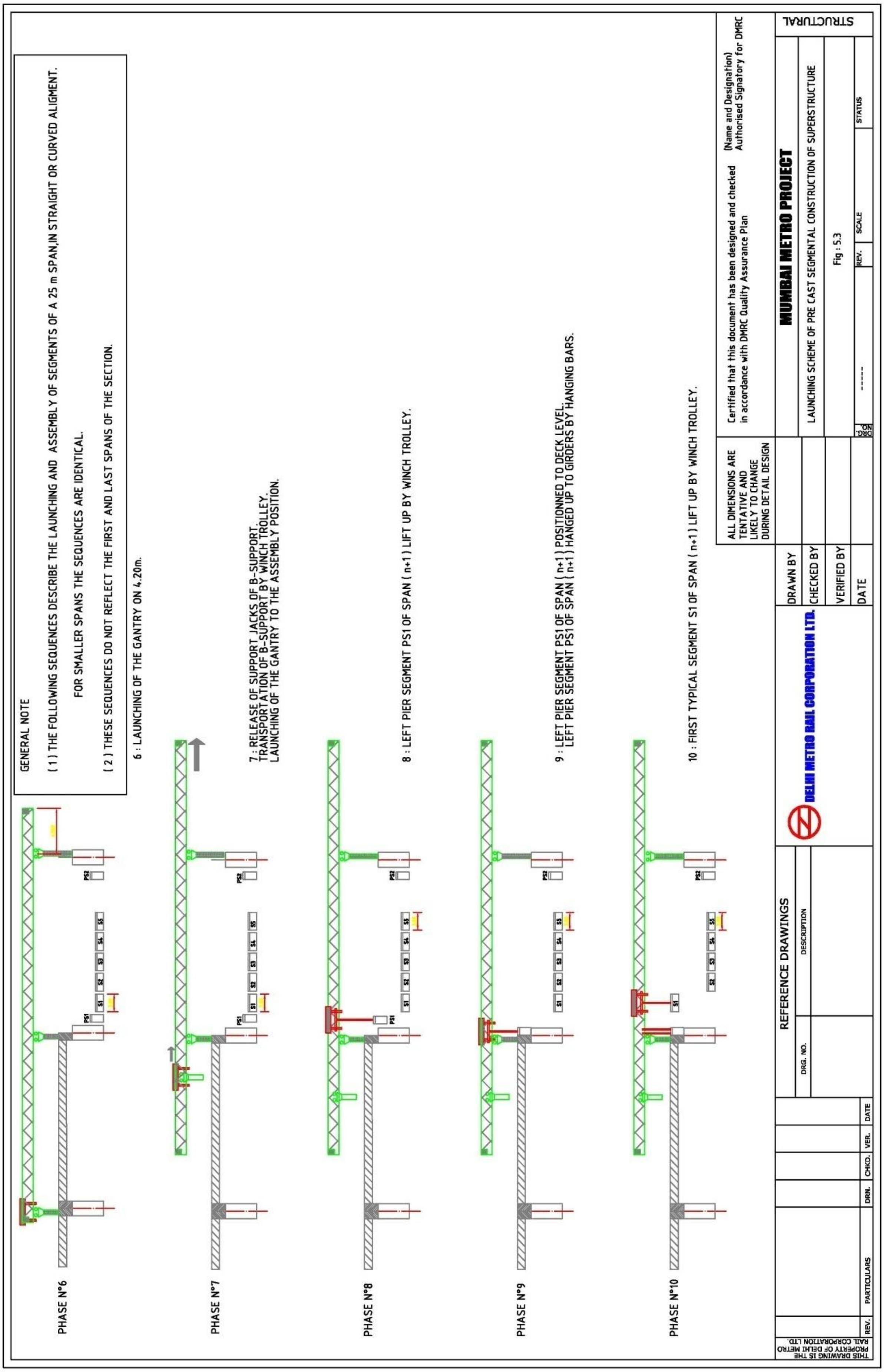
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(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
6 : LAUNCHING OF THE GANTRY ON 4.20m.
7 : RELEASE OF SUPPORT JACKS OF B-SUPPORT.
TRANSPORTATION OF B-SUPPORT BY WINCH TROLLEY.
LAUNCHING OF THE GANTRY TO THE ASSEMBLY POSITION.
8 : LEFT PIER SEGMENT PS1 OF SPAN (n+1) LIFT UP BY WINCH TROLLEY.
9 : LEFT PIER SEGMENT PS1 OF SPAN (n+1) POSITIONNED TO DECK LEVEL.
LEFT PIER SEGMENT PS1 OF SPAN (n+1) HANGED UP TO GIRDERS BY HANGING BARS.
10 : FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) LIFT UP BY WINCH TROLLEY.
PHASE N°6
PHASE N°7
PHASE N°8
PHASE N°9
PHASE N°10
PS1
PS2
S1
S2
S3
S4
S5
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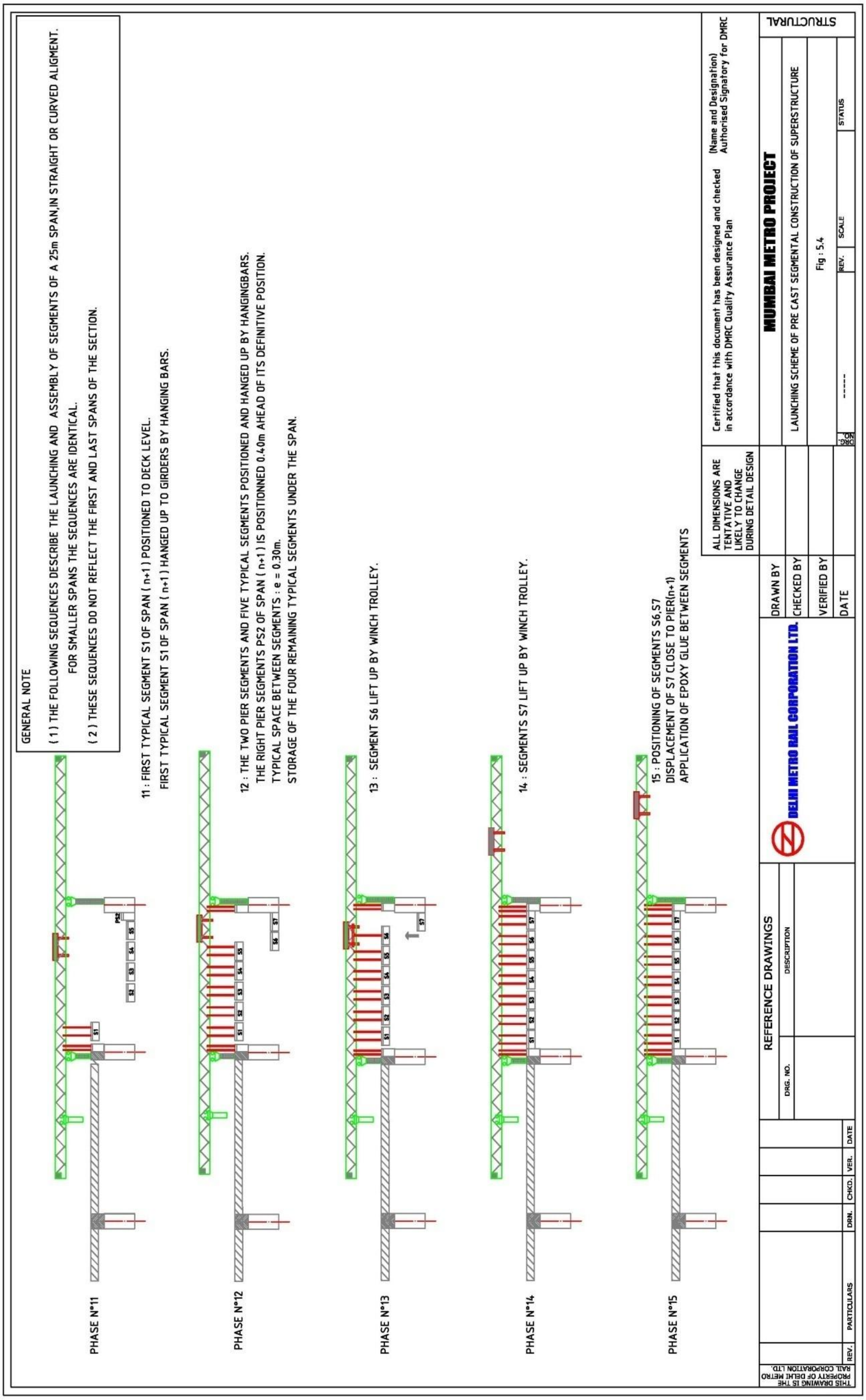
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FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
PHASE N°11
11 : FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) POSITIONED TO DECK LEVEL.
FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) HANGED UP TO GIRDERS BY HANGING BARS.
PHASE N°12
12 : THE TWO PIER SEGMENTS AND FIVE TYPICAL SEGMENTS POSITIONED AND HANGED UP BY HANGINGBARS.
THE RIGHT PIER SEGMENTS PS2 OF SPAN (n+1) IS POSITIONNED 0.40m AHEAD OF ITS DEFINITIVE POSITION.
TYPICAL SPACE BETWEEN SEGMENTS : e = 0.30m.
STORAGE OF THE FOUR REMAINING TYPICAL SEGMENTS UNDER THE SPAN.
PHASE N°13
13 : SEGMENT S6 LIFT UP BY WINCH TROLLEY.
PHASE N°14
14 : SEGMENTS S7 LIFT UP BY WINCH TROLLEY.
PHASE N°15
15 : POSITIONING OF SEGMENTS S6,S7
DISPLACEMENT OF S7 CLOSE TO PIER(n+1)
APPLICATION OF EPOXY GLUE BETWEEN SEGMENTS
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LAUNCHING SCHEME OF PRE CAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE
Fig : 5.4
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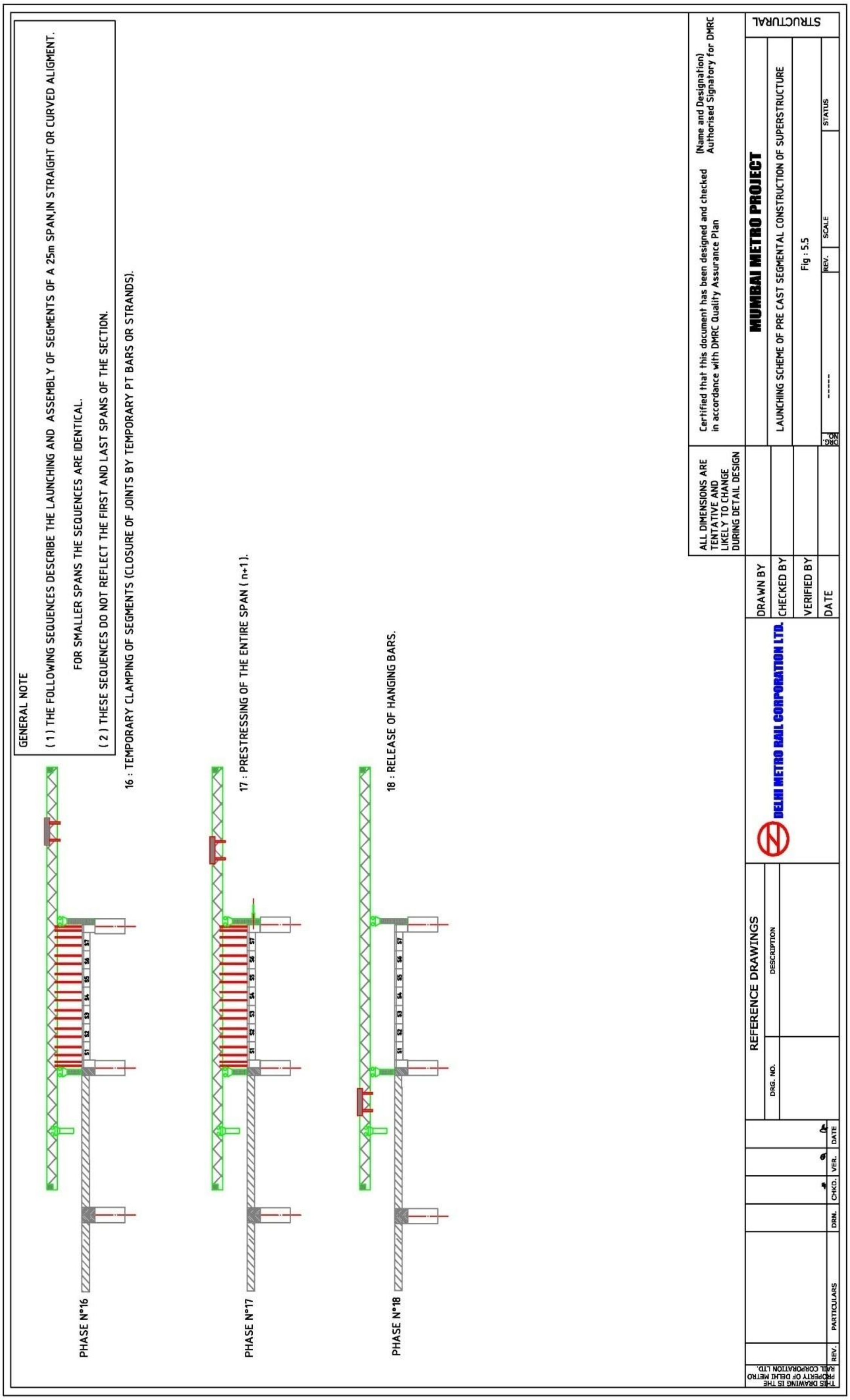
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(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
16 : TEMPORARY CLAMPING OF SEGMENTS (CLOSURE OF JOINTS BY TEMPORARY PT BARS OR STRANDS).
17 : PRESTRESSING OF THE ENTIRE SPAN (n+1).
18 : RELEASE OF HANGING BARS.
PHASE N°16
PHASE N°17
PHASE N°18
S1 S2 S3 S4 S5 S6 S7
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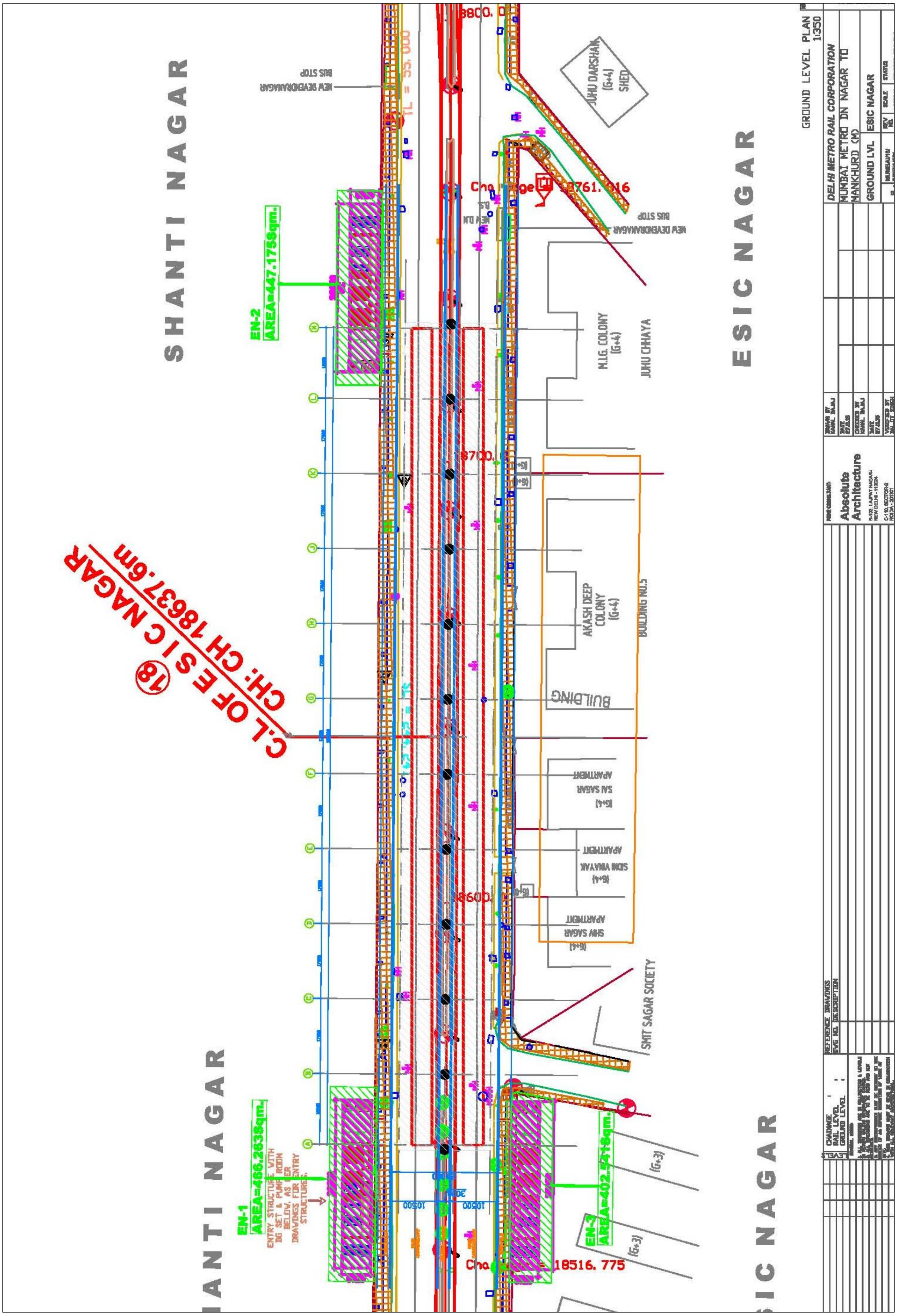
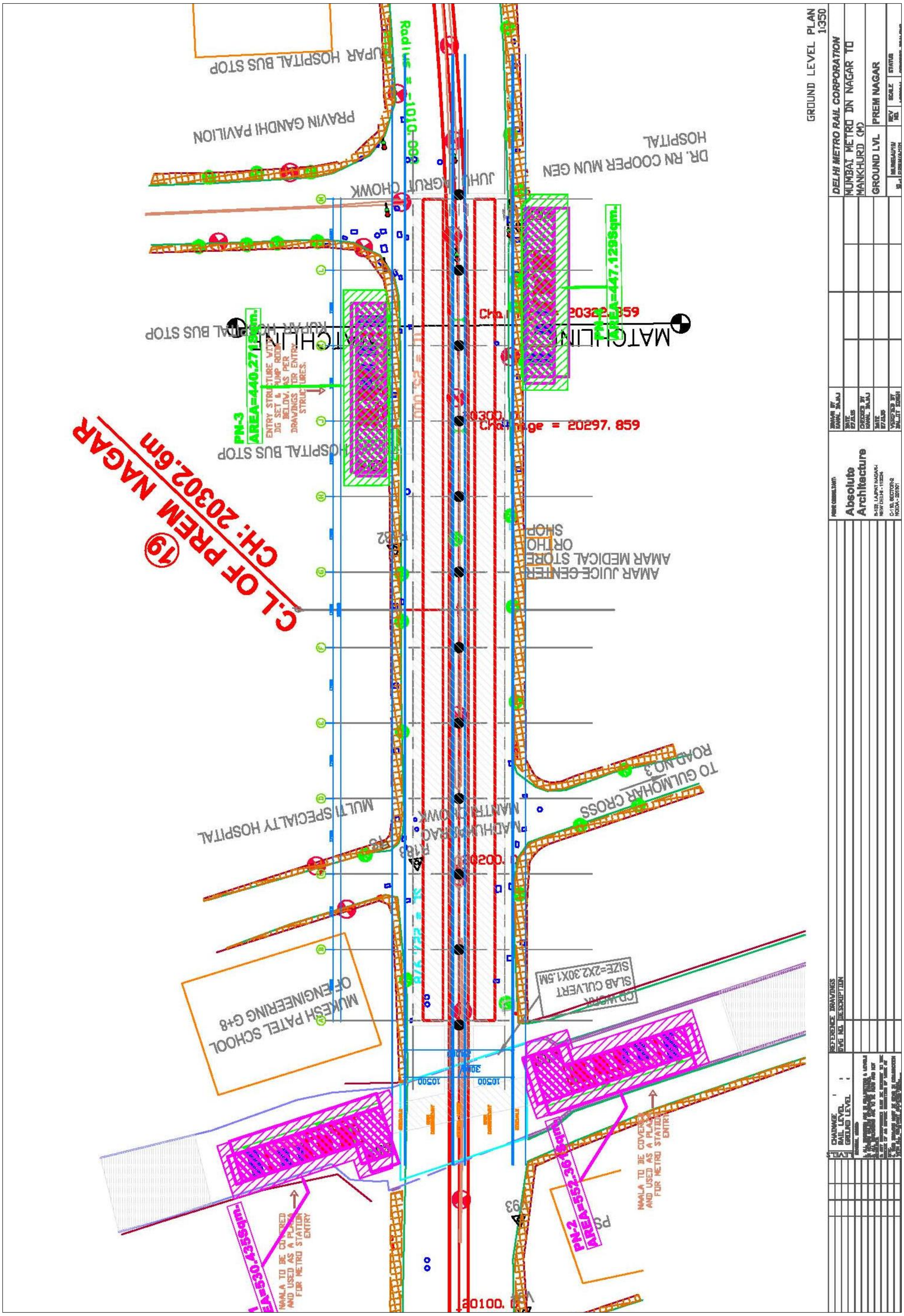
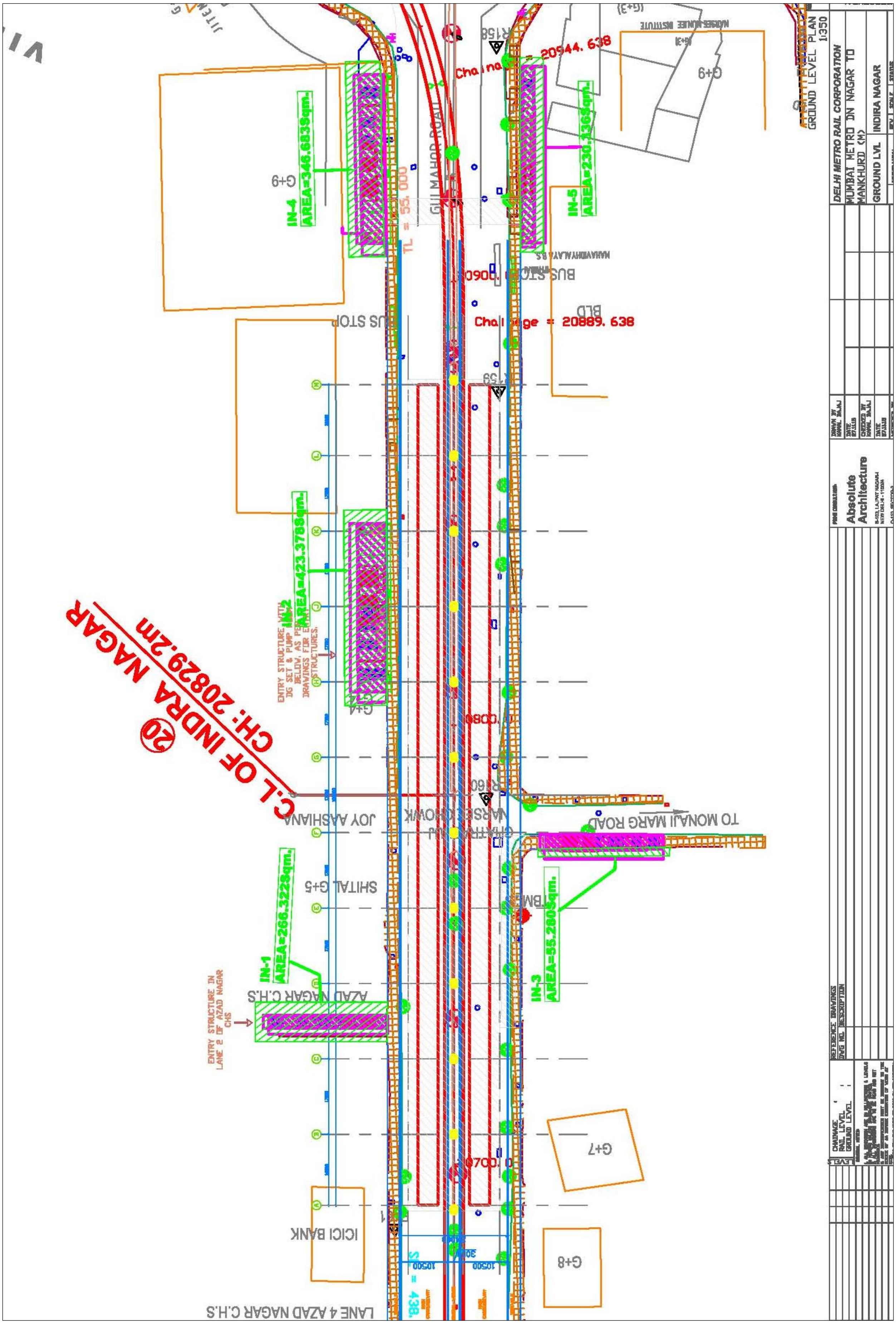
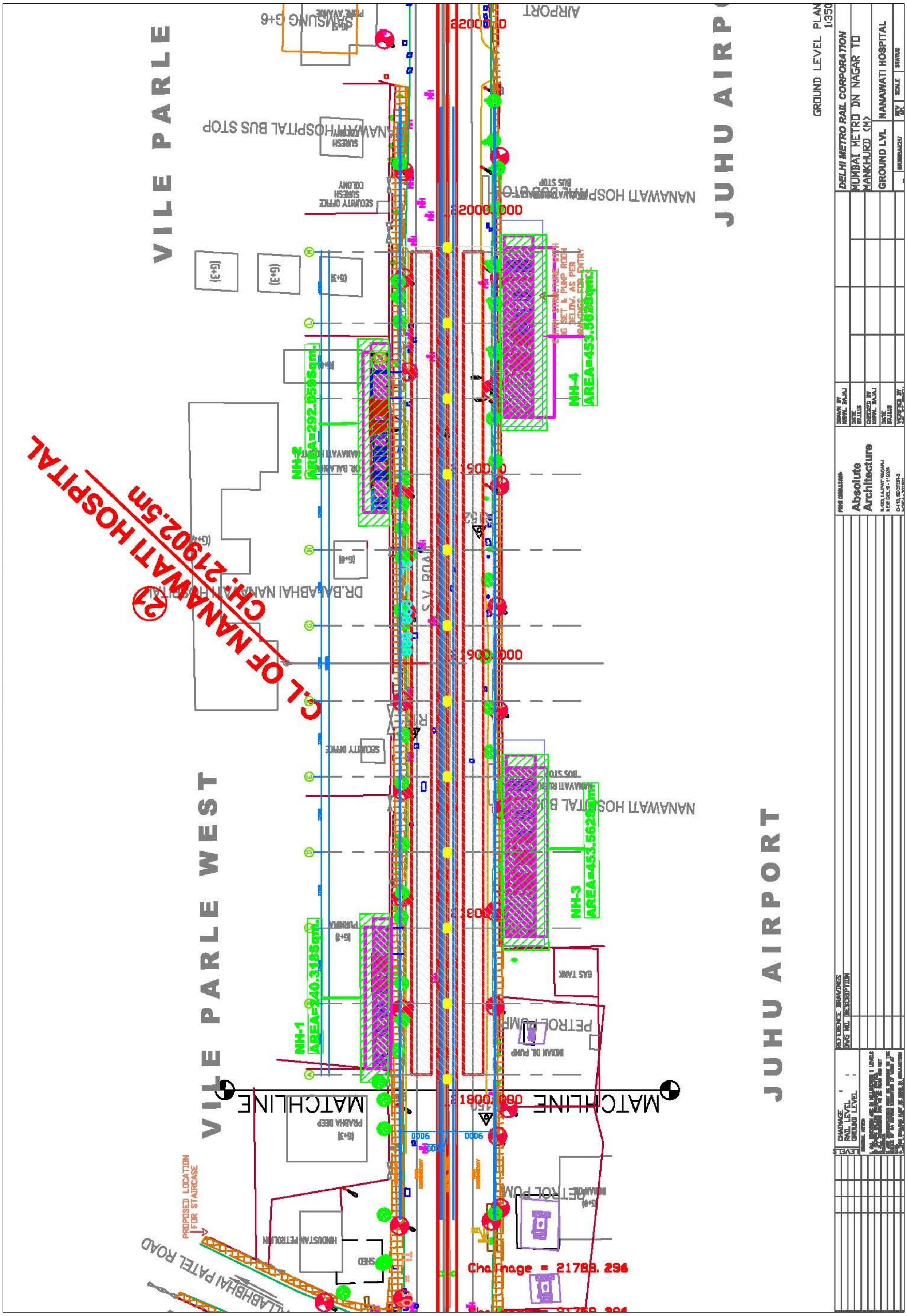
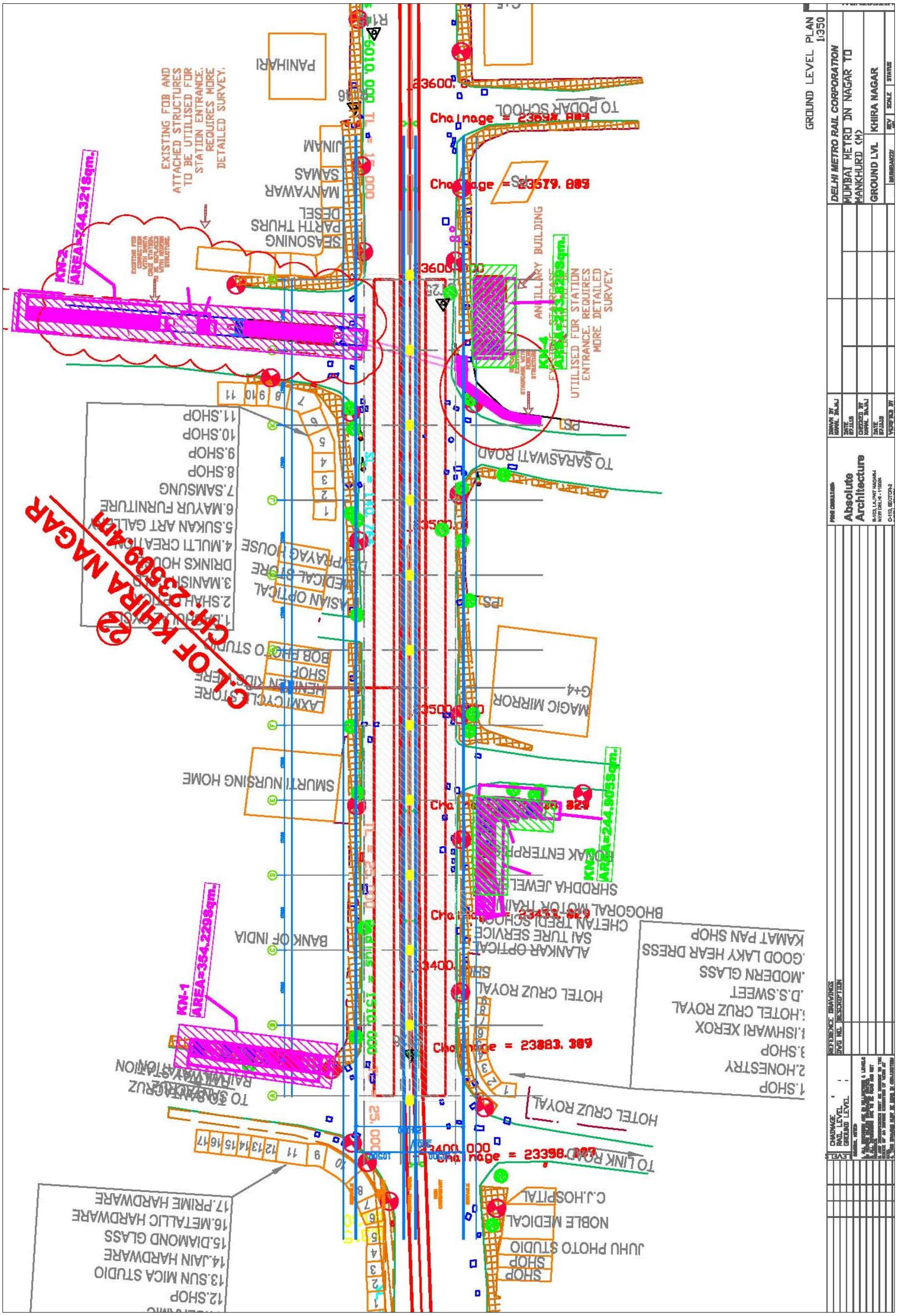

SHANTI NAGAR
ESIC NAGAR
C.L. OF E S I C NAGAR
CH: CH 18637.6m
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
AKASH DEEP COLONY
SMIT SAGAR SOCIETY
Absolute Architecture

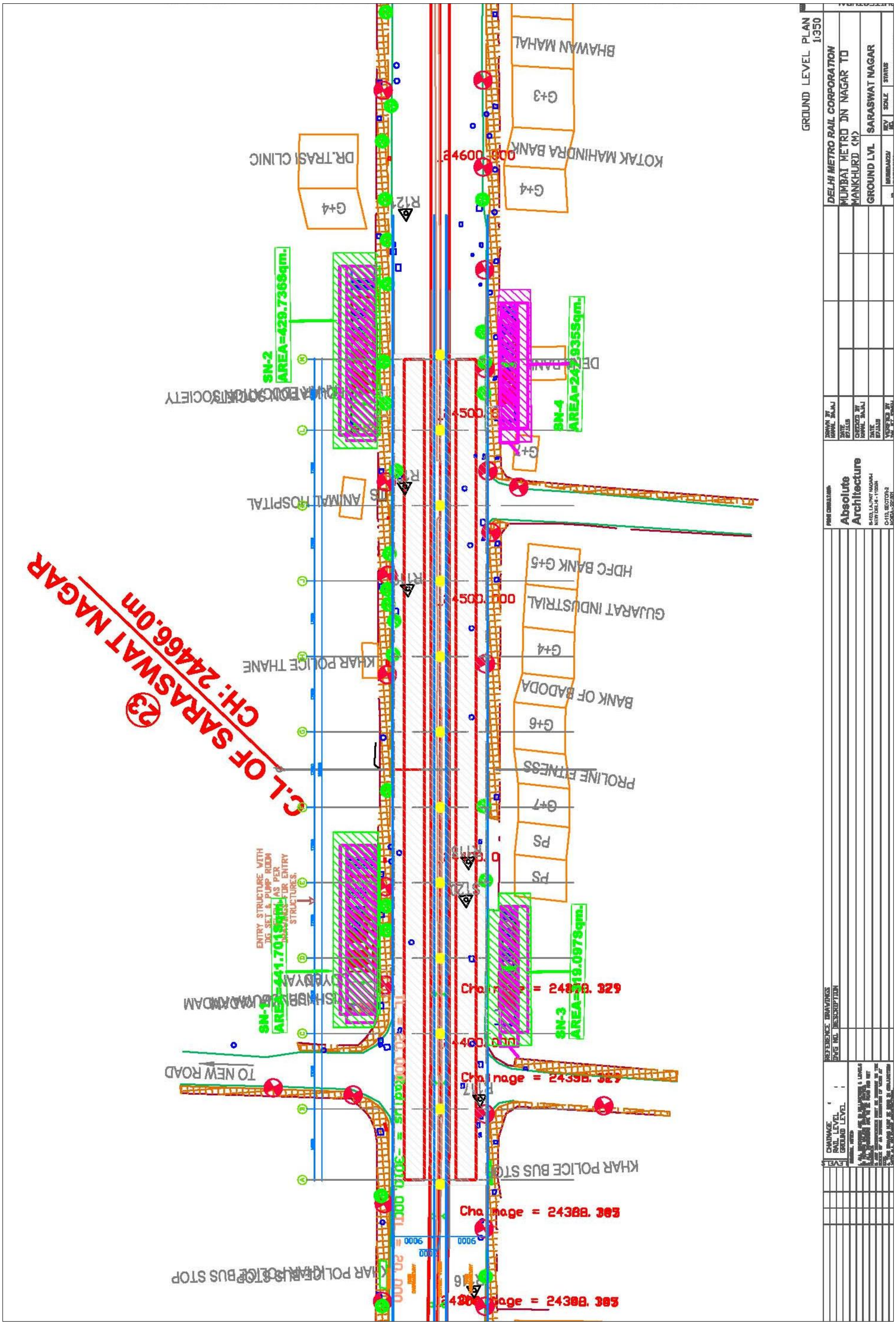


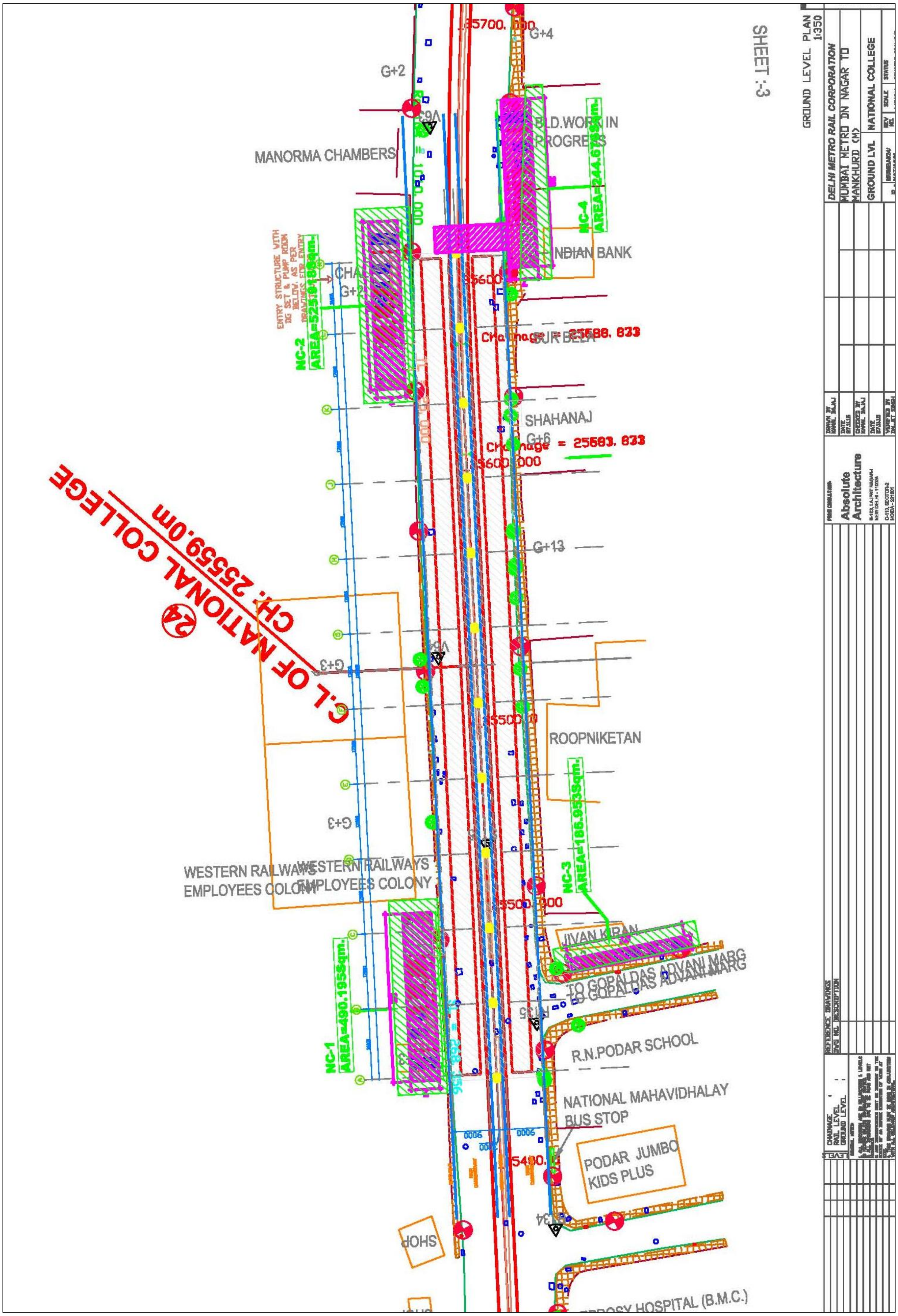
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL PREM NAGAR
Absolute Architecture
C.L OF PREM NAGAR
CH: 20302.6m
19
MATCHLINE
Chainage = 20297.859
SLAB CULVERT SIZE=2X2.30X1.5M

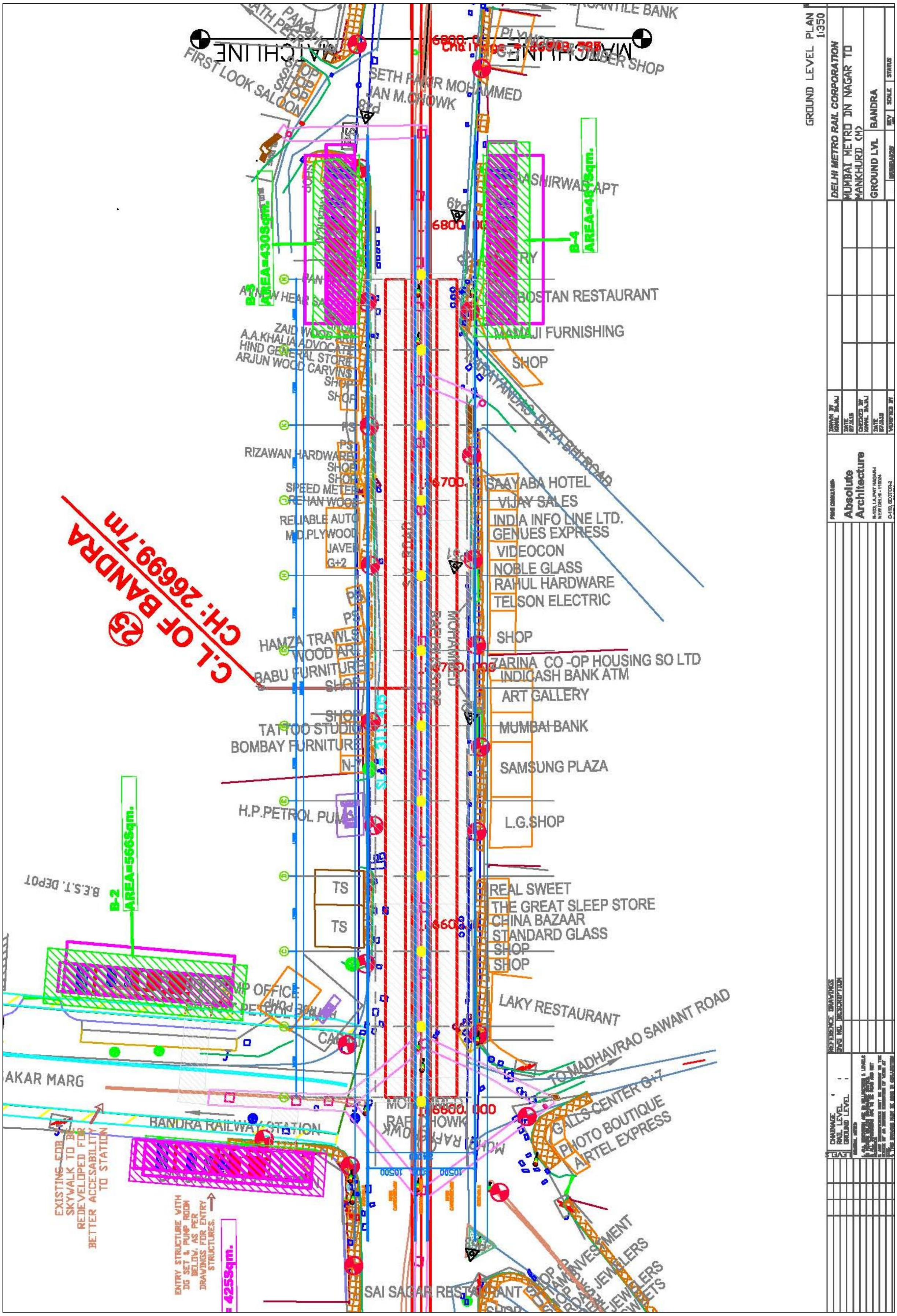

C.L OF INDRA NAGAR
CH: 20829.2m
20
Chainage = 20889. 638
Chainage = 20944. 638
IN-1
AREA=266.3225sqm.
IN-2
AREA=423.3788sqm.
IN-3
AREA=55.2805sqm.
IN-4
AREA=346.6835sqm.
IN-5
AREA=230.1365sqm.
ENTRY STRUCTURE WITH DG SET & PUMP. BELOW, AS PER DRAWINGS FOR ENTRY STRUCTURES.
ENTRY STRUCTURE IN LANE 2 OF AZAD NAGAR CHS
GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
INDIRA NAGAR
Absolute Architecture
TO MONAJI MARG ROAD
ICICI BANK
LANE 4 AZAD NAGAR C.H.S
AZAD NAGAR C.H.S
SHITAL G+5
JOY AASHIANA
BUS STOP
G+9
G+7
G+8

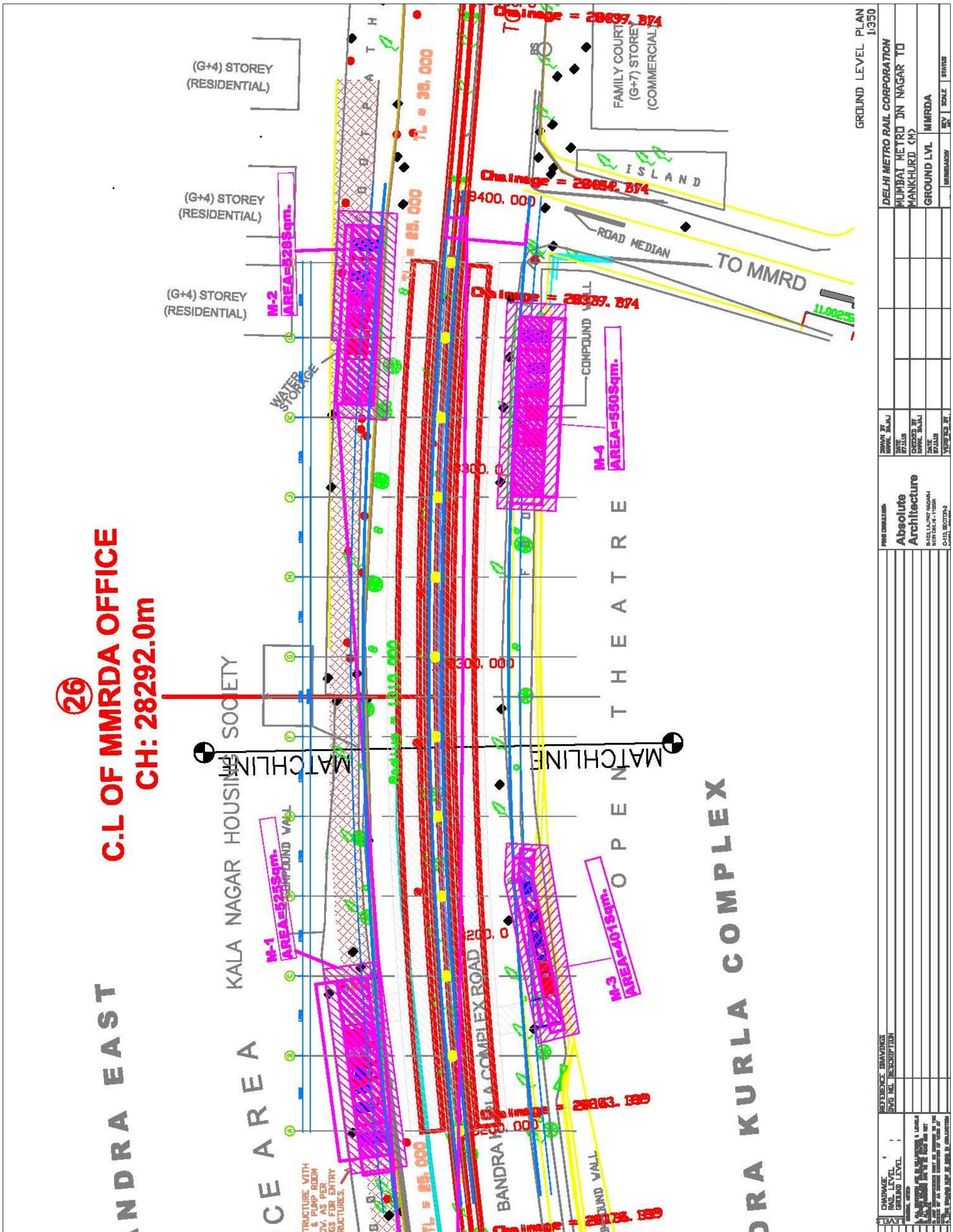

VILE PARLE
VILE PARLE WEST
JUHU AIRPORT
C.L OF NANAWATI HOSPITAL
CH: 21902.5m
MATCHLINE
S.V. ROAD
NH-1
NH-2
NH-3
NH-4
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL NANAWATI HOSPITAL
Absolute Architecture


GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL KHIRA NAGAR
Absolute Architecture
C.L OF KHIRA NAGAR
CH: 23509.4m
EXISTING FOB AND ATTACHED STRUCTURES TO BE UTILISED FOR STATION ENTRANCE. REQUIRES MORE DETAILED SURVEY.
KN-1
AREA=354.229Sqm.
KN-2
AREA=744.321Sqm.
KN-3
AREA=244.905Sqm.
KN-4

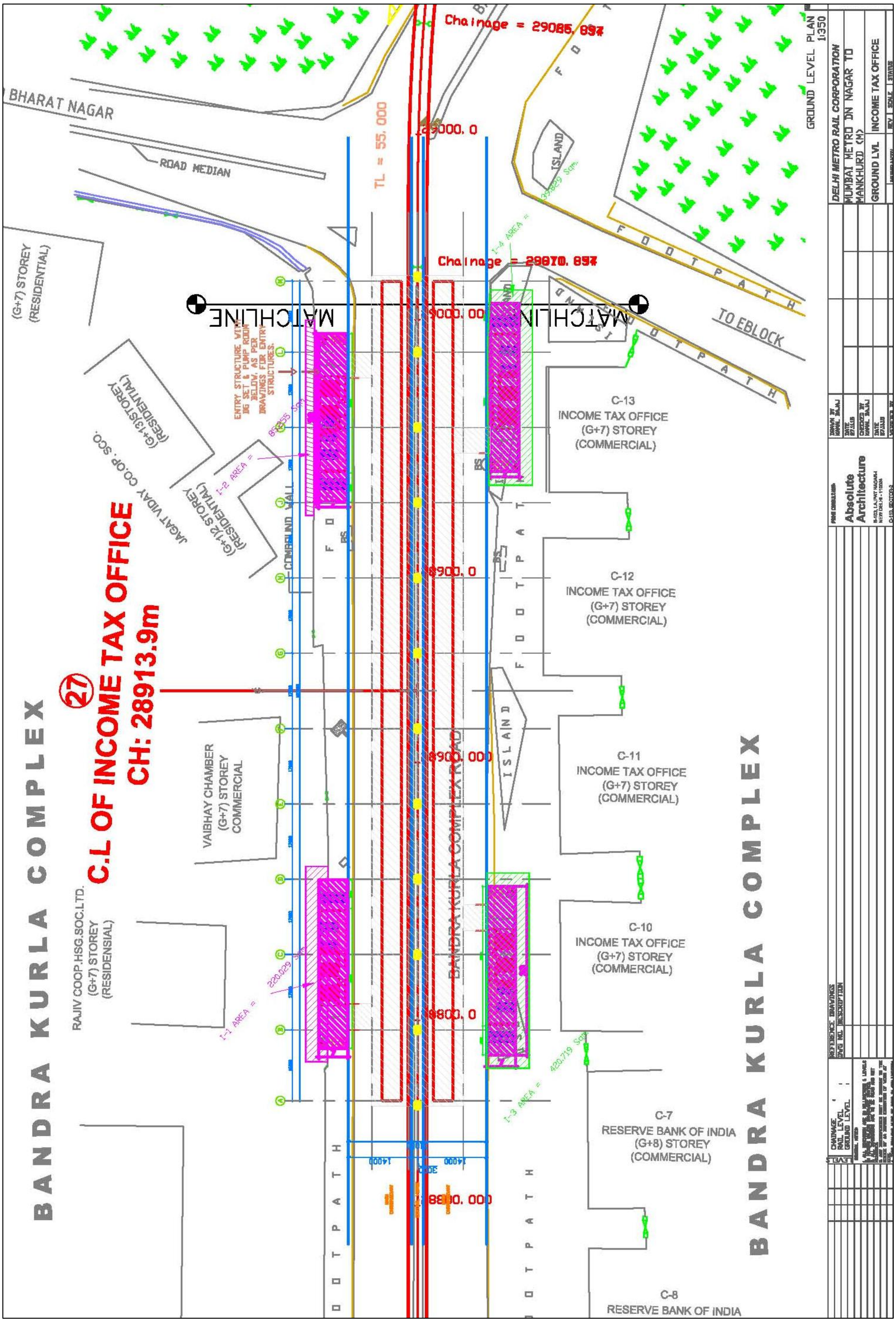

C.L OF SARASWAT NAGAR
CH: 24466.0m
23
GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL SARASWAT NAGAR
Absolute Architecture
BHAWAN MAHAL
KOTAK MAHINDRA BANK
DR.TRASI CLINIC
ANIMAL HOSPITAL
HDFC BANK G+5
GUJARAT INDUSTRIAL
KHAR POLICE THANE
BANK OF BADODA
PROLINE FITNESS
TO NEW ROAD
KHAR POLICE BUS STOP
SN-1
SN-2
SN-3
SN-4
AREA=420.7365sqm.
Chainage = 24388.385

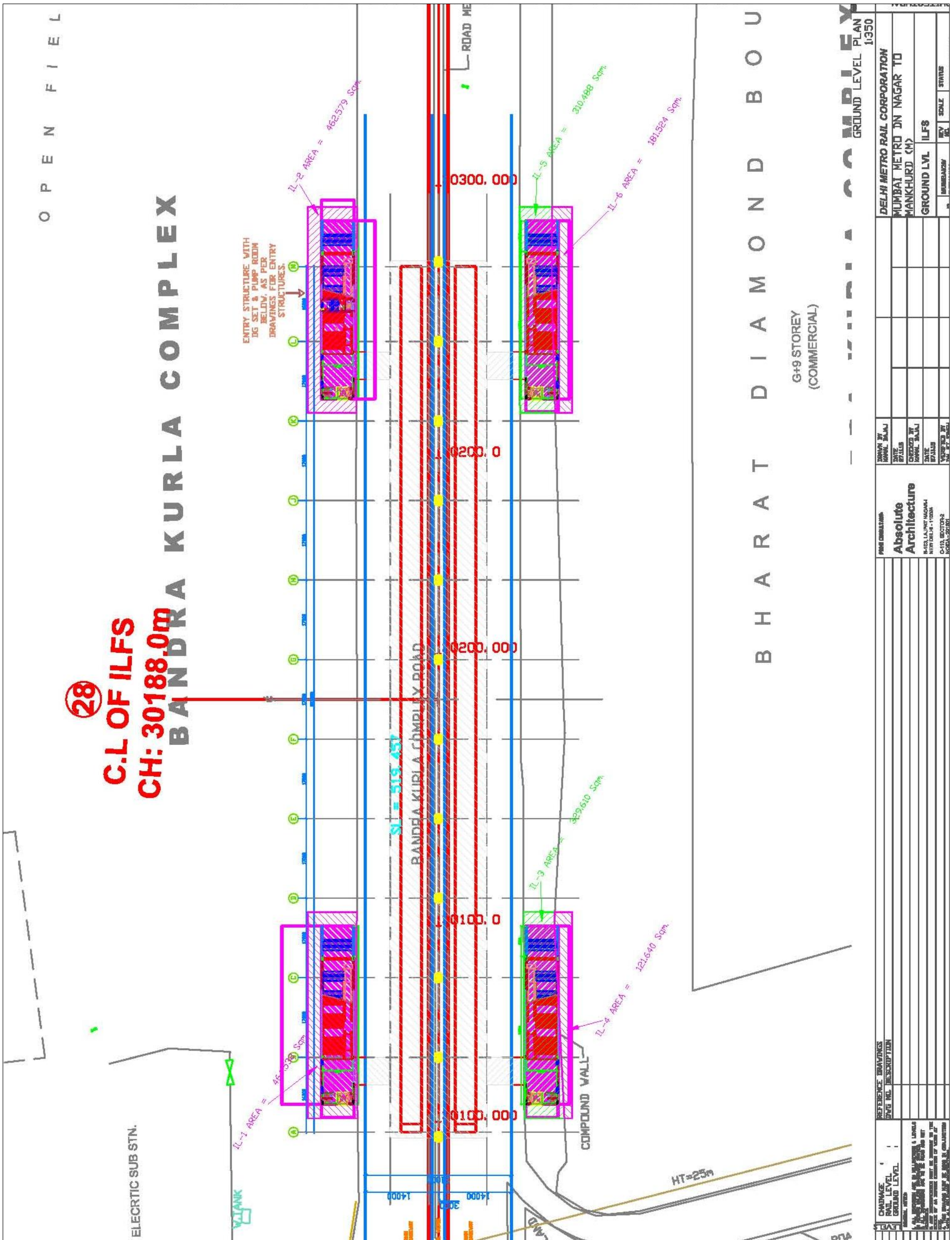

SHEET :-3
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL NATIONAL COLLEGE
Absolute Architecture
C.L OF NATIONAL COLLEGE
CH: 25559.0m
24
MANORMA CHAMBERS
BLD.WORK IN PROGRESS
INDIAN BANK
NC-4
NC-2
NC-3
NC-1
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW. AS PER DRAWINGS FOR ENTRY
Chainage = 25588.833
Chainage = 25583.833
SHAHANAJ
G+6
G+13
G+2
G+4
G+3
ROOPNIKETAN
WESTERN RAILWAYS EMPLOYEES COLONY
JIVAN KIRAN
TO GOPALDAS ADVANI MARG
R.N.PODAR SCHOOL
NATIONAL MAHAVIDHALAY BUS STOP
PODAR JUMBO KIDS PLUS
SHOP
HOSPITAL (B.M.C.)

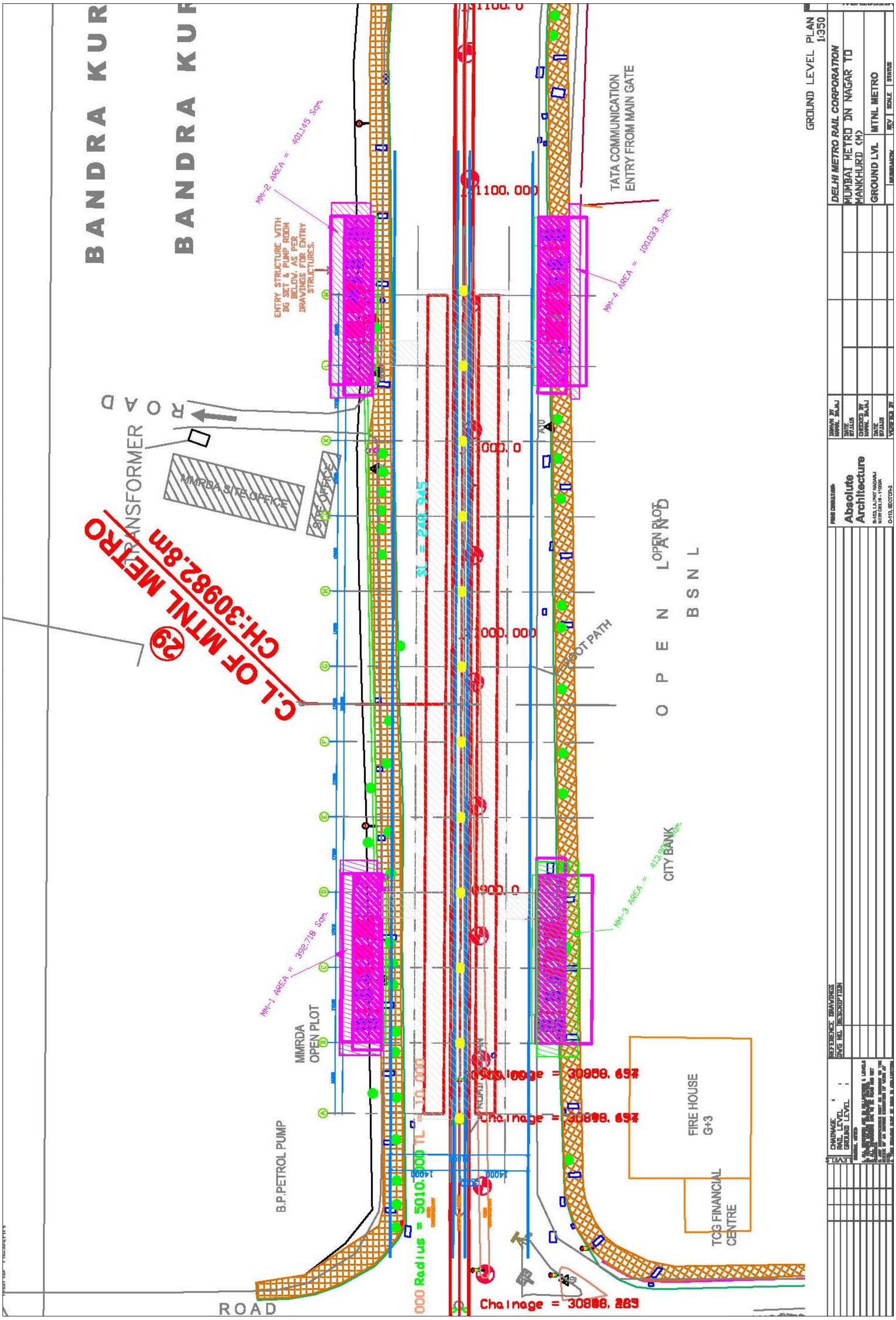


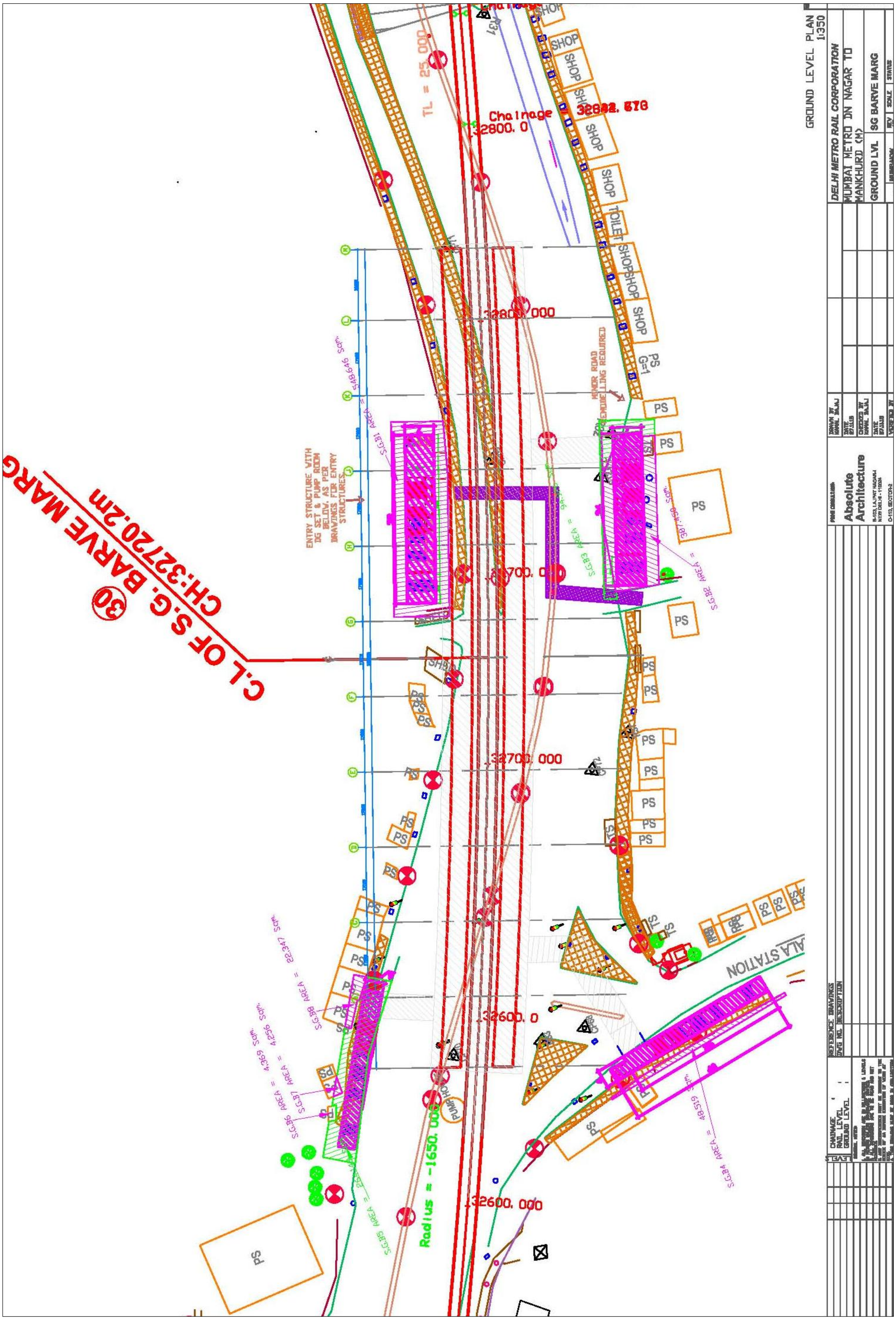


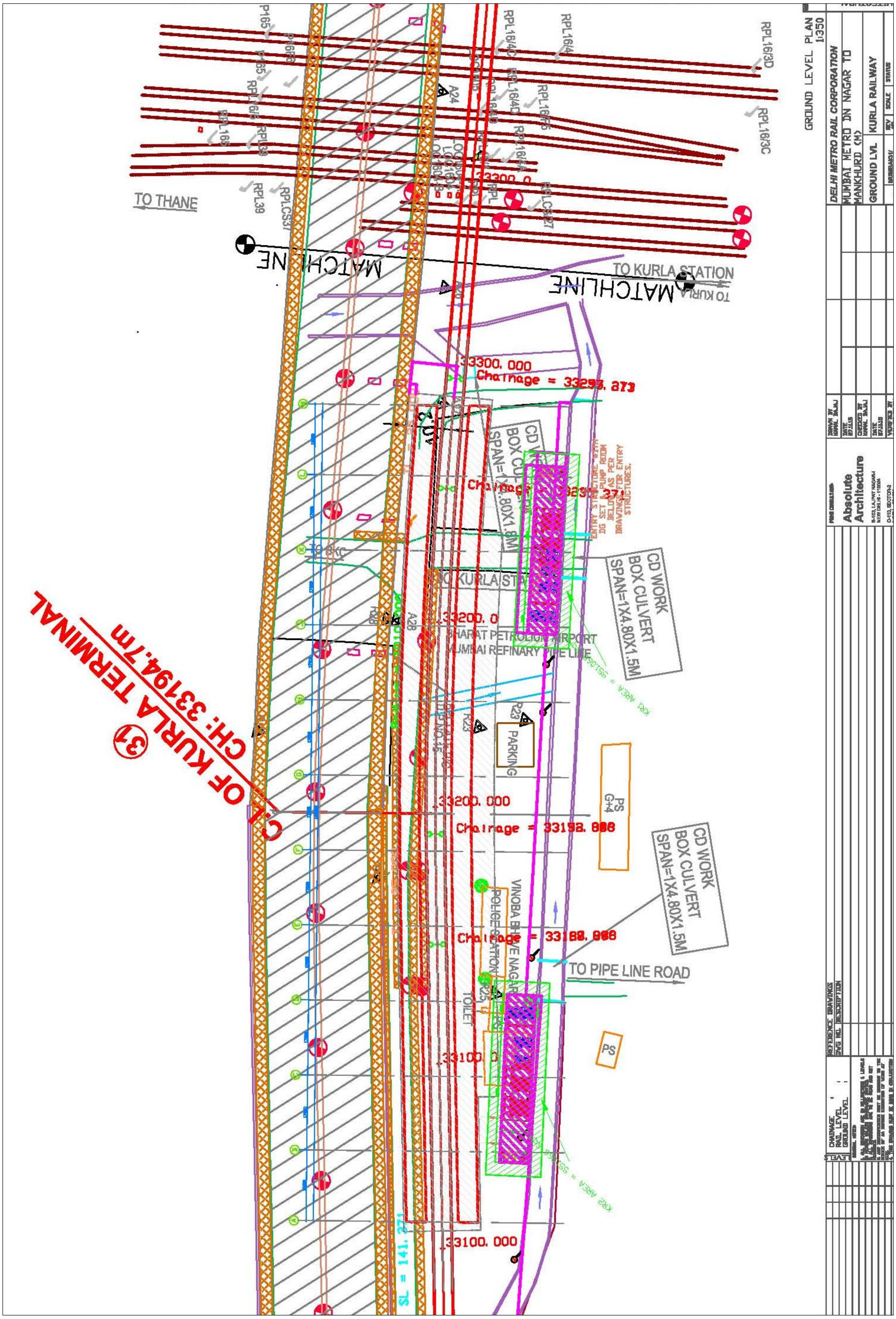
26
C.L OF MMRDA OFFICE
CH: 28292.0m
BANDRA EAST
BANDRA KURLA COMPLEX
KALA NAGAR HOUSING SOCIETY
OPEN THEATRE
MATCHLINE
MATCHLINE
TO MMRD
ROAD MEDIAN
ISLAND
(G+4) STOREY (RESIDENTIAL)
(G+4) STOREY (RESIDENTIAL)
(G+4) STOREY (RESIDENTIAL)
FAMILY COURT (G+7) STOREY (COMMERCIAL)
WATER STORAGE
COMPOUND WALL
COMPOUND WALL
M-1 AREA=525Sqm.
M-2 AREA=528Sqm.
M-3 AREA=401Sqm.
M-4 AREA=550Sqm.
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW, AS PER DRAWINGS FOR ENTRY STRUCTURES.
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL.
MMRDA
Absolute Architecture

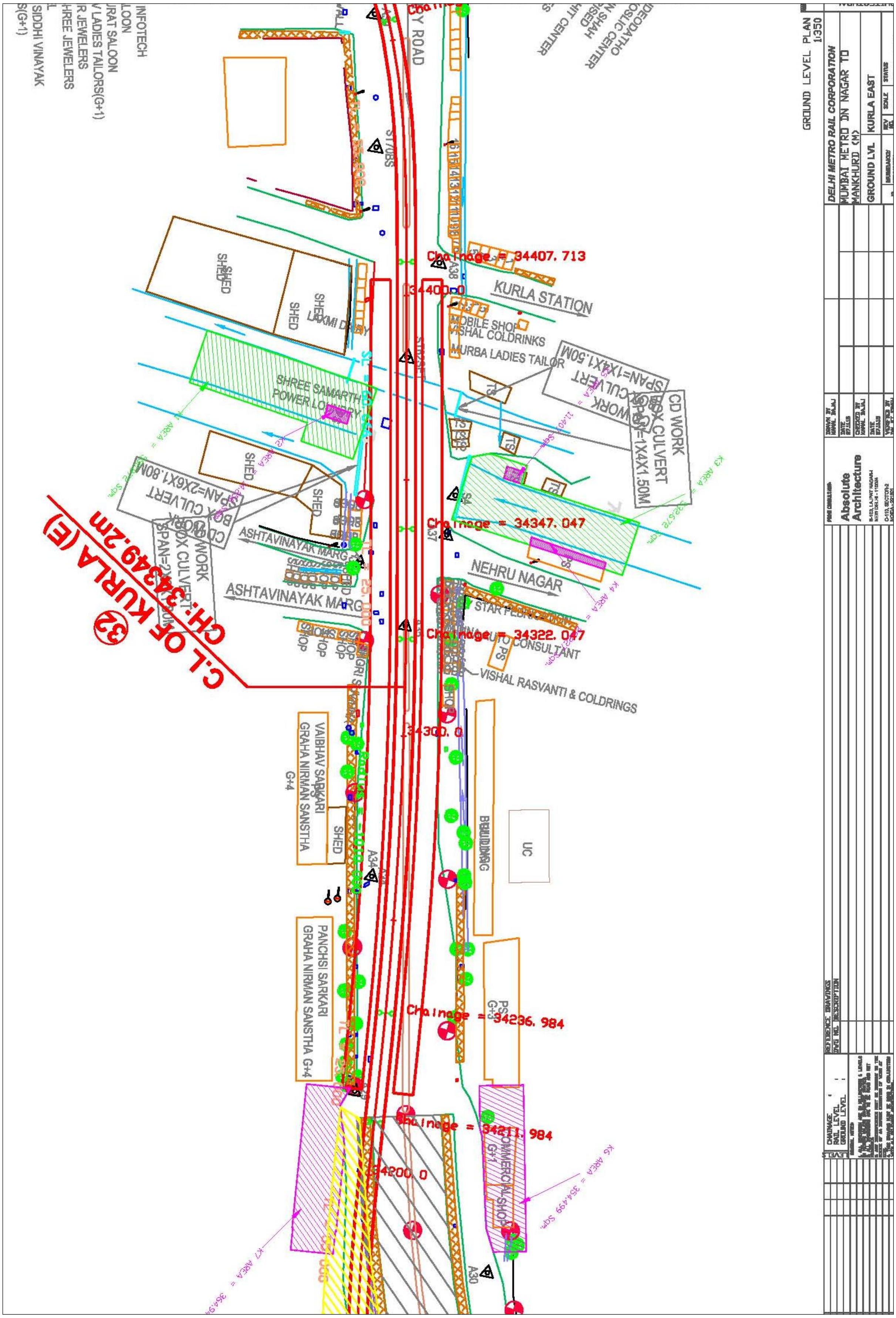

Chainage = 29085.897
Chainage = 28970.897
BHARAT NAGAR
ROAD MEDIAN
TL = 55.000
ISLAND
TO EBLOCK
FOOTPATH
MATCHLINE
(G+7) STOREY (RESIDENTIAL)
(G+13)STOREY (RESIDENTIAL)
(G+12 STOREY (RESIDENTIAL)
JAGAT VIDAY CO.OP. SCO.
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW. AS PER DRAWINGS FOR ENTRY STRUCTURES.
C-13
INCOME TAX OFFICE
(G+7) STOREY
(COMMERCIAL)
C-12
INCOME TAX OFFICE
(G+7) STOREY
(COMMERCIAL)
C-11
INCOME TAX OFFICE
(G+7) STOREY
(COMMERCIAL)
C-10
INCOME TAX OFFICE
(G+7) STOREY
(COMMERCIAL)
C-7
RESERVE BANK OF INDIA
(G+8) STOREY
(COMMERCIAL)
C-8
RESERVE BANK OF INDIA
27
C.L OF INCOME TAX OFFICE
CH: 28913.9m
VAIBHAY CHAMBER
(G+7) STOREY
COMMERCIAL
RAJIV COOP.HSG.SOC.LTD.
(G+7) STOREY
(RESIDENSIAL)
BANDRA KURLA COMPLEX ROAD
BANDRA KURLA COMPLEX
BANDRA KURLA COMPLEX
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL INCOME TAX OFFICE
Absolute Architecture

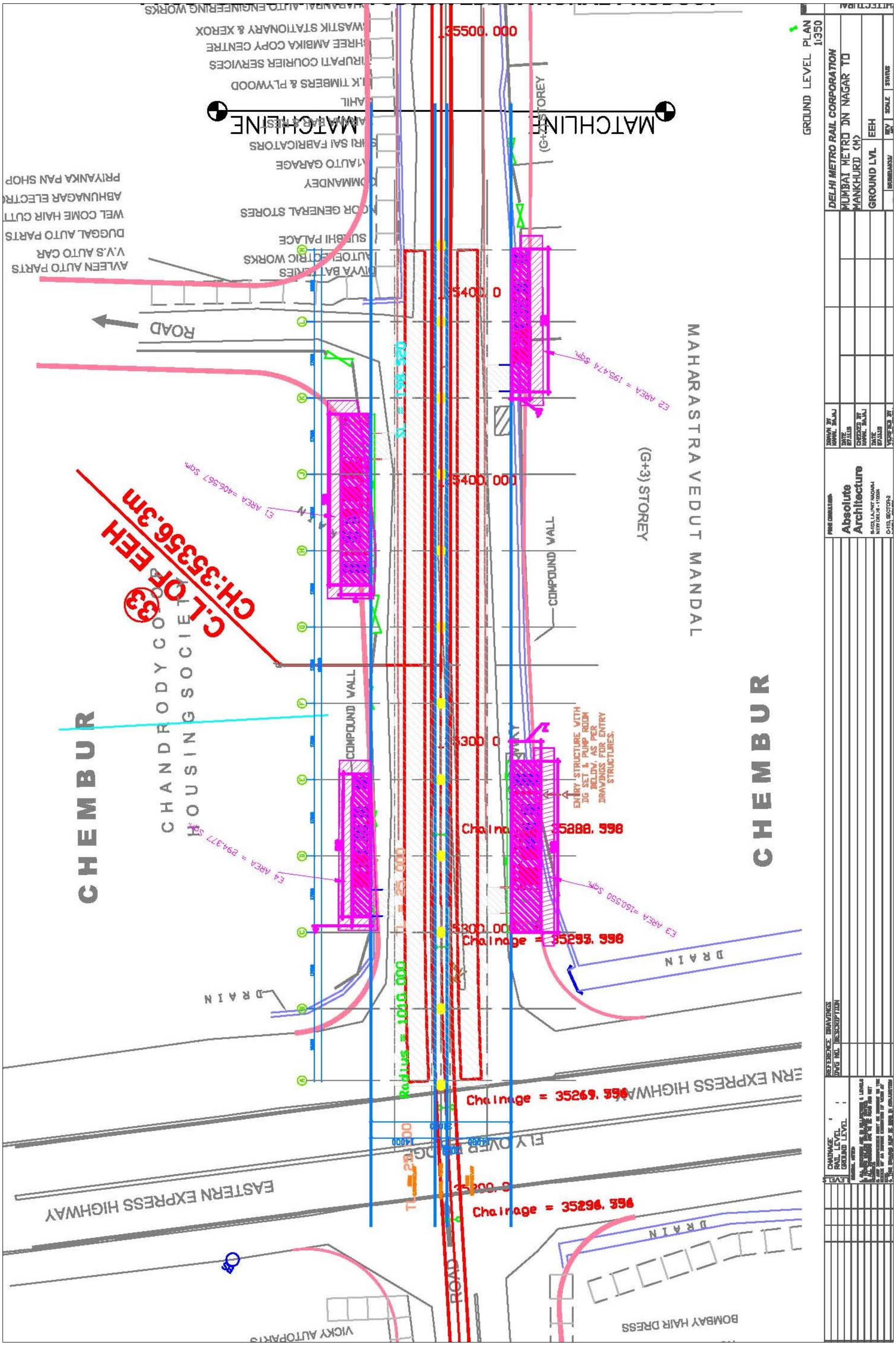

C.L OF ILFS
CH: 30188.0m
BANDRA KURLA COMPLEX
BANDRA KURLA COMPLEX ROAD
G+9 STOREY
(COMMERCIAL)
ELECTRIC SUB STN.
COMPOUND WALL
HIGHTANTION LINE
HT=25m
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW. AS PER DRAWINGS FOR ENTRY STRUCTURES.
GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
ILFS
Absolute Architecture

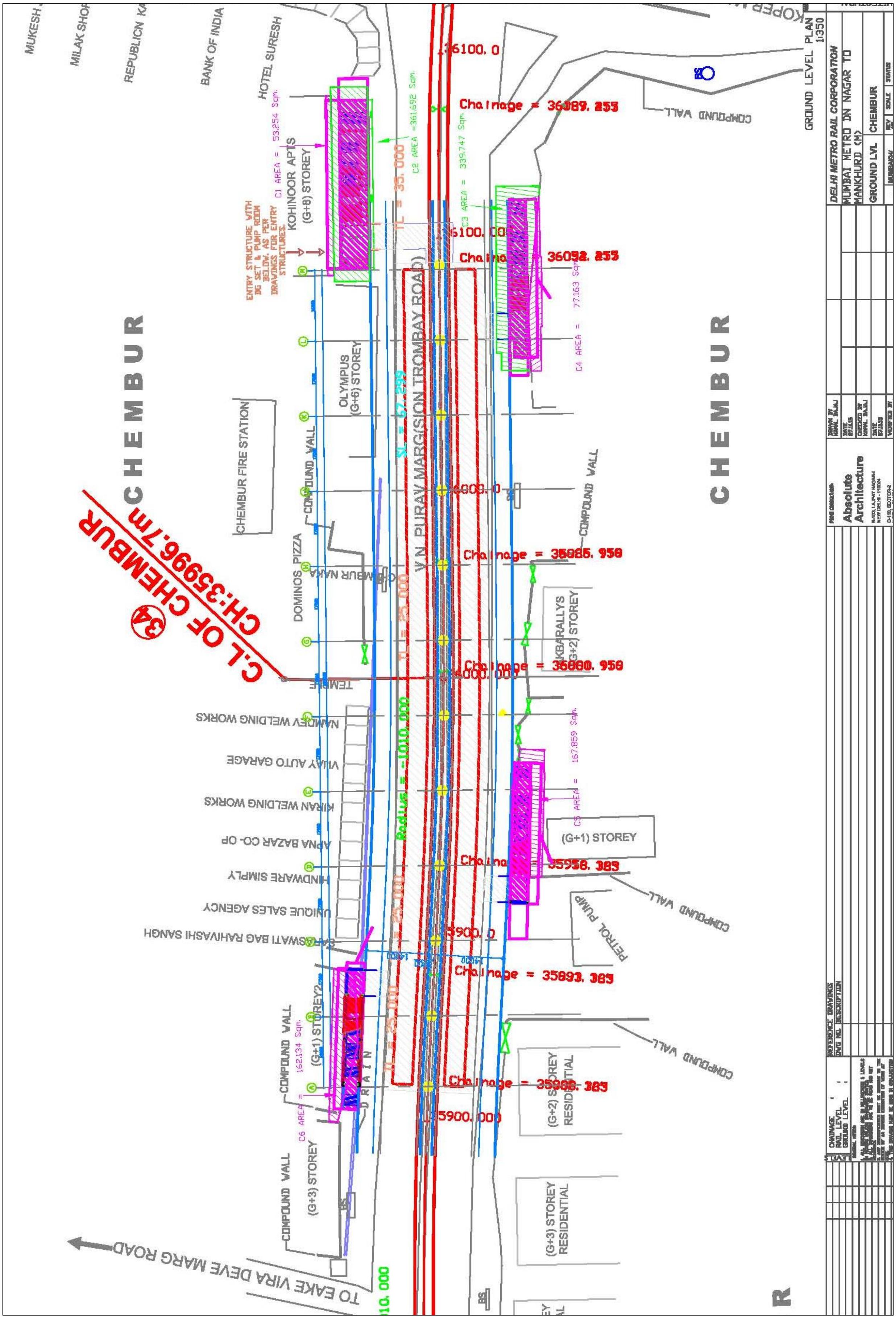

GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
MTNL METRO
Absolute Architecture
TATA COMMUNICATION ENTRY FROM MAIN GATE
BANDRA KURLA
BANDRA KURLA
ROAD
TRANSFORMER
MMRDA SITE OFFICE
SITE OFFICE
C.L OF MTNL METRO
CH:30982.8m
OPEN LAND
BSNL
OPEN PLOT
FOOT PATH
CITY BANK
MMRDA OPEN PLOT
B.P.PETROL PUMP
FIRE HOUSE G+3
TCG FINANCIAL CENTRE
ROAD
Chainage = 30888.263

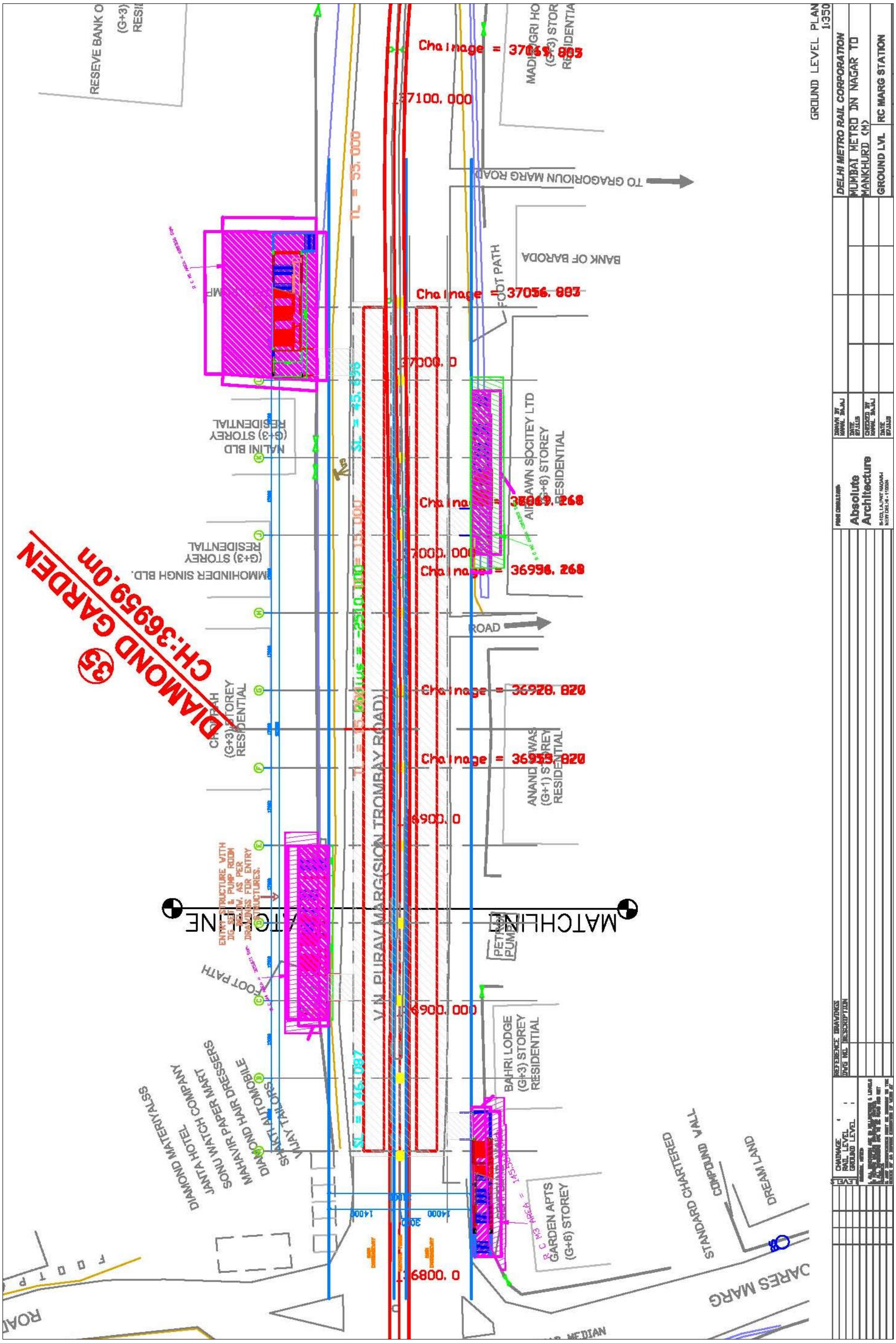

C.L OF S.G. BARVE MARG
CH:32720.2m
GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL.
SG BARVE MARG
Absolute Architecture
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW. AS PER DRAWINGS FOR ENTRY STRUCTURES.

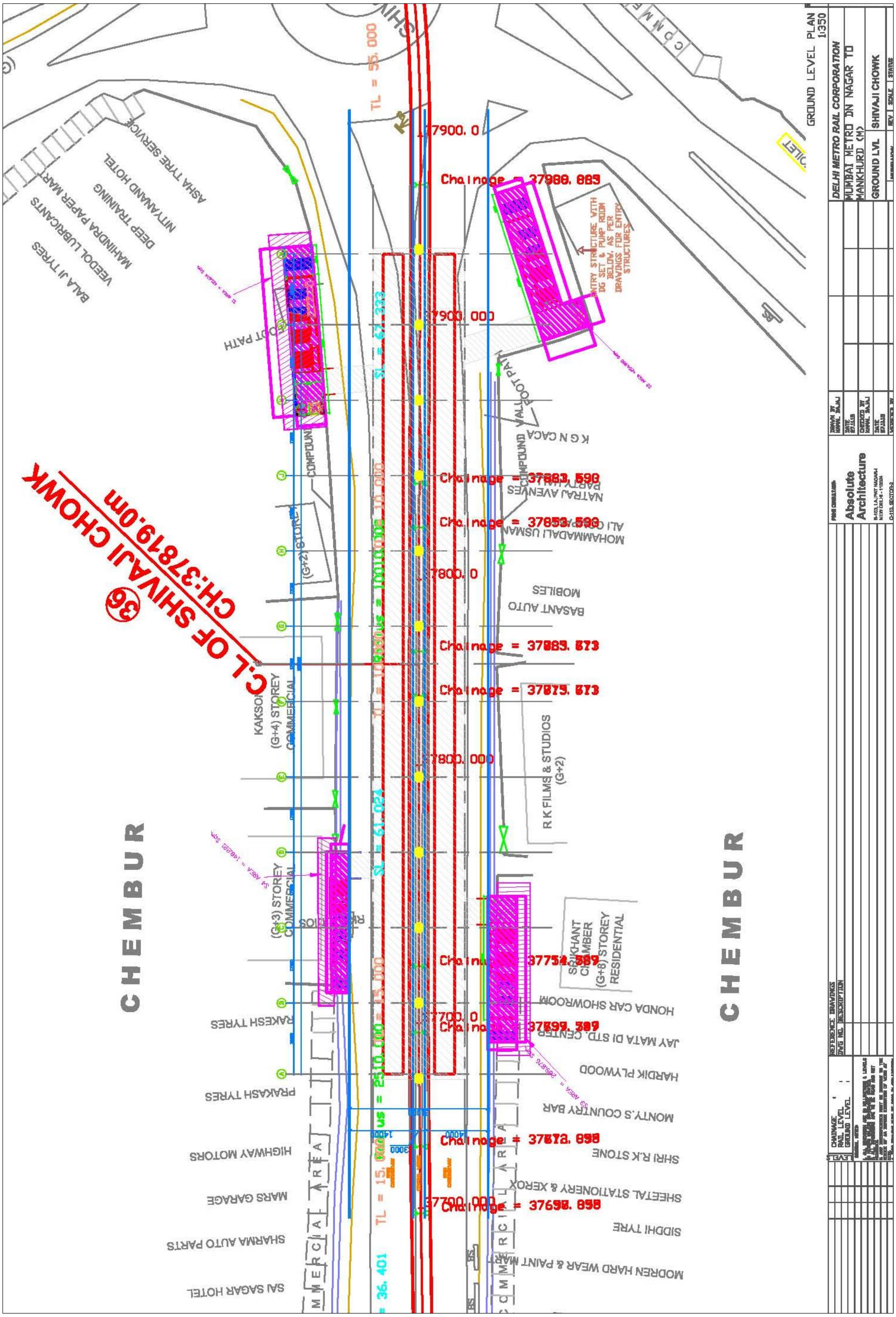

GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
KURLA RAILWAY
TO THANE
MATCHLINE
TO KURLA STATION
C/L OF KURLA TERMINAL
CH: 33194.7m
CD WORK
BOX CULVERT
SPAN=1X4.80X1.5M
TO PIPE LINE ROAD
PARKING
POLICE STATION
TOILET
Absolute Architecture

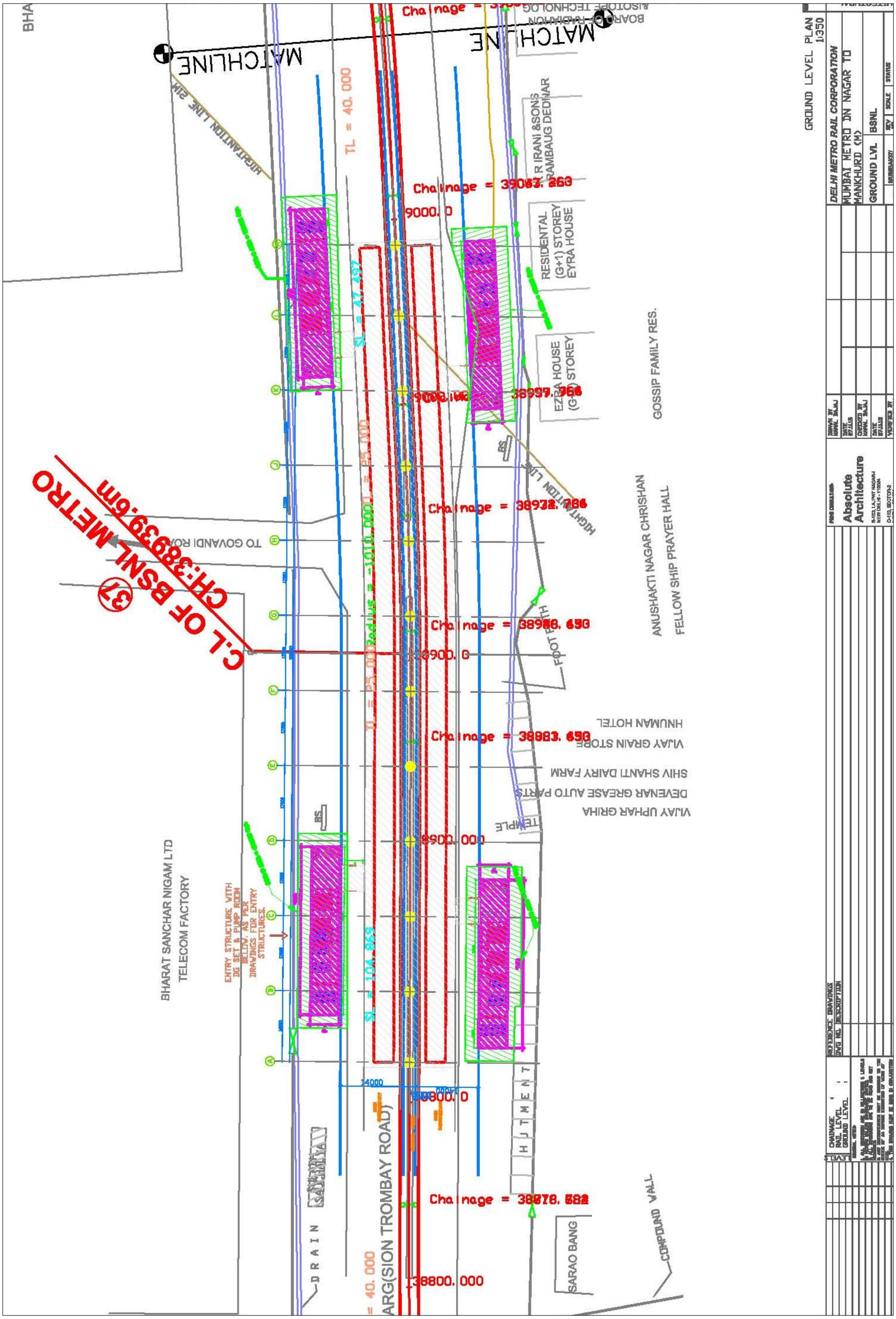

GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL. KURLA EAST
Absolute Architecture
C.L OF KURLA (E)
CH: 34349.2m
32
Chainage = 34407.713
Chainage = 34347.047
Chainage = 34322.047
Chainage = 34236.984
Chainage = 34211.984
34400.0
34300.0
34200.0
KURLA STATION
NEHRU NAGAR
ASHTAVINAYAK MARG
MOBILE SHOP
VISHAL COLDRINKS
MURBA LADIES TAILOR
SHREE SAMARTH POWER LOUNDRY
VISHAL RASVANTI & COLDRINGS
VAIBHAV SARKARI GRAHA NIRMAN SANSTHA G+4
PANCHSI SARKARI GRAHA NIRMAN SANSTHA G+4
CD WORK
BOX CULVERT
SPAN=1X4X1.50M
SPAN=2X6X1.80M
SHED
BUILDING
UC
COMMERCIAL SHOP G+1
PS G+3
A30
A34
A37
A38

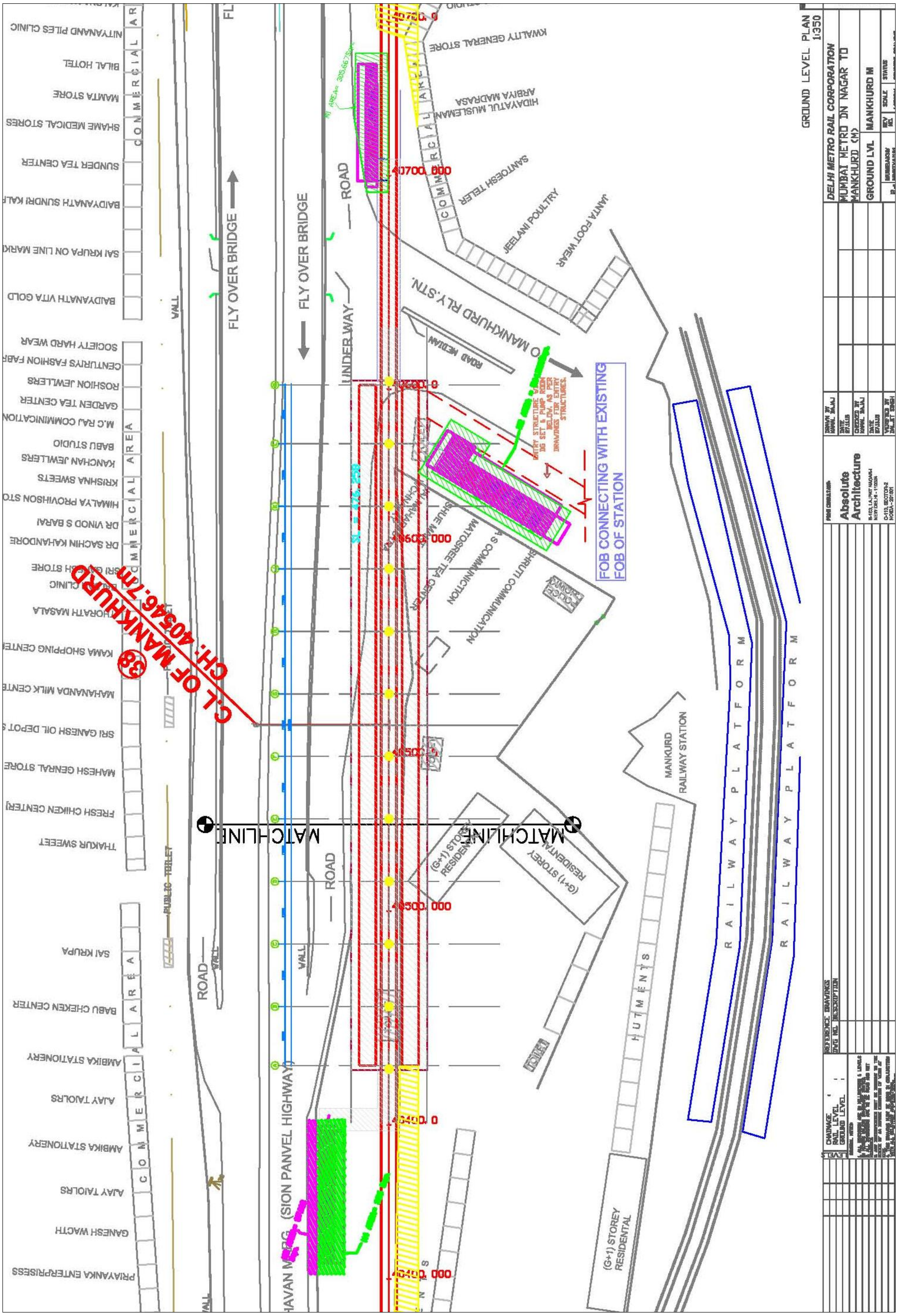

MATCHLINE
MATCHLINE
ROAD
CHEMBUR
CHEMBUR
MAHARASTRA VEDUT MANDAL
(G+3) STOREY
COMPOUND WALL
CHANDRODY CO OP HOUSING SOCIETY
C.L OF EEH
CH:35356.3m
DRAIN
EASTERN EXPRESS HIGHWAY
FLY OVER BRIDGE
BOMBAY HAIR DRESS
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL EEH
Absolute Architecture

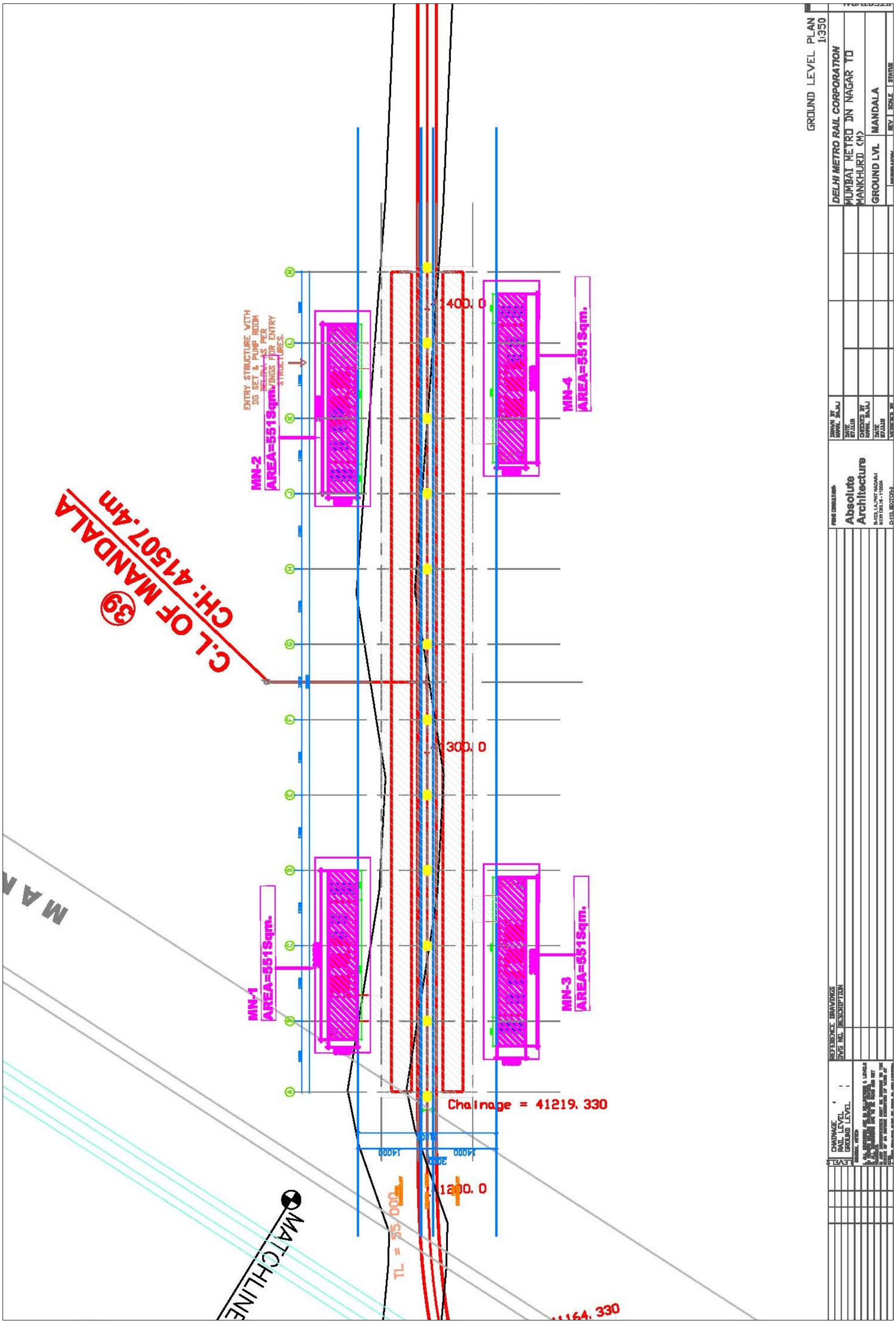

C.L OF CHEMBUR
CH:35996.7m
34
CHEMBUR
CHEMBUR
V N PURAV MARG(SION TROMBAY ROAD)
CHEMBUR FIRE STATION
KOHINOOR APTS
(G+8) STOREY
OLYMPUS
(G+6) STOREY
DOMINOS PIZZA
CHEMBUR NAKA
TEMPLE
NAMDEV WELDING WORKS
VIJAY AUTO GARAGE
KIRAN WELDING WORKS
APNA BAZAR CO- OP
HINDWARE SIMPLY
UNIQUE SALES AGENCY
SARASWATI BAG RAHIVASHI SANGH
TO EAKE VIRA DEVE MARG ROAD
COMPOUND WALL
PETROL PUMP
(G+1) STOREY
(G+2) STOREY
(G+3) STOREY
(G+3) STOREY RESIDENTIAL
Chainage = 36089.255
Chainage = 36052.255
Chainage = 35985.958
Chainage = 35980.958
Chainage = 35958.383
Chainage = 35893.383
36100.0
35900.0
HOTEL SURESH
BANK OF INDIA
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
CHEMBUR
Absolute Architecture

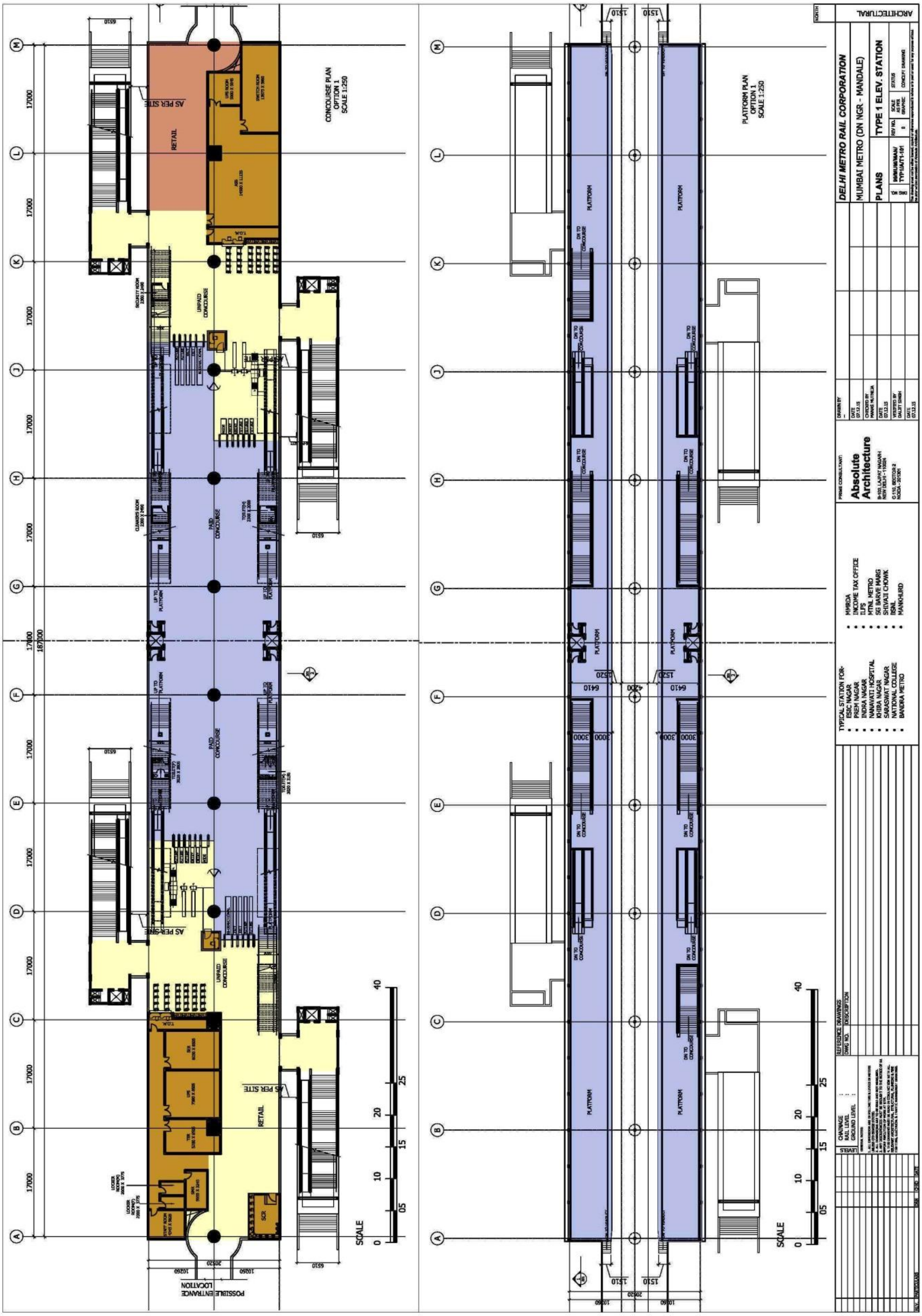

GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
RC MARG STATION
Absolute Architecture
DIAMOND GARDEN
CH:36959.0m
35
V.N.PURAV MARG(SION TROMBAY ROAD)
MATCHLINE
Chainage = 37069.803
Chainage = 37056.803
Chainage = 36967.268
Chainage = 36996.268
Chainage = 36928.820
Chainage = 36959.820
37100.000
37000.0
37000.000
36900.0
36900.000
36800.0
TO GRAGORIUM MARG ROAD
BANK OF BARODA
FOOT PATH
AIR LAWN SOCITEY LTD (G+6) STOREY RESIDENTIAL
ANAND NIWAS (G+1) STOREY RESIDENTIAL
BAHRI LODGE (G+3) STOREY RESIDENTIAL
GARDEN APTS (G+6) STOREY
NALINI BLD (G+3) STOREY RESIDENTIAL
IMMOHINDER SINGH BLD. (G+3) STOREY RESIDENTIAL
RESEVE BANK O
STANDARD CHARTERED
COMPOUND WALL
DREAM LAND
CARES MARG
DIAMOND MATERIYALSS
JANTA HOTEL COMPANY
SONU WATCH COMPANY
MAHAVIR PAPER MART
DIAMOND HAIR DRESSERS
DIAMOND AUTOMOBILE
SHAKTI TAILORS
VIJAY TAILORS
ROAD
MEDIAN

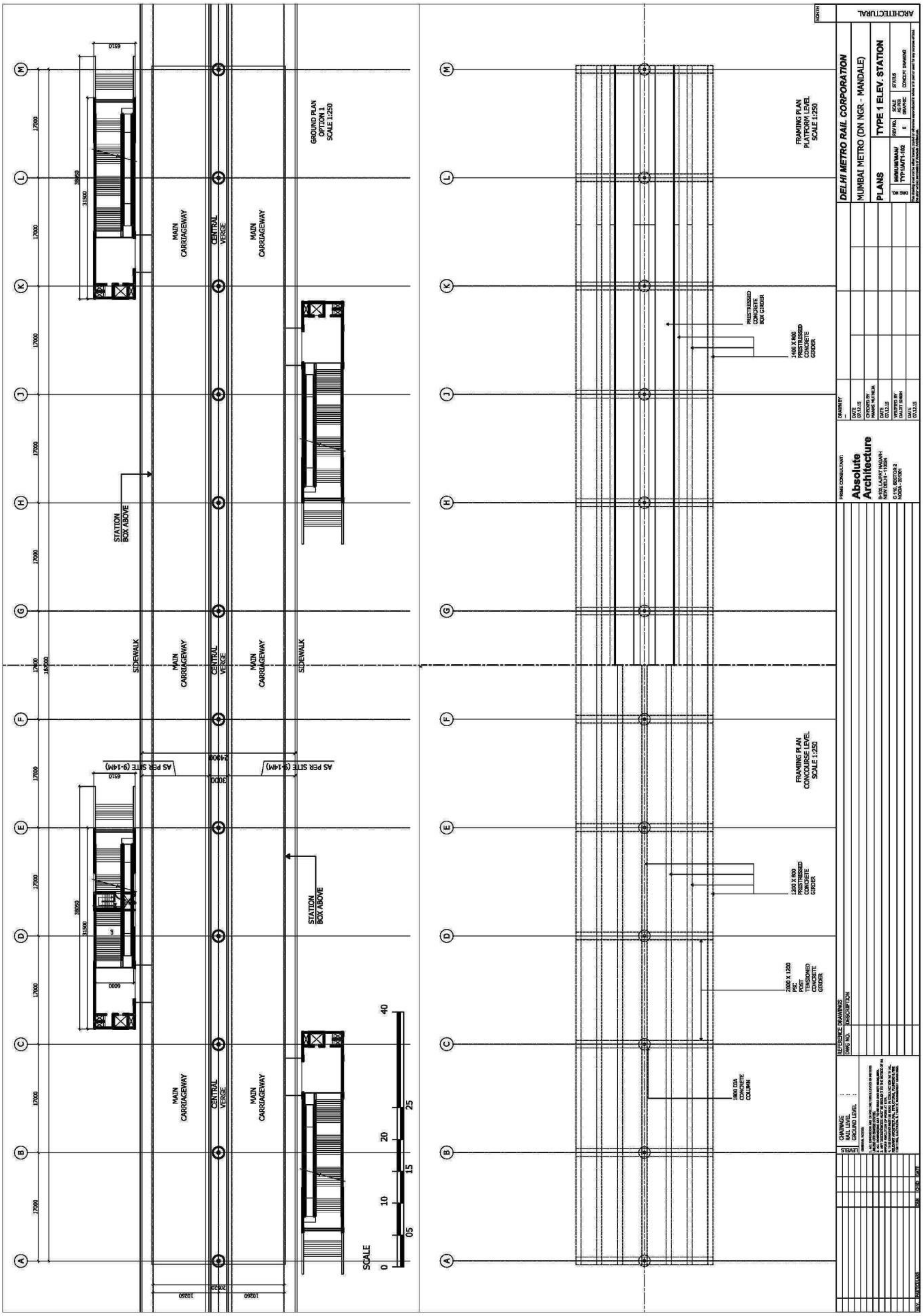

C.L OF SHIVAJI CHOWK
CH:37819.0m
36
CHEMBUR
CHEMBUR
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
SHIVAJI CHOWK
Absolute Architecture


MATCHLINE
MATCHLINE
C.L OF BSNL METRO
CH:38939.6m
37
TO GOVANDI ROAD
BHARAT SANCHAR NIGAM LTD
TELECOM FACTORY
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW. AS PER DRAWINGS FOR ENTRY STRUCTURES.
GOSSIP FAMILY RES.
ANUSHAKTI NAGAR CHRISHAN
FELLOW SHIP PRAYER HALL
RESIDENTAL (G+1) STOREY EYRA HOUSE
EZRA HOUSE
HUMAN HOTEL
VIJAY GRAIN STORE
SHIV SHANTI DAIRY FARM
DEVENAR GREASE AUTO PARTS
VIJAY UPHAR GRIHA
TEMPLE
SARAO BANG
COMPOUND WALL
DRAIN
FOOT PATH
HIGHTANTION LINE
Chainage = 39067.260
Chainage = 38937.786
Chainage = 38938.786
Chainage = 38988.650
Chainage = 38883.650
Chainage = 38876.582
39000.0
38900.0
38900.000
38800.0
38800.000
TL = 40.000
SL = 47.497
SL = 104.865
Radius = -1010.000
GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL BSNL
Absolute Architecture

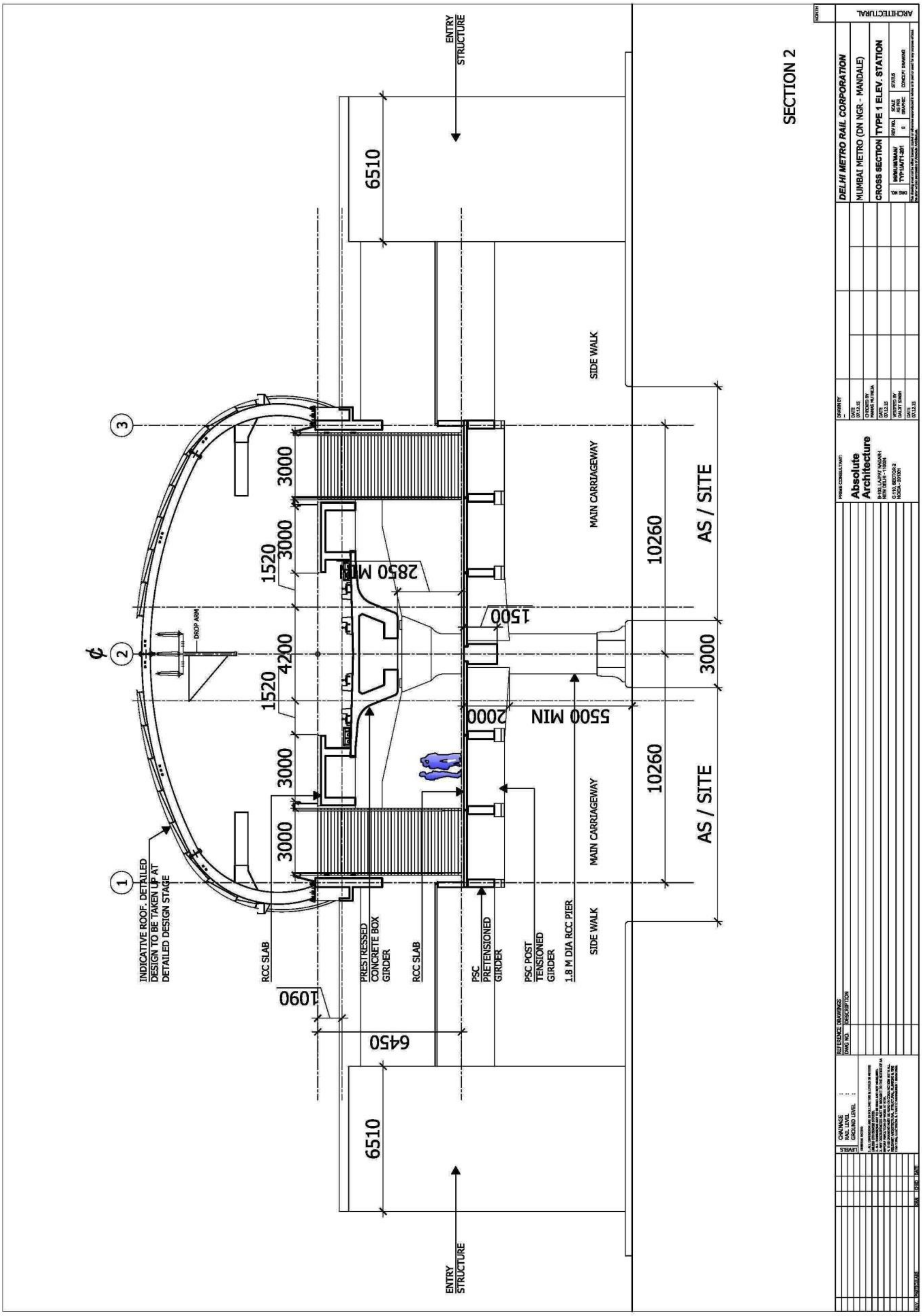

GROUND LEVEL PLAN 1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
MANKHURD M
Absolute Architecture
C.L OF MANKHURD
CH: 40546.7m
38
FLY OVER BRIDGE
UNDER WAY
ROAD
MATCHLINE
FOB CONNECTING WITH EXISTING FOB OF STATION
MANKHURD RLY. STN.
MANKURD RAILWAY STATION
RAILWAY PLATFORM
HUTMENTS
(G+1) STOREY RESIDENTIAL
SION PANVEL HIGHWAY
COMMERCIAL AREA
40700.000
40600.000
40500.000
40400.000
PUBLIC TOILET
KWALITY GENERAL STORE
JEELANI POULTRY
JANTA FOOT WEAR
SANTOSH TELER

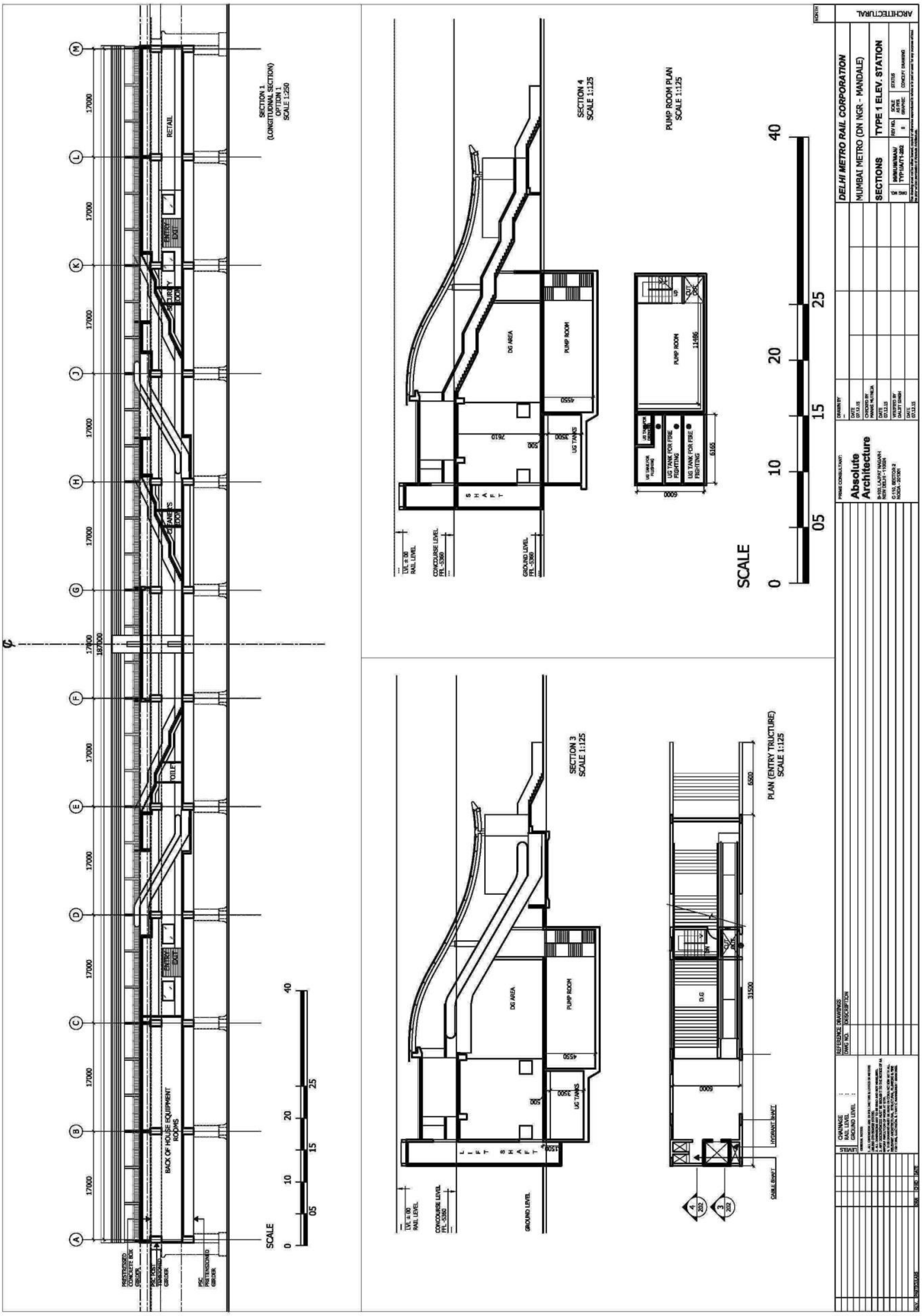

C.L OF MANDALA
CH: 41507.4m
39
MN-1
AREA=551Sqm.
MN-2
AREA=551Sqm.
MN-3
AREA=551Sqm.
MN-4
AREA=551Sqm.
ENTRY STRUCTURE WITH DG SET & PUMP ROOM BELOW AS PER DRAWINGS FOR ENTRY STRUCTURES.
41400.0
41300.0
41200.0
Chainage = 41219.330
TL = 55.000
MATCHLINE
GROUND LEVEL PLAN
1:350
DELHI METRO RAIL CORPORATION
MUMBAI METRO DN NAGAR TO MANKHURD (M)
GROUND LVL
MANDALA
Absolute Architecture


CONCOURSE PLAN
OPTION 1
SCALE 1:250
PLATFORM PLAN
OPTION 1
SCALE 1:250
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 1 ELEV. STATION
PLANS
ARCHITECTURAL
Absolute Architecture
TYPICAL STATION FOR-
ESIC NAGAR
PREM NAGAR
INDIRA NAGAR
NANAVATI HOSPITAL
KHIRA NAGAR
SARASWAT NAGAR
NATIONAL COLLEGE
BANDRA METRO
MMRDA
INCOME TAX OFFICE
ILFS
MTNL METRO
SG BARVE MARG
SHIVAJI CHOWK
BSNL
MANKHURD
RETAIL
UNPAID CONCOURSE
PAID CONCOURSE
PLATFORM
SCALE
POSSIBLE ENTRANCE LOCATION



GROUND PLAN
OPTION 1
SCALE 1:250
FRAMING PLAN
PLATFORM LEVEL
SCALE 1:250
FRAMING PLAN
CONCOURSE LEVEL
SCALE 1:250
MAIN CARRIAGEWAY
CENTRAL VERGE
SIDEWALK
STATION BOX ABOVE
AS PER SITE (9-14M)
SCALE
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 1 ELEV. STATION
PLANS
Absolute Architecture
ARCHITECTURAL


SECTION 2
ENTRY STRUCTURE
ENTRY STRUCTURE
6510
6510
6450
1090
3000
3000
1520
4200
1520
3000
3000
2850 MIN
1500
2000
5500 MIN
10260
10260
3000
AS / SITE
AS / SITE
SIDE WALK
MAIN CARRIAGEWAY
MAIN CARRIAGEWAY
SIDE WALK
DROP ARM
INDICATIVE ROOF. DETAILED DESIGN TO BE TAKEN UP AT DETAILED DESIGN STAGE
RCC SLAB
PRESTRESSED CONCRETE BOX GIRDER
RCC SLAB
PSC PRETENSIONED GIRDER
PSC POST TENSIONED GIRDER
1.8 M DIA RCC PIER
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
CROSS SECTION TYPE 1 ELEV. STATION
Absolute Architecture
ARCHITECTURAL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SCALE 1:125
SECTION 3
SCALE 1:125
PLAN (ENTRY TRUCTURE)
SCALE 1:125
SCALE
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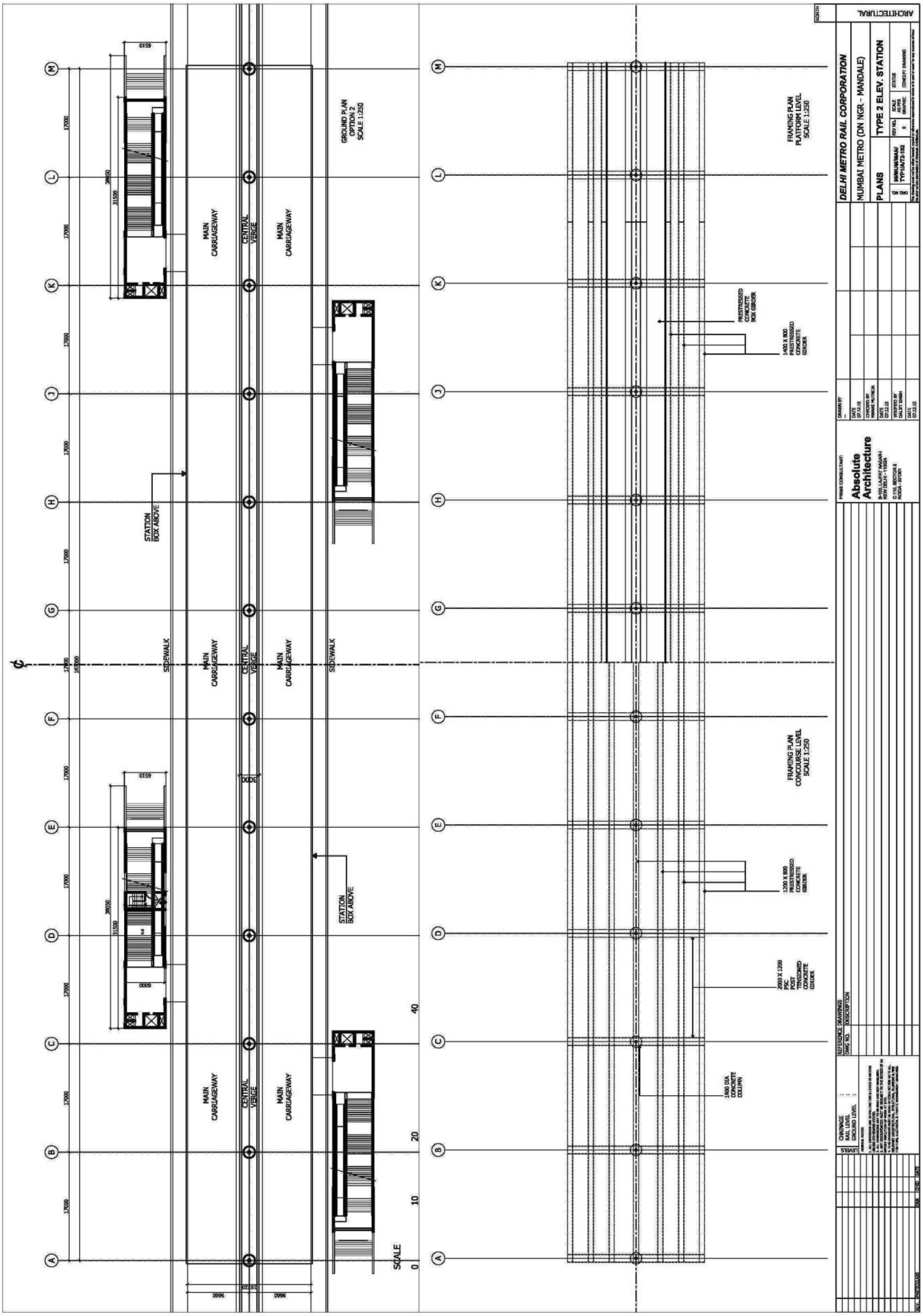
MUMBAI METRO (DN NGR - MANDALE)
SECTIONS
TYPE 1 ELEV. STATION
Absolute Architecture
ARCHITECTURAL


CONCOURSE PLAN
OPTION 2
SCALE 1:250
PLATFORM PLAN
OPTION 2
SCALE 1:250
RETAIL
AS PER SITE
UNPAID CONCOURSE
PAID CONCOURSE
PLATFORM
POSSIBLE ENTRANCE LOCATION
SCALE
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 2 ELEV. STATION
PLANS
Absolute Architecture
TYPICAL STATION FOR-
KURLA RAILWAY
KURAL (E)
ARCHITECTURAL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CENTRAL VERGE
SIDEWALK
STATION BOX ABOVE
FRAMING PLAN
PLATFORM LEVEL
SCALE 1:250
FRAMING PLAN
CONCOURSE LEVEL
SCALE 1:250
SCALE
0
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20
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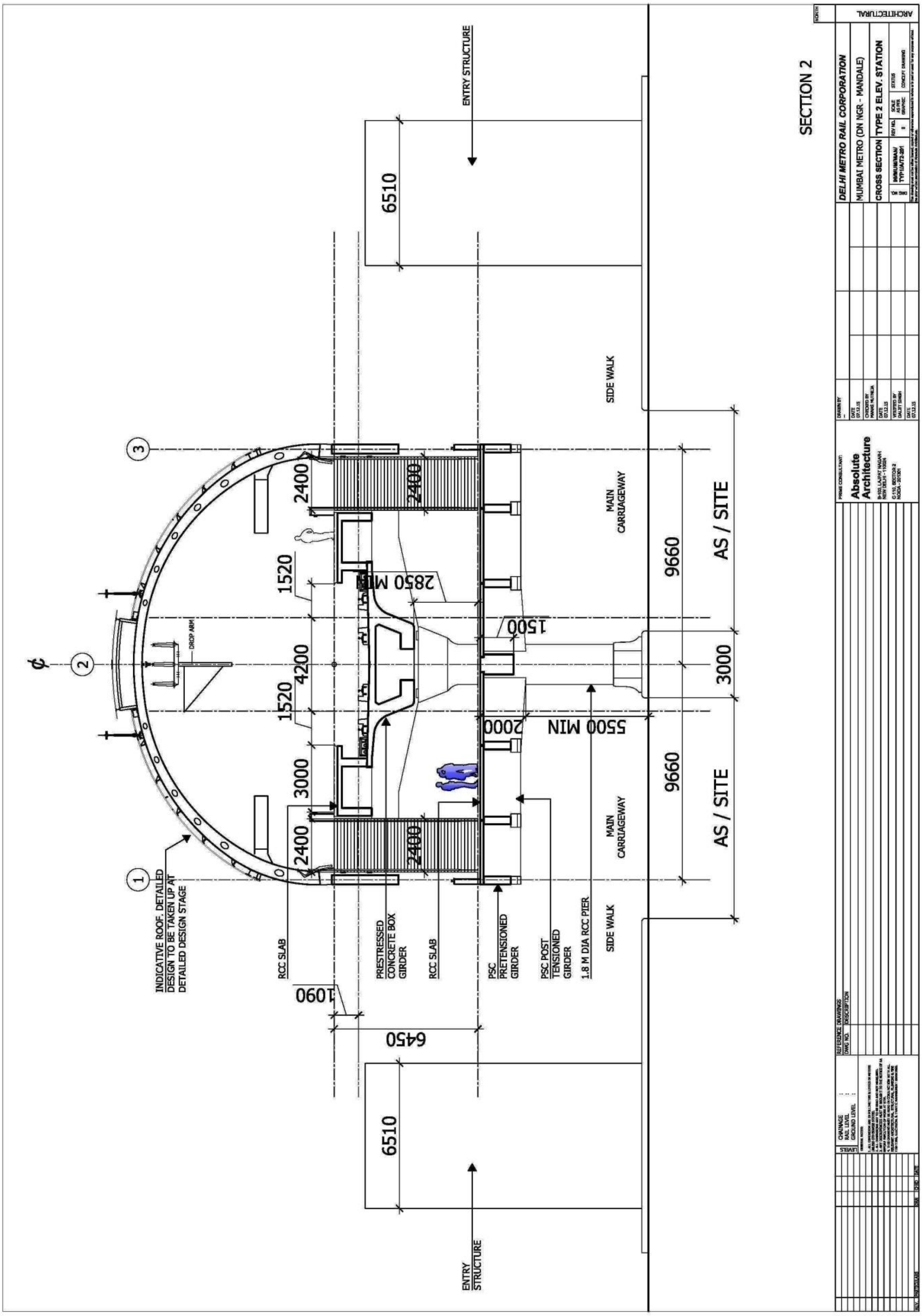
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 2 ELEV. STATION
PLANS
ARCHITECTURAL
Absolute Architecture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SIDE WALK
MAIN CARRIAGEWAY
AS / SITE
9660
3000
2400
1520
4200
3000
2850 MIN
1500
2000
5500 MIN
DROP ARM
INDICATIVE ROOF. DETAILED DESIGN TO BE TAKEN UP AT DETAILED DESIGN STAGE
RCC SLAB
PRESTRESSED CONCRETE BOX GIRDER
RCC SLAB
PSC PRETENSIONED GIRDER
PSC POST TENSIONED GIRDER
1.8 M DIA RCC PIER
1090
6450
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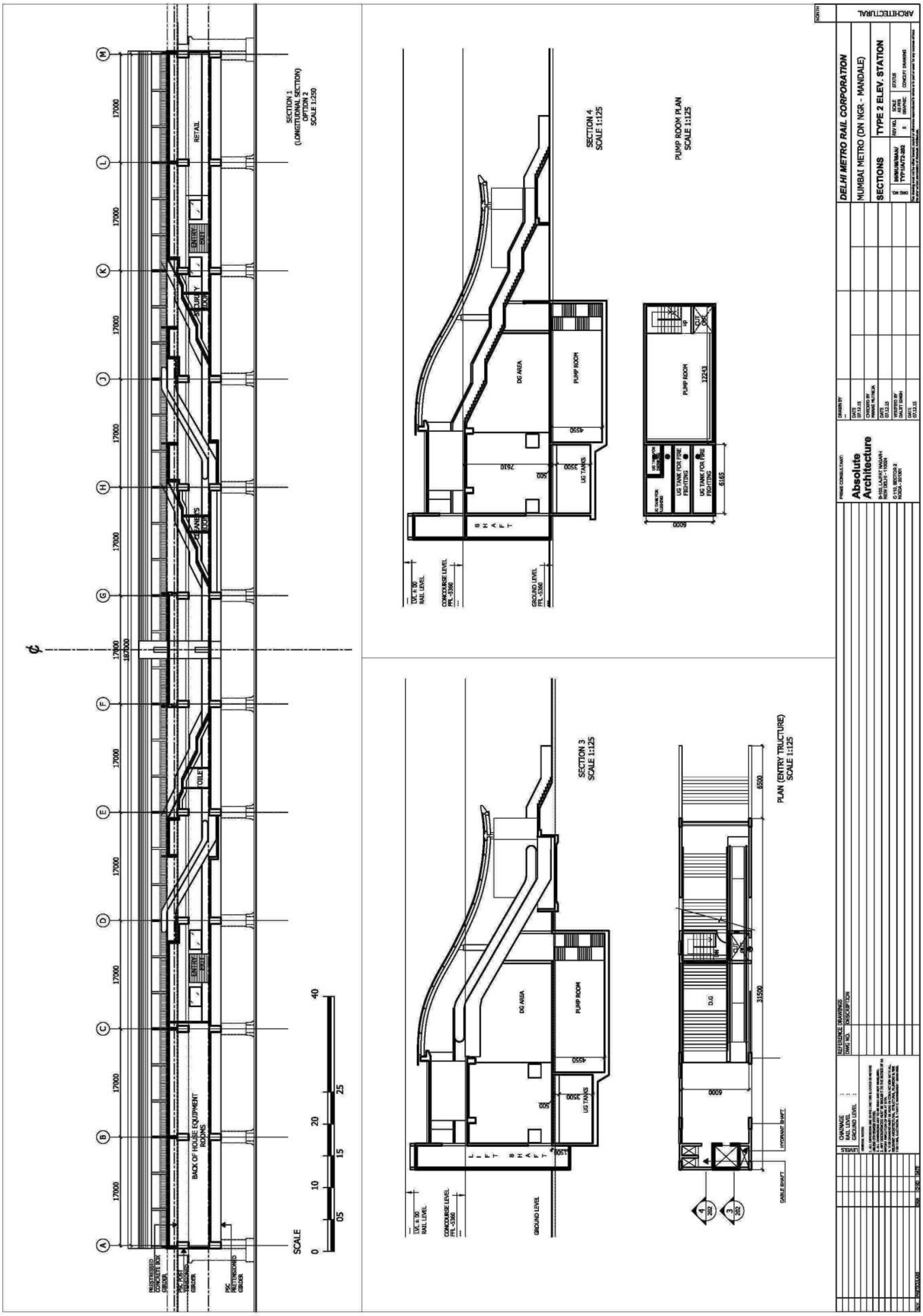
MUMBAI METRO (DN NGR - MANDALE)
CROSS SECTION TYPE 2 ELEV. STATION
Absolute Architecture
ARCHITECTURAL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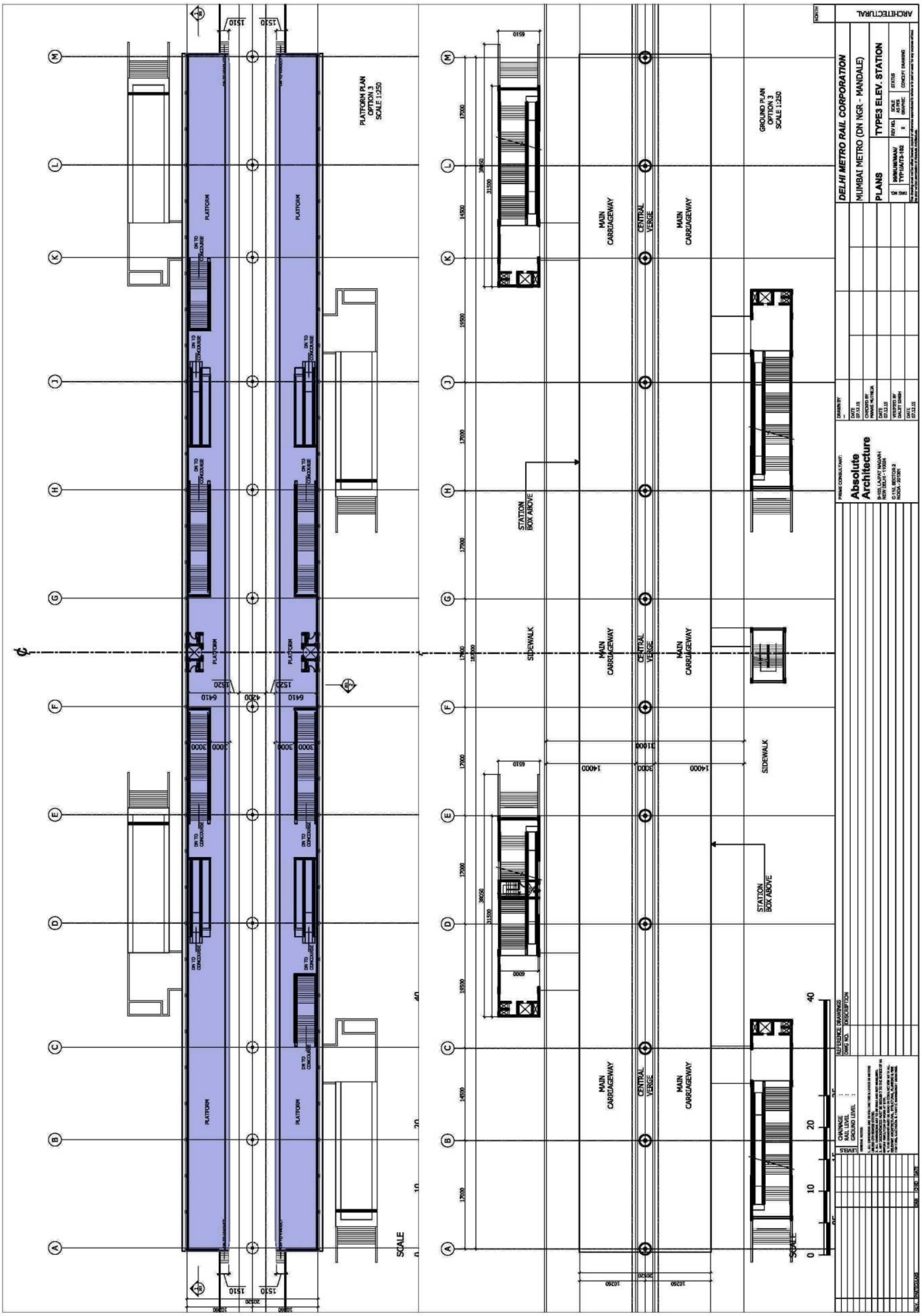
SCALE 1:125
SECTION 3
SCALE 1:125
PLAN (ENTRY TRUCTURE)
SCALE 1:125
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
SECTIONS
TYPE 2 ELEV. STATION
Absolute Architecture
ARCHITECTURAL


CONCOURSE PLAN
OPTION 3
SCALE 1:250
PD LVL PLAN
OPTION 3
SCALE 1:250
UNPAID CONCOURSE
PAID CONCOURSE
RETAIL
SERVICE AREA
UNPAID AREA
AS PER SITE
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
PLANS
TYPE 3 ELEV. STATION
Absolute Architecture
ARCHITECTURAL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GROUND PLAN
OPTION 3
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PLATFORM
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CENTRAL VERGE
SIDEWALK
STATION BOX ABOVE
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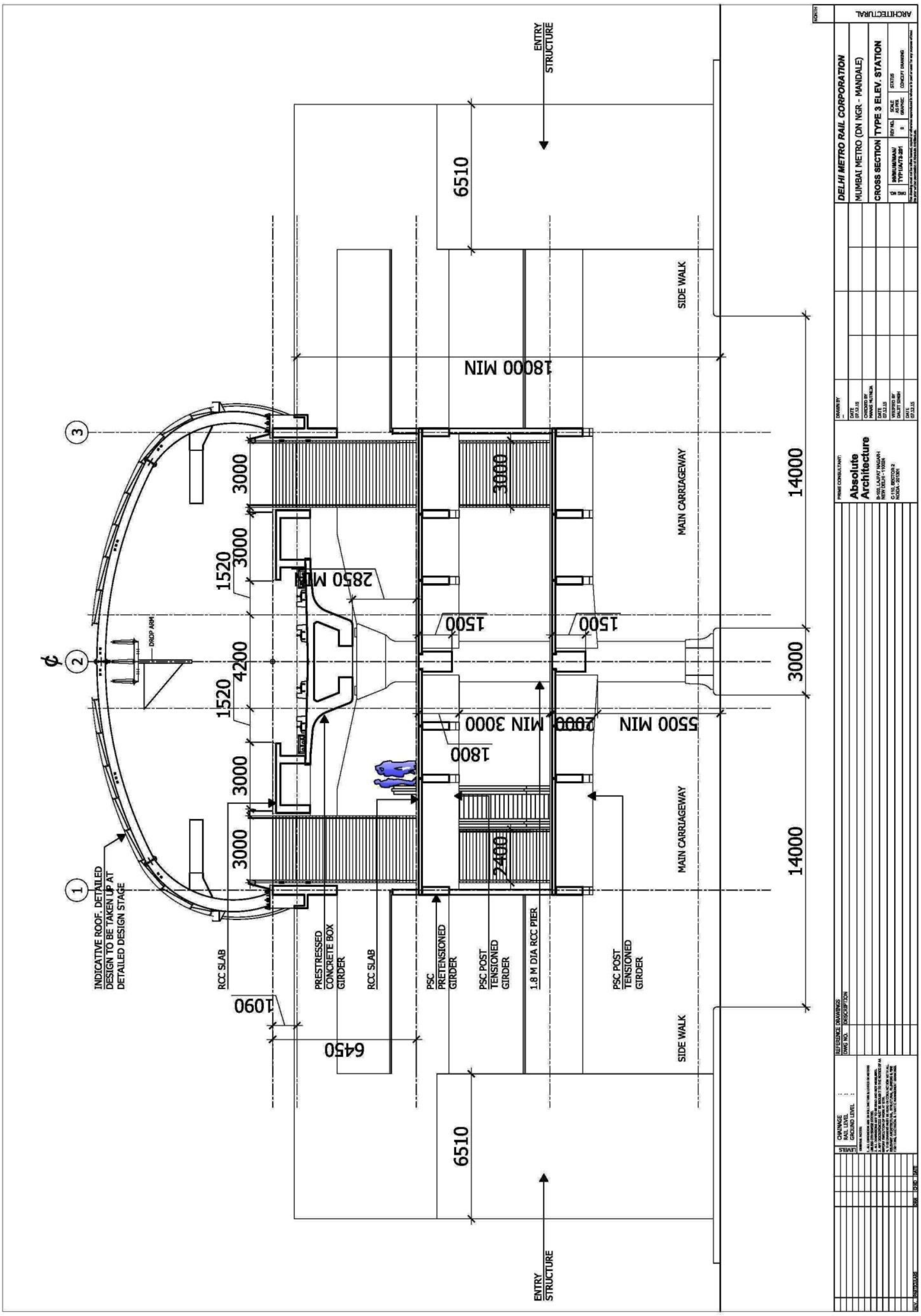
MUMBAI METRO (DN NGR - MANDALE)
TYPE3 ELEV. STATION
PLANS
Absolute Architecture
ARCHITECTURAL
SCALE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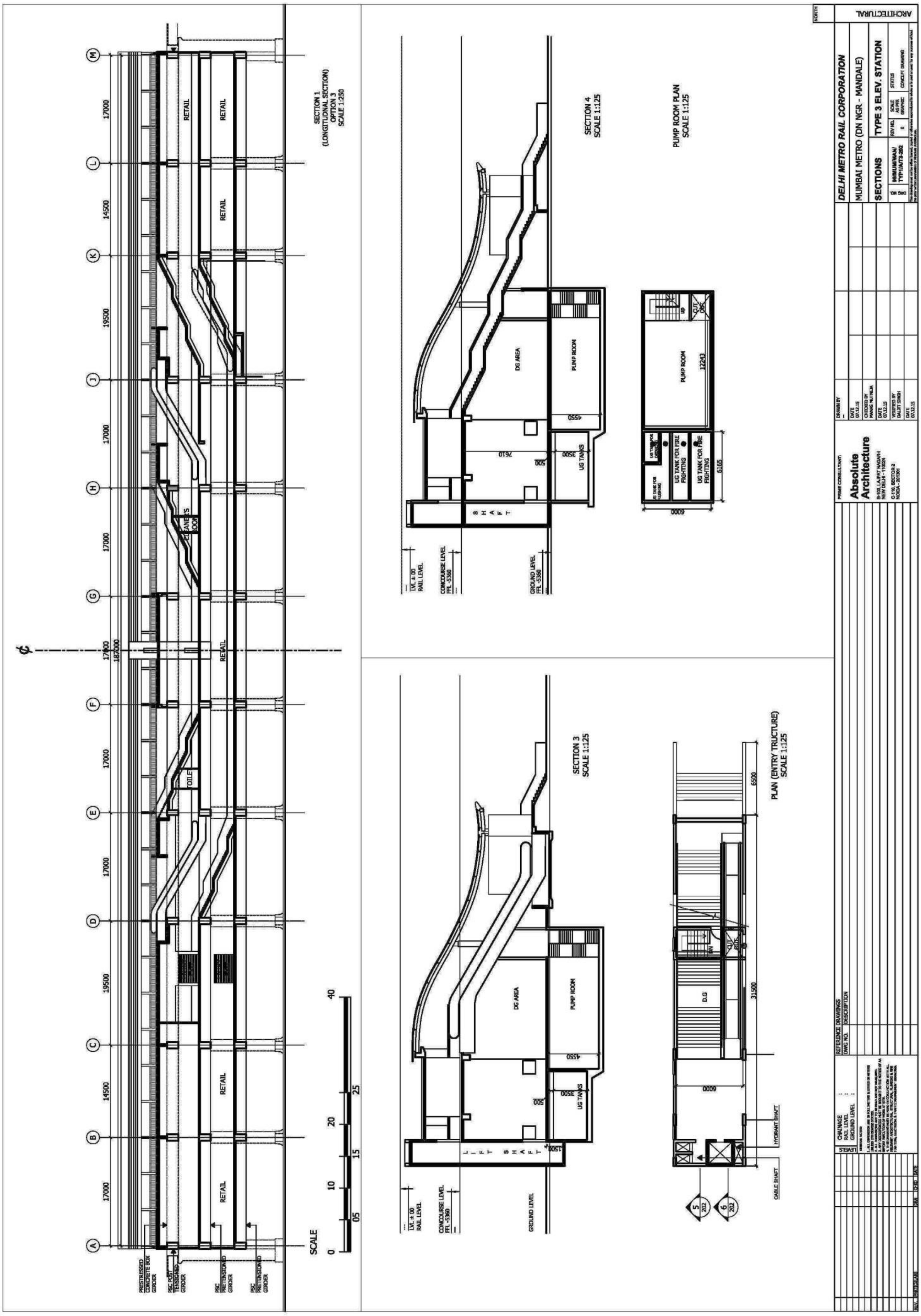
PRESTRESSED CONCRETE BOX GIRDER
RCC SLAB
PSC PRETENSIONED GIRDER
PSC POST TENSIONED GIRDER
1.8 M DIA RCC PIER
PSC POST TENSIONED GIRDER
DROP ARM
ENTRY STRUCTURE
ENTRY STRUCTURE
SIDE WALK
MAIN CARRIAGEWAY
MAIN CARRIAGEWAY
SIDE WALK
18000 MIN
2850 MIN
MIN 3000
5500 MIN
6510
6510
6450
1090
14000
3000
14000
1520
1520
4200
1500
1500
1800
2400
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
CROSS SECTION TYPE 3 ELEV. STATION
Absolute Architecture
ARCHITECTURAL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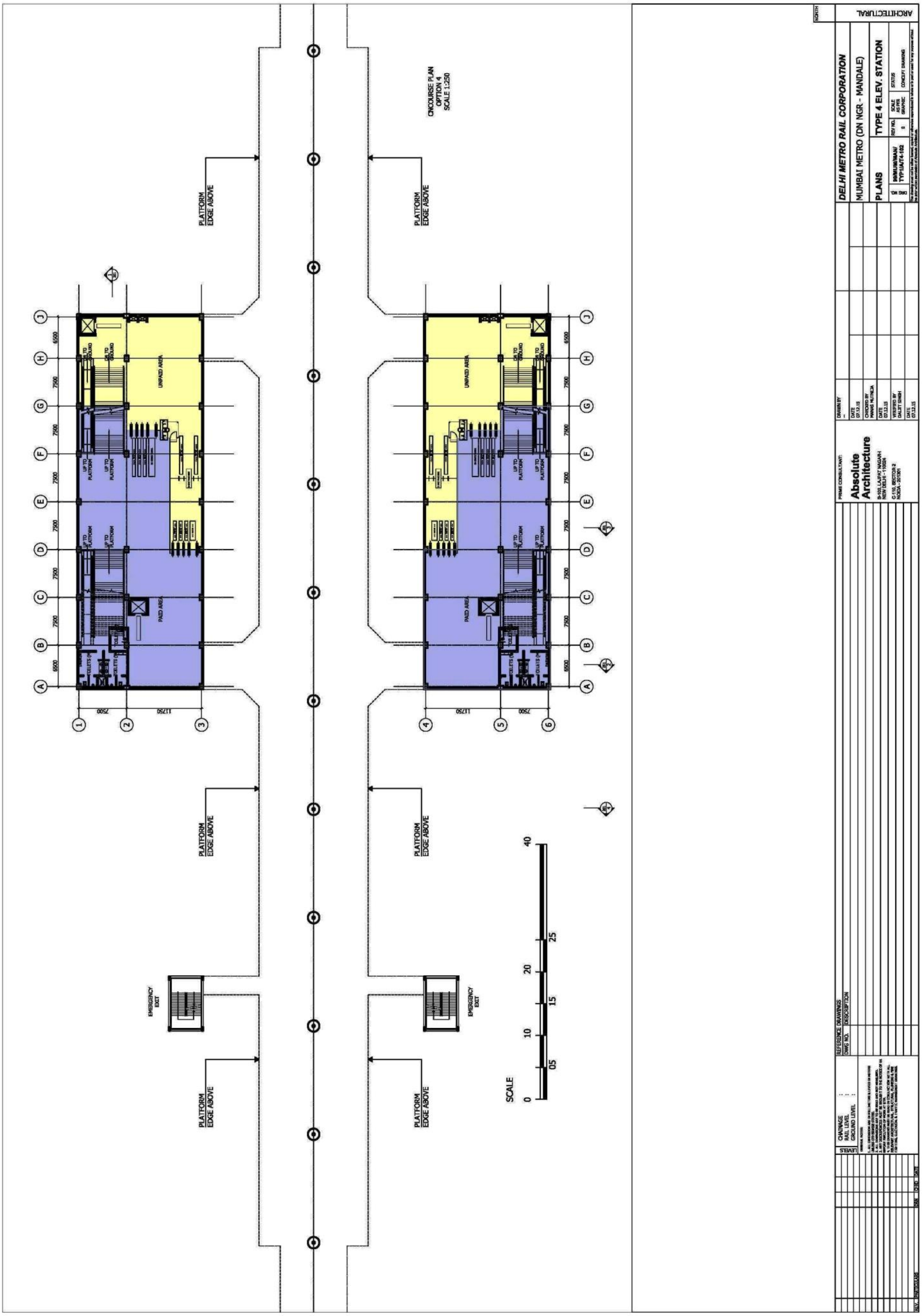
PUMP ROOM PLAN
SCALE 1:125
SECTION 3
SCALE 1:125
PLAN (ENTRY TRUCTURE)
SCALE 1:125
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
SECTIONS
TYPE 3 ELEV. STATION
Absolute
Architecture
ARCHITECTURAL


GROUND PLAN
OPTION 4
SCALE 1:250
MAIN CARRIAGEWAY
CENTRAL VERGE
PLATFORM EDGE ABOVE
DROP OFF
UNPAID AREA
UP TO CONCOURSE
CAR PARK
EMERGENCY EXIT
AS PER SITE
SCALE
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 4 ELEV. STATION
PLANS
Absolute Architecture
ARCHITECTURAL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EMERGENCY
EXIT
SCALE
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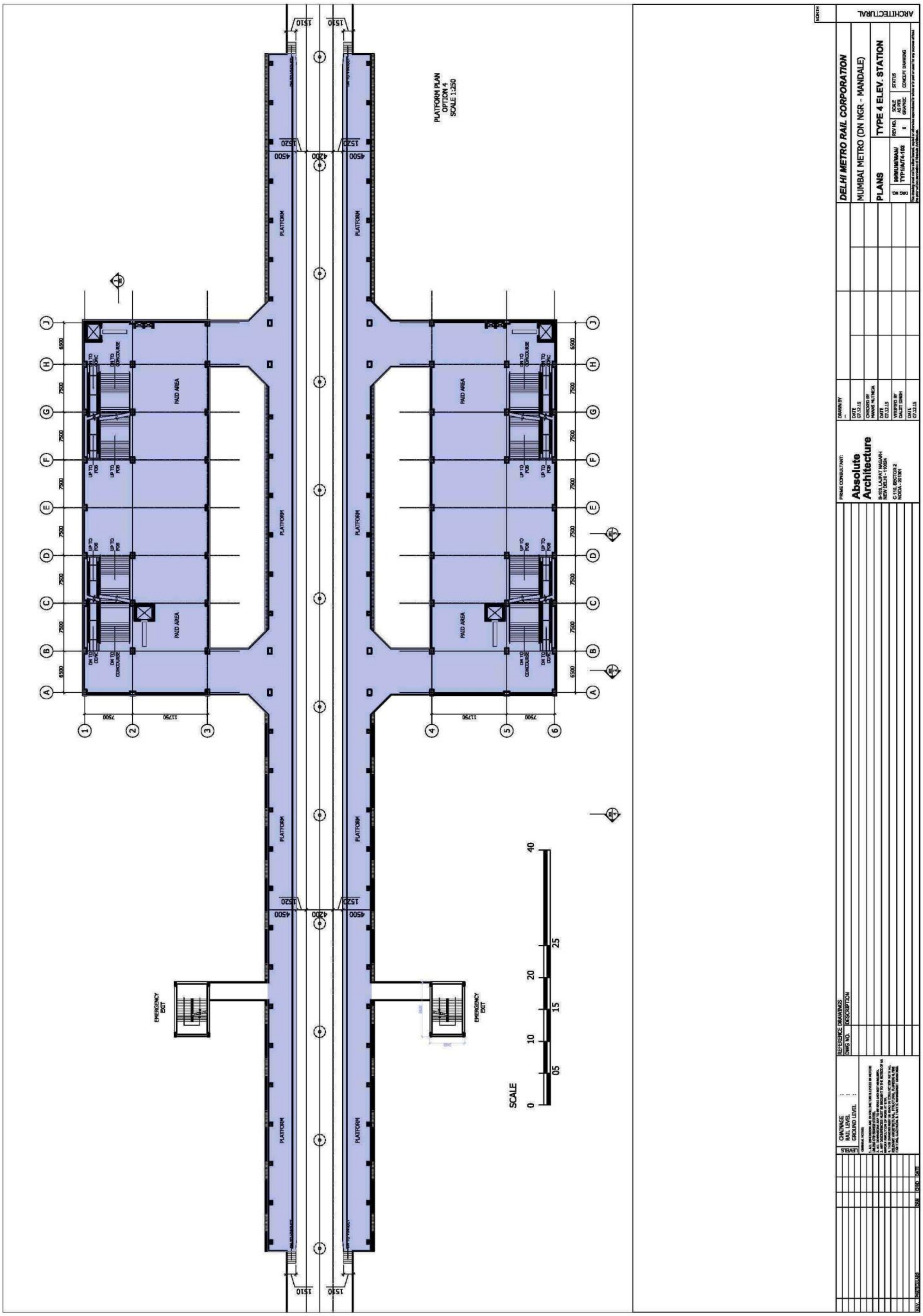
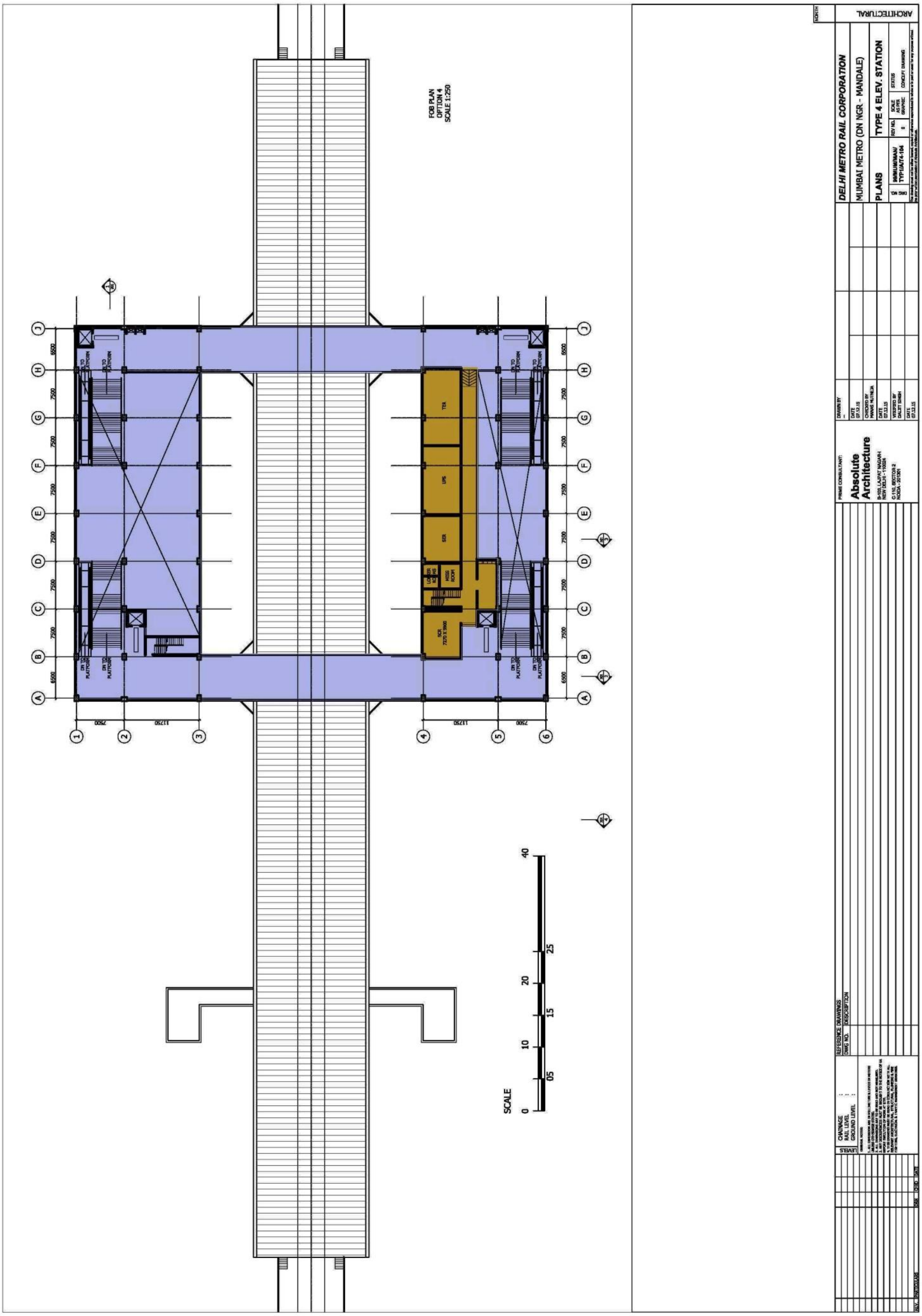
MUMBAI METRO (DN NGR - MANDALE)
TYPE 4 ELEV. STATION
PLANS
Absolute
Architecture
ARCHITECTURAL


PLATFORM PLAN
OPTION 4
SCALE 1:250
PLATFORM
PAID AREA
EMERGENCY EXIT
SCALE
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 4 ELEV. STATION
PLANS
Absolute Architecture
ARCHITECTURAL


FOB PLAN
OPTION 4
SCALE 1:250
SCALE
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DELHI METRO RAIL CORPORATION
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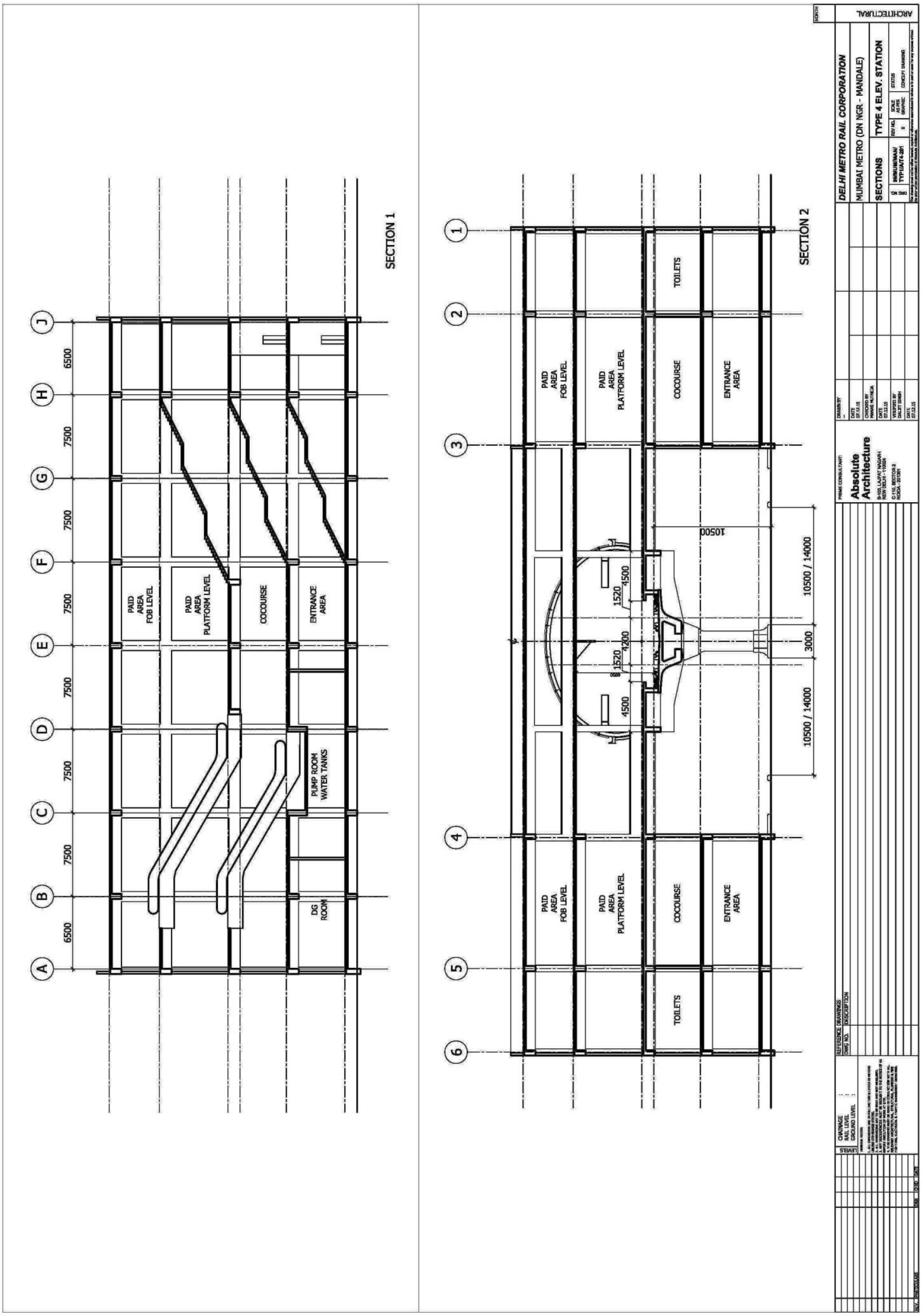
TYPE 4 ELEV. STATION
PLANS
Absolute
Architecture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SECTION 2
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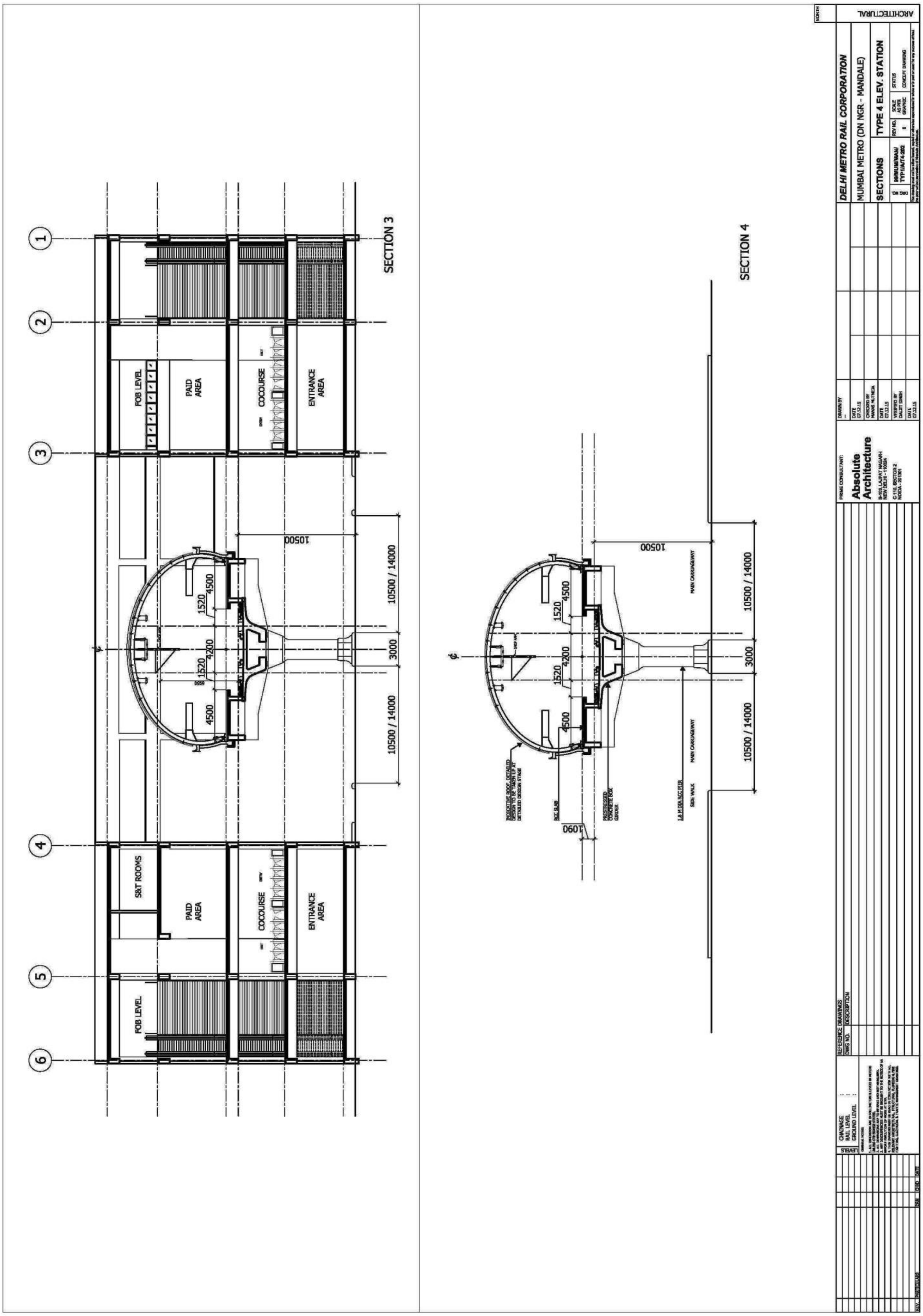
PAID AREA PLATFORM LEVEL
COCOURSE
ENTRANCE AREA
PUMP ROOM WATER TANKS
DG ROOM
TOILETS
6500
7500
10500
10500 / 14000
3000
1520
4500
4200
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
SECTIONS
TYPE 4 ELEV. STATION
Absolute Architecture
ARCHITECTURAL


SECTION 3
SECTION 4
FOB LEVEL
PAID AREA
COCOURSE
ENTRANCE AREA
S&T ROOMS
10500
10500 / 14000
3000
4500
1520
4200
1090
DELHI METRO RAIL CORPORATION
MUMBAI METRO (DN NGR - MANDALE)
TYPE 4 ELEV. STATION
SECTIONS
Absolute Architecture
ARCHITECTURAL

Annexure-5.1

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-1 & Figure-2 to this appendix.

Figure -1 Typical Elevated Station Layout

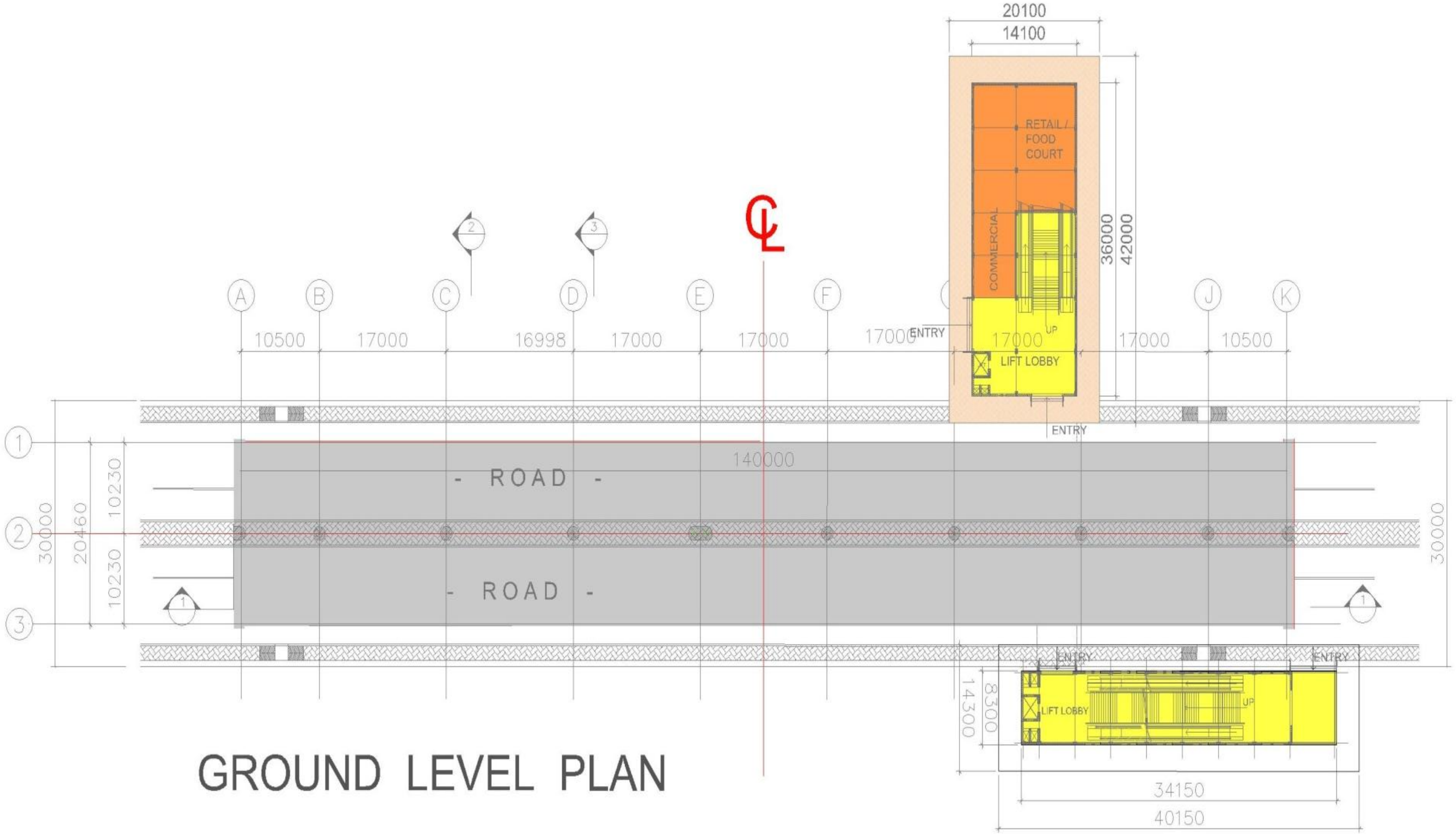
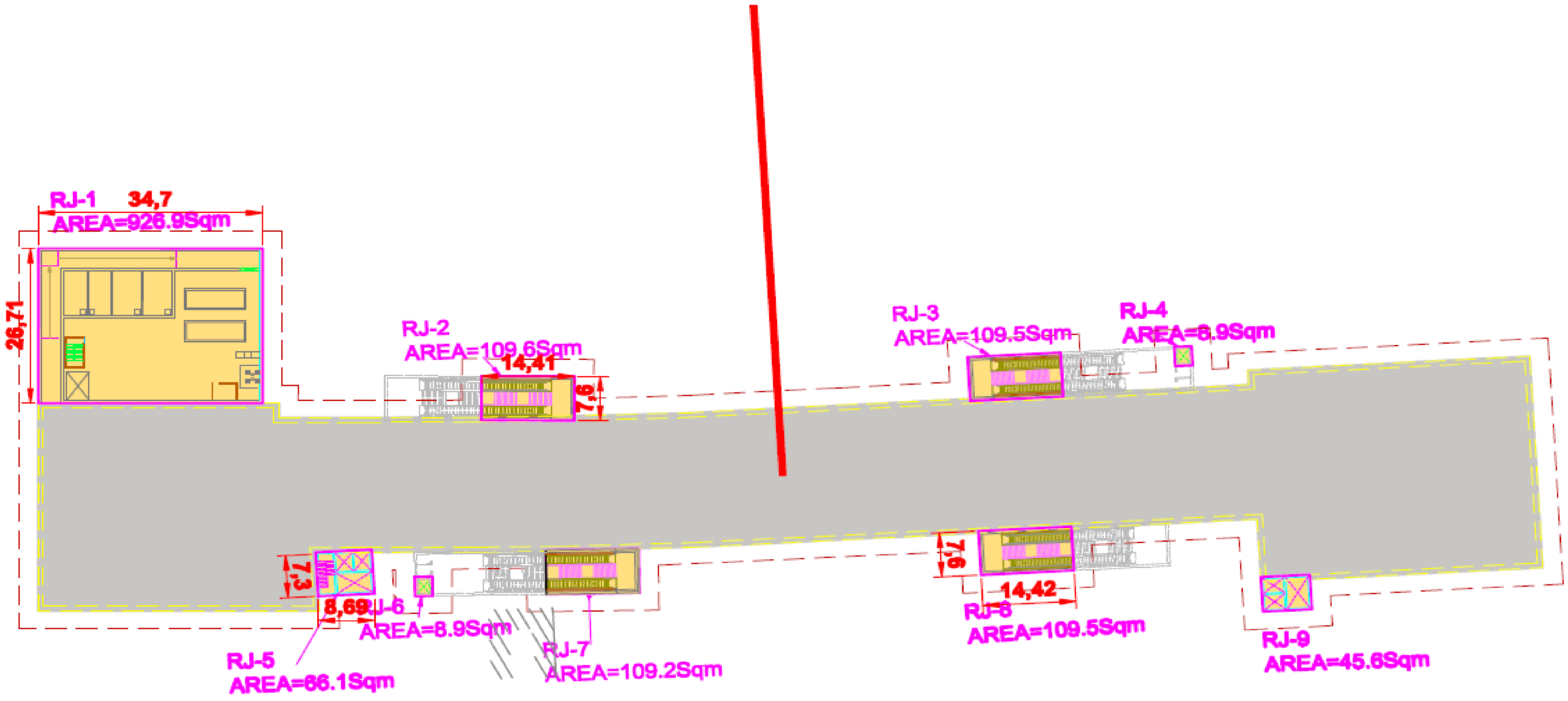


Figure-2 Typical Underground Station Layout

Ground Level Plan



Chapter 6 –Train Operation Plan

Chapter - 6

TRAIN OPERATION PLAN

6.1 OPERATION PHILOSOPHY

The underlying operation philosophy is to make the Metro System more attractive and economical, the main features being:

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- Multi-tasking of train operation and maintenance staff.

6.2 STATIONS

Details of stations for Mumbai Metro (Dahisar East to Mandala Metro Corridor) are given below:

Details of Stations

Dahisar(E) to Mandala Metro Corridor (Mumbai)				
		CHAINAGE (M)	INTER STATION DISTANCE(M)	REMARKS
1	DAHISAR (E)	0.0	-	ELEVATED
2	DAHISAR (W)	711.0	711.0	ELEVATED
3	RUSHI SANKUL	2422.7	1711.7	ELEVATED
4	I C COLONY	3383.1	960.4	ELEVATED
5	LIC COLONY	4468.4	1085.3	ELEVATED
6	DON BOSCO	5537.5	1069.1	ELEVATED
7	KASTUR PARK	6465.9	928.4	ELEVATED
8	EKATA NAGAR	7571.8	1105.9	ELEVATED
9	KANDIVALI NAGAR	8200.3	628.5	ELEVATED
10	CHARKOP	9535.5	1335.2	ELEVATED
11	MALAD METRO	10846.0	1310.5	ELEVATED
12	KASTURI PARK	12243.4	1397.4	ELEVATED
13	BANGUR NAGAR	13183.1	939.7	ELEVATED
14	OSHIWARA METRO	14455.5	1272.4	ELEVATED
15	SAMARTHA NAGAR	15468.7	1013.2	ELEVATED
16	SHASTRI NAGAR	16433.0	964.3	ELEVATED
17	D N NAGAR	17578.6	1145.6	ELEVATED
18	ESIC NAGAR	18637.6	1059.0	ELEVATED
19	PREM NAGAR	20302.6	1665.0	ELEVATED
20	INDIRA NAGAR	20829.2	526.6	ELEVATED

Dahisar(E) to Mandala Metro Corridor (Mumbai)				
		CHAINAGE (M)	INTER STATION DISTANCE(M)	REMARKS
21	NANAVATI HOSPITAL	21902.5	1073.3	ELEVATED
22	KHIRA NAGAR	23509.4	1606.9	ELEVATED
23	SARASWAT NAGAR	24466	956.6	ELEVATED
24	NATIONAL COLLEGE	25559	1093	ELEVATED
25	BANDRA METRO	26699.7	1140.7	ELEVATED
26	MMRDA OFFICE	28292	1592.3	ELEVATED
27	INCOME TAX OFFICE	28913.9	621.9	ELEVATED
28	ILFS	30188	1274.1	ELEVATED
29	MTNL METRO	30982.8	794.8	ELEVATED
30	S G BARVE MARG	32720.2	1737.4	ELEVATED
31	KURLA TERMINAL	33194.7	474.5	ELEVATED
32	KURLA (E)	34349.2	1154.5	ELEVATED
33	EEH	35356.3	1007.1	ELEVATED
34	CHEMBUR	35996.7	640.4	ELEVATED
35	DIAMOND GARDEN	36959	962.3	ELEVATED
36	SHIVAJI CHOWK	37819	860	ELEVATED
37	B S N L METRO	38939.6	1120.6	ELEVATED
38	MANKHURD	40546.7	1607.1	ELEVATED
39	MANDALA METRO	41507.4	960.7	ELEVATED

6.3 TRAIN OPERATION PLAN

Train operation has been planned in two loops to meet the PHPDT demand. One train on given headway will run from Dahisar (E) to Mandala section and other train would be run on LIC to Income tax office(ITO) section. This would generate more PHPDT capacity on the common section between LIC to ITO.

Reversal facility would be required at LIC station for running the train between LIC to ITO section.

6.3.1 Salient Features:

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

6.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Dahisar East to Mandala Metro and LIC to ITO for the year 2019, 2021 and 2031 for the purpose of planning are indicated in Attachment I/A1, I/B1 & I/C1 and Attachment I/A2, I/B2 & I/C2 respectively and has been taken as the maximum of the PHPDT in the forward & reverse directions.

6.3.3 Train Formation

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

Composition

DMC	:	Driving Motor Car
MC	:	Motor Car
TC	:	Trailer Car
6-car train composition:		DMC+TC+MC+ MC+TC+DMC

Capacity@ 6 passengers per square meter of standee area

DMC	:	282 passengers (Sitting-42, Standing-240)
MC	:	298 passengers (Sitting-50, Standing-248)
TC	:	298 passengers (Sitting-50, Standing-248)
6 Car Train	:	1756 Passengers (Sitting-284, Standing-1472)

6.3.4 Train Operation Plan

Based on the projected PHPDT demand, train operation has been planned for Mumbai Metro (Dahisar East to Mandala Metro corridor and LIC to ITO corridor) for the year 2019, 2021 and 2031 as detailed below:

Train operation plan for Dahisar East to Mandala Metro corridor and LIC to ITO corridor with train carrying **capacity @ 6 persons per square meter of standee area** for Mumbai Metro is given below:

- **Year 2019** (Refer **Attachment I /A1 and Attachment I /A2**)

-Dahisar to LIC and ITO to Mandala section- Train operation with 6 car Trains with headway of 7 min between Dahisar to LIC and ITO to Mandala section is planned in the first year of operation i.e. 2019 with Peak Hour Peak Direction Capacity of 15051 @ 6 persons per square meter of standee area (Capacity of 19234 @ 8 persons per square meter of standee area under dense loading conditions).

-LIC to ITO section- Train operation with 6 car Trains with headway of 3.5 min between LIC to ITO is planned in the first year of operation i.e. 2019 with Peak Hour Peak Direction Capacity of 30103 @ 6 persons per square meter of standee area (Capacity of 38469 @ 8 persons per square meter of standee area under dense loading conditions).

- **Year 2021** (Refer **Attachment I/B1 and Attachment I/B2**)

-Dahisar to LIC and ITO to Mandala section- Train operation with 6 car Trains with headway of 6 min between Dahisar to LIC and ITO to Mandala section is planned in the first year of operation i.e. 2021 with Peak Hour Peak Direction Capacity of 17560 @ 6 persons per square meter of standee area (Capacity of 22440 @ 8 persons per square meter of standee area under dense loading conditions).

-LIC to ITO section- Train operation with 6 car Trains with headway of 3 min between LIC to ITO is planned in the first year of operation i.e. 2021 with Peak Hour

Peak Direction Capacity of 35120 @ 6 persons per square meter of standee area (Capacity of 44880 @ 8 persons per square meter of standee area under dense loading conditions).

- **Year 2031** (Refer **Attachment I/C1 and Attachment I/C2**)

-Dahisar to LIC and ITO to Mandala section- Train operation with 6 car Trains with headway of 5.50 min between Dahisar to LIC and ITO to Mandala section is planned in the first year of operation i.e. 2031 with Peak Hour Peak Direction Capacity of 19156 @ 6 persons per square meter of standee area (Capacity of 24480 @ 8 persons per square meter of standee area under dense loading conditions).

-LIC to ITO section- Train operation with 6 car Trains with headway of 2.75 min between LIC to ITO is planned in the first year of operation i.e. 2031 with Peak Hour Peak Direction Capacity of 38313 @ 6 persons per square meter of standee area (Capacity of 48960 @ 8 persons per square meter of standee area under dense loading conditions).

The PHPDT capacity provided for Dahisar East to Mandala Metro corridor and LIC to ITO corridor in different years of operation is given below :

PHPDT Capacity Provided

Section	Year	PHPDT demand	Headway planned	No. of cars	Train carrying capacity @ 6 person/sqm
Dahisar to LIC	2019	13977	7	6	15051
LIC to ITO		29373	3.5		30103
ITO to Mandala		17169	7		15051
Dahisar to LIC	2021	15999	6		17560
LIC to ITO		35142	3		35120
ITO to Mandala		21167	6		17560
Dahisar to LIC	2031	18282	5.5		19156
LIC to ITO		38509	2.75		38313
ITO to Mandala		17426	5.5		19156

6.3.5 Train Frequency

Dahisar East to Mandala Metro corridor and LIC to ITO corridor

S.N.	Corridor	Year	Headway(Minutes)
1.1	Dahisar East to Mandala Metro corridor	2019	7
1.2	LIC to ITO corridor		7
2.1	Dahisar East to Mandala Metro corridor	2021	6

S.N.	Corridor	Year	Headway(Minutes)
2.2	LIC to ITO corridor		6
3.1	Dahisar East to Mandala Metro corridor	2031	5.5
3.2	LIC to ITO corridor		5.5

No services are proposed between 00.00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and Rolling stock.

Directional split of 50:50 has been maintained between trains running in either direction.

6.3.6 Hourly Train Operation Plan

The hourly distribution of daily transport capacity for Dahisar East to Mandala Metro corridor is presented in **Table 1.1A, 1.2A & 1.3A** for years 2019, 2021 & 2031 and enclosed as **Attachment II.**

The hourly distribution of daily transport capacity for LIC to ITO corridor is presented in **Table 1.1B, 1.2B & 1.3B** for years 2019, 2021 & 2031 and enclosed as **Attachment II.**

6.3.7 Vehicle Kilometer

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Dahisar East to Mandala Metro corridor and LIC to ITO corridor is given in **Table 3.1 and Table 3.2** enclosed as **Attachment IV** respectively.

6.3.8 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** & has been tabulated below :

Year-wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	No. of car per rake	No. of Coaches
Dahisar East to Mandala Metro corridor	2019	7	42	6	252
LIC to ITO corridor		7			
Dahisar East to Mandala Metro corridor	2021	6	48		288
LIC to ITO corridor		6			
Dahisar East to Mandala Metro corridor	2031	5.5	52		312
LIC to ITO corridor		5.5			

Requirement of coaches is calculated based on following assumptions:-

Assumptions -

(i) Train Composition planned as under:

6 Car Train Compositions : DMC+TC+MC+ MC+TC+DMC
Train Carrying Capacity of 6 Car
Train@6 person per square meter : 1756 passengers
Train@8 person per square meter : 2244 passengers

(ii) Coach requirement has been calculated based on headway during peak hours.
(iii) Traffic reserve is taken as one trains to cater to failure of train on line and to make up for operational time lost.
(iv) Repair and maintenance reserve has been estimated as 10 % of total requirement (Bare +Traffic Reserve).
(v) The calculated number of rakes in fraction is rounded off to next higher number.
(vi) Schedule speed is taken as 35 KMPH.
(vii) Total Turn Round time is taken as 6 min at terminal stations.

6.4 ROLLING STOCK (Technical data)

Numbers of cars	:	6
Composition	:	DMC+TC+MC+MC+TC+DMC
Power System [Kv/Hz]	:	25 KV AC
Acceleration [m/s^2]	:	1.0
Deceleration [m/s^2]	:	1.0
Emergency Braking [m/s^2]	:	1.35
Maximum Design speed [kmph]	:	90
Track Gauge [mm]	:	1435
Width over body of rolling Stock [mm]	:	3200

6.5 COST ESTIMATE

The estimated cost per car at March' 2015 Price level (exclusive of taxes and duties) may be assumed as Rs. 10 Crores per car. Total 42 rakes (252 cars) would be required in horizon year 2019 for Mumbai Metro (Dahisar East to Mandala Metro and LIC to ITO). Accordingly budget provision of INR 2520 Crores is to be kept in the estimate for Rolling Stock, with revenue operation targeted for year 2019.

6.6 RECOMMENDATION

TOP chapter has been prepared considering 6-car train with 67% motoring. Trains with 6 car train consist (with 67% powering cars) operating @ 90 seconds headway can achieve PHPDT of approximately 72,000 with loading of 6 Passengers per sq m. The traffic projections do not suggest such requirements. However, for higher PHPDT requirements in future(up to approximately 96,000@ average train capacity of 2400 passengers with 62% motoring), the train consist of 8 cars (addition of one 'T+M' Unit) can be adopted in future. In case such scenario is planned, platform lengths shall be planned for 8 car trains.

Also, it is recommended that 3.2 m wide stock, suitable on SG may be adopted

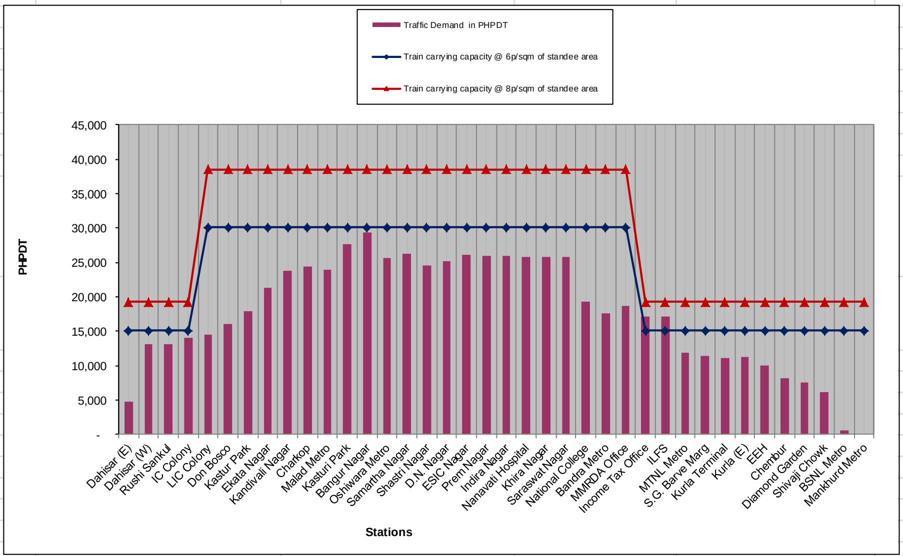
Attachment - I/A1

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to Mandala Metro Corridor)

Year:	2019
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	7.00 (Dahisar to LIC and ITO to Mandala station)
Headway (min)	3.50 (LIC to ITO)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Dahisar (E)	Dahisar (W)	4,744	15,051	19,234
2	Dahisar (W)	Rushi Sankool	13,177	15,051	19,234
3	Rushi Sankul	IC Colony	13,143	15,051	19,234
4	IC Colony	LIC Colony	13,977	15,051	19,234
5	LIC Colony	Don Bosco	14,572	30,103	38,469
6	Don Bosco	Kastur Park	16,101	30,103	38,469
7	Kastur Park	Ekata Nagar	17,931	30,103	38,469
8	Ekata Nagar	Kandivali Nagar	21,316	30,103	38,469
9	Kandivali Nagar	Charkop	23,735	30,103	38,469
10	Charkop	Malad Metro	24,428	30,103	38,469
11	Malad Metro	Kasturi Park	23,976	30,103	38,469
12	Kasturi Park	Bangur Nagar	27,600	30,103	38,469
13	Bangur Nagar	Oshiwara Metro	**29,373**	30,103	38,469
14	Oshiwara Metro	Samartha Nagar	25,583	30,103	38,469
15	Samartha Nagar	Shastri Nagar	26,307	30,103	38,469
16	Shastri Nagar	D.N. Nagar	24,496	30,103	38,469
17	D.N. Nagar	ESIC Nagar	25,157	30,103	38,469
18	ESIC Nagar	Prem Nagar	26,090	30,103	38,469
19	Prem Nagar	Indira Nagar	25,900	30,103	38,469
20	Indira Nagar	Nanavati Hospital	25,971	30,103	38,469
21	Nanavati Hospital	Khira Nagar	25,820	30,103	38,469
22	Khira Nagar	Saraswat Nagar	25,753	30,103	38,469
23	Saraswat Nagar	National College	25,857	30,103	38,469
24	National College	Bandra Metro	19,218	30,103	38,469
25	Bandra Metro	MMRDA Office	17,586	30,103	38,469
26	MMRDA Office	Income Tax Office	18,644	30,103	38,469
27	Income Tax Office	ILFS	17,169	15,051	19,234
28	ILFS	MTNL Metro	17,132	15,051	19,234
29	MTNL Metro	S.G. Barve Marg	11,799	15,051	19,234
30	S.G. Barve Marg	Kurla Terminal	11,379	15,051	19,234
31	Kurla Terminal	Kurla (E)	11,036	15,051	19,234
32	Kurla (E)	EEH	11,198	15,051	19,234
33	EEH	Chembur	10,088	15,051	19,234
34	Chembur	Diamond Garden	8,160	15,051	19,234
35	Diamond Garden	Shivaji Chowk	7,480	15,051	19,234
36	Shivaji Chowk	BSNL Metro	6,124	15,051	19,234
37	BSNL Metro	Mankhurd Metro	563	15,051	19,234
38	Mankhurd Metro	Mandala Metro	0	15,051	19,234



NOTE

Train operation has been planned in 2 loops to meet the PHPDT demand. Trains on 7 minute headway will run from Dahisar East to Mandala Metro corridor and LIC to ITO corridor respectively. This would generate more PHPDT capacity on the common section between LIC to ITO section.

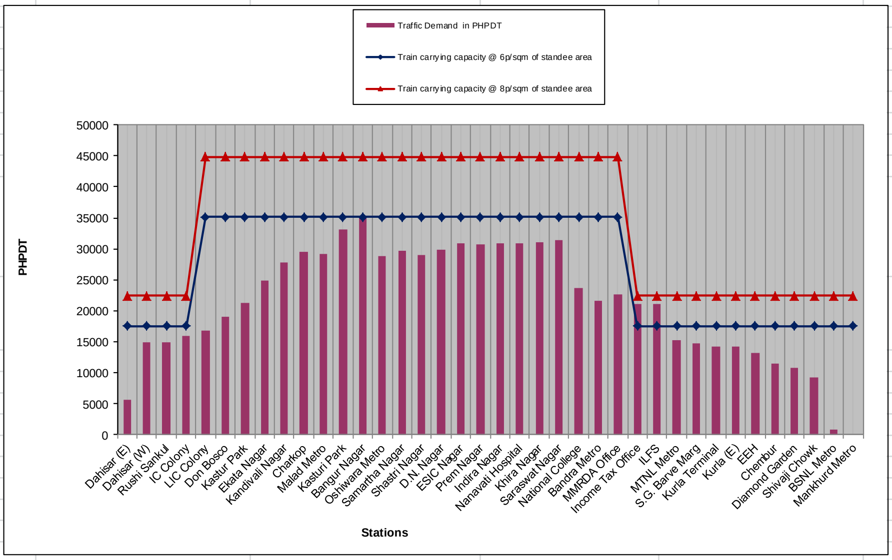
Attachment - I/B1

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to Mandala Metro Corridor)

Year:	2021
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	6.00 (Dahisar to LIC and ITO to Mandala station)
Headway (min)	3.00 (LIC to ITO)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Dahisar (E)	Dahisar (W)	5709	17,560	22,440
2	Dahisar (W)	Rushi Sankool	14907	17,560	22,440
3	Rushi Sankul	IC Colony	14883	17,560	22,440
4	IC Colony	LIC Colony	15999	17,560	22,440
5	LIC Colony	Don Bosco	16859	35,120	44,880
6	Don Bosco	Kastur Park	18986	35,120	44,880
7	Kastur Park	Ekata Nagar	21187	35,120	44,880
8	Ekata Nagar	Kandivali Nagar	24950	35,120	44,880
9	Kandivali Nagar	Charkop	27808	35,120	44,880
10	Charkop	Malad Metro	29582	35,120	44,880
11	Malad Metro	Kasturi Park	29156	35,120	44,880
12	Kasturi Park	Bangur Nagar	33072	35,120	44,880
13	Bangur Nagar	Oshiwara Metro	**35142**	35,120	44,880
14	Oshiwara Metro	Samartha Nagar	28789	35,120	44,880
15	Samartha Nagar	Shastri Nagar	29615	35,120	44,880
16	Shastri Nagar	D.N. Nagar	28922	35,120	44,880
17	D.N. Nagar	ESIC Nagar	29795	35,120	44,880
18	ESIC Nagar	Prem Nagar	30819	35,120	44,880
19	Prem Nagar	Indira Nagar	30758	35,120	44,880
20	Indira Nagar	Nanavati Hospital	30875	35,120	44,880
21	Nanavati Hospital	Khira Nagar	30914	35,120	44,880
22	Khira Nagar	Saraswat Nagar	31088	35,120	44,880
23	Saraswat Nagar	National College	31326	35,120	44,880
24	National College	Bandra Metro	23754	35,120	44,880
25	Bandra Metro	MMRDA Office	21544	35,120	44,880
26	MMRDA Office	Income Tax Office	22720	35,120	44,880
27	Income Tax Office	ILFS	21167	17,560	22,440
28	ILFS	MTNL Metro	21140	17,560	22,440
29	MTNL Metro	S.G. Barve Marg	15234	17,560	22,440
30	S.G. Barve Marg	Kurla Terminal	14677	17,560	22,440
31	Kurla Terminal	Kurla (E)	14251	17,560	22,440
32	Kurla (E)	EEH	14166	17,560	22,440
33	EEH	Chembur	13112	17,560	22,440
34	Chembur	Diamond Garden	11436	17,560	22,440
35	Diamond Garden	Shivaji Chowk	10816	17,560	22,440
36	Shivaji Chowk	BSNL Metro	9169	17,560	22,440
37	BSNL Metro	Mankhurd Metro	771	17,560	22,440
38	Mankhurd Metro	Mandala Metro	0	17,560	22,440



NOTE

Train operation has been planned in 2 loops to meet the PHPDT demand. Trains on 6 minute headway will run from Dahisar East to Mandala Metro corridor and LIC to ITO corridor respectively. This would generate more PHPDT capacity on the common section between LIC to ITO section.

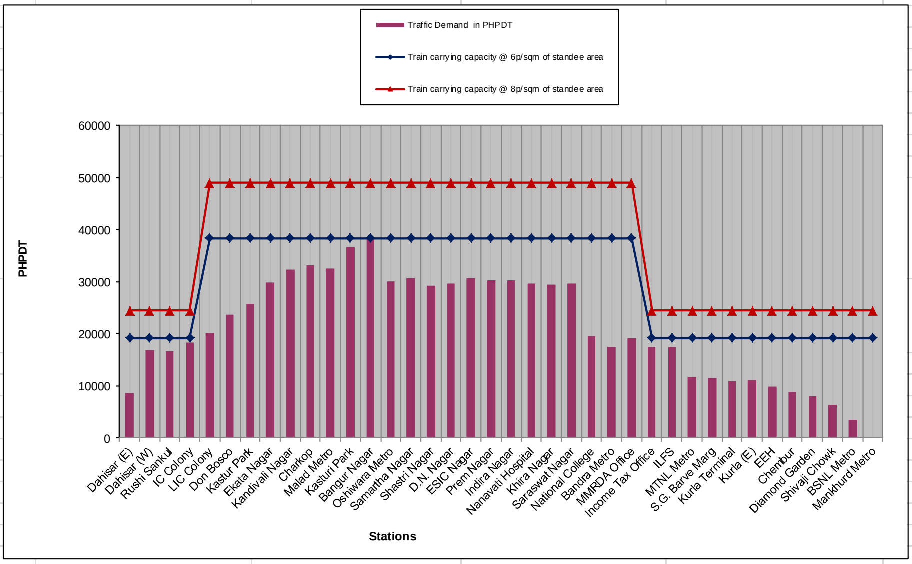
Attachment - I/C1

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to Mandala Metro Corridor)

Year:	2031
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	5.50 (Dahisar to LIC and ITO to Mandala station)
Headway (min)	2.75 (LIC to ITO)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Dahisar (E)	Dahisar (W)	8580	19,156	24,480
2	Dahisar (W)	Rushi Sankool	16764	19,156	24,480
3	Rushi Sankul	IC Colony	16721	19,156	24,480
4	IC Colony	LIC Colony	18282	19,156	24,480
5	LIC Colony	Don Bosco	20252	38,313	48,960
6	Don Bosco	Kastur Park	23759	38,313	48,960
7	Kastur Park	Ekata Nagar	25691	38,313	48,960
8	Ekata Nagar	Kandivali Nagar	29881	38,313	48,960
9	Kandivali Nagar	Charkop	32359	38,313	48,960
10	Charkop	Malad Metro	33061	38,313	48,960
11	Malad Metro	Kasturi Park	32451	38,313	48,960
12	Kasturi Park	Bangur Nagar	36684	38,313	48,960
13	Bangur Nagar	Oshiwara Metro	**38509**	38,313	48,960
14	Oshiwara Metro	Samartha Nagar	29979	38,313	48,960
15	Samartha Nagar	Shastri Nagar	30675	38,313	48,960
16	Shastri Nagar	D.N. Nagar	29221	38,313	48,960
17	D.N. Nagar	ESIC Nagar	29738	38,313	48,960
18	ESIC Nagar	Prem Nagar	30683	38,313	48,960
19	Prem Nagar	Indira Nagar	30209	38,313	48,960
20	Indira Nagar	Nanavati Hospital	30277	38,313	48,960
21	Nanavati Hospital	Khira Nagar	29630	38,313	48,960
22	Khira Nagar	Saraswat Nagar	29494	38,313	48,960
23	Saraswat Nagar	National College	29627	38,313	48,960
24	National College	Bandra Metro	19630	38,313	48,960
25	Bandra Metro	MMRDA Office	17550	38,313	48,960
26	MMRDA Office	Income Tax Office	19110	38,313	48,960
27	Income Tax Office	ILFS	17426	19,156	24,480
28	ILFS	MTNL Metro	17413	19,156	24,480
29	MTNL Metro	S.G. Barve Marg	11794	19,156	24,480
30	S.G. Barve Marg	Kurla Terminal	11481	19,156	24,480
31	Kurla Terminal	Kurla (E)	10821	19,156	24,480
32	Kurla (E)	EEH	11016	19,156	24,480
33	EEH	Chembur	9893	19,156	24,480
34	Chembur	Diamond Garden	8845	19,156	24,480
35	Diamond Garden	Shivaji Chowk	7988	19,156	24,480
36	Shivaji Chowk	BSNL Metro	6294	19,156	24,480
37	BSNL Metro	Mankhurd Metro	3443	19,156	24,480
38	Mankhurd Metro	Mandala Metro	0	19,156	24,480



NOTE

Train operation has been planned in 2 loops to meet the PHPDT demand. Trains on 5.50 minute headway will run from Dahisar East to Mandala Metro corridor and LIC to ITO corridor respectively. This would generate more PHPDT capacity on the common section between LIC to ITO section.

Attachment- II A

TABLE 1.1A

Hourly Train Operation Plan

Mumbai Metro(Dahisar East to Mandala Metro Corridor)

Year- 2019

7 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**7**	**9**	**9**
9 to 10	**7**	**9**	**9**
10 to 11	**7**	**9**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	2
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**7**	**9**	**9**
18 to 19	**7**	**8**	**8**
19 to 20	**7**	**9**	**9**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**99**	**99**

TABLE 1.2A
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to Mandala Metro Corridor)

		Year- 2021	
6 min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	2
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**106**	**106**

TABLE 1.3A
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to Mandala Metro Corridor)
Year- 2031

5.50 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	8
8 to 9	**5.5**	**11**	**10**
9 to 10	**5.5**	**11**	**10**
10 to 11	**5.5**	**11**	**10**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.5**	**10**	**11**
18 to 19	**5.5**	**10**	**11**
19 to 20	**5.5**	**10**	**11**
20 to 21	8	8	8
21 to 22	12	5	5
22 to 23	16	4	4
Total No. of train trips per direction per day		**131**	**131**

Attachment- II B

TABLE 1.1A

Hourly Train Operation Plan

Mumbai Metro(Dahisar East to LIC and ITO Mandala Metro Corridor)

Year- 2019

7 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**7**	**9**	**9**
9 to 10	**7**	**9**	**9**
10 to 11	**7**	**9**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	2
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**7**	**9**	**9**
18 to 19	**7**	**8**	**8**
19 to 20	**7**	**9**	**9**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**99**	**99**

TABLE 1.2A
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to LIC and ITO Mandala Metro Corridor)

Year- 2021

6 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	2
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**106**	**106**

TABLE 1.3A
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to LIC and ITO to Mandala Metro Corridor)
Year- 2031

5.50 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	8
8 to 9	**5.5**	**11**	**10**
9 to 10	**5.5**	**11**	**10**
10 to 11	**5.5**	**11**	**10**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.5**	**10**	**11**
18 to 19	**5.5**	**10**	**11**
19 to 20	**5.5**	**10**	**11**
20 to 21	8	8	8
21 to 22	12	5	5
22 to 23	16	4	4
Total No. of train trips per direction per day		**131**	**131**

				Attachment III	
			TABLE 2.1		
Mumbai Metro(Dahisar East to Mandala Metro Corridor)					
	PHPDT for the year 2019				
S.No	From Station	To Station	Peak hour Load	Directional Split to Dahisar (E)	Directional Split to Mandala
1	Dahisar (E)	Dahisar (W)	4,744	50%	50%
2	Dahisar (W)	Rushi Sankool	13,177	50%	50%
3	Rushi Sankul	IC Colony	13,143	50%	50%
4	IC Colony	LIC Colony	13,977	50%	50%
5	LIC Colony	Don Bosco	14,572	50%	50%
6	Don Bosco	Kastur Park	16,101	50%	50%
7	Kastur Park	Ekata Nagar	17,931	50%	50%
8	Ekata Nagar	Kandivali Nagar	21,316	50%	50%
9	Kandivali Nagar	Charkop	23,735	50%	50%
10	Charkop	Malad Metro	24,428	50%	50%
11	Malad Metro	Kasturi Park	23,976	50%	50%
12	Kasturi Park	Bangur Nagar	27,600	50%	50%
13	Bangur Nagar	Oshiwara Metro	**29,373**	50%	50%
14	Oshiwara Metro	Samartha Nagar	25,583	50%	50%
15	Samartha Nagar	Shastri Nagar	26,307	50%	50%
16	Shastri Nagar	D.N. Nagar	24,496	50%	50%
17	D.N. Nagar	ESIC Nagar	25157	50%	50%
18	ESIC Nagar	Prem Nagar	26090	50%	50%
19	Prem Nagar	Indira Nagar	25,900	50%	50%
20	Indira Nagar	Nanavati Hospital	25,971	50%	50%
21	Nanavati Hospital	Khira Nagar	25,820	50%	50%
22	Khira Nagar	Saraswat Nagar	25,753	50%	50%
23	Saraswat Nagar	National College	25,857	50%	50%
24	National College	Bandra Metro	19,218	50%	50%
25	Bandra Metro	MMRDA Office	17,586	50%	50%
26	MMRDA Office	Income Tax Office	18,644	50%	50%
27	Income Tax Office	ILFS	17,169	50%	50%
28	ILFS	MTNL Metro	17,132	50%	50%
29	MTNL Metro	S.G. Barve Marg	11,799	50%	50%
30	S.G. Barve Marg	Kurla Terminal	11379	50%	50%
31	Kurla Terminal	Kurla (E)	11036	50%	50%
32	Kurla (E)	EEH	11198	50%	50%
33	EEH	Chembur	10088	50%	50%
34	Chembur	Diamond Garden	8160	50%	50%
35	Diamond Garden	Shivaji Chowk	7480	50%	50%
36	Shivaji Chowk	BSNL Metro	6124	50%	50%
37	BSNL Metro	Mankhurd Metro	563	50%	50%
38	Mankhurd Metro	Mandala Metro	0	50%	50%

Attachment IV

TABLE 3.1
Mumbai Metro (Dahisar East to Mandala Metro Corridor)
Vehicle Kilometer

Year	2019	2021	2031
Section Length	41.96	41.96	41.96
No of cars per train	6	6	6
No of working Days in a year	340	340	340
Number of Trains per day each Way	99	106	131
Daily Train -KM	8309	8896	10994
Annual Train - KM (10^5)	28.25	30.25	37.38
Annual Vehicle - KM (10^5)	169.50	181.48	224.28

Attachment - I/A2

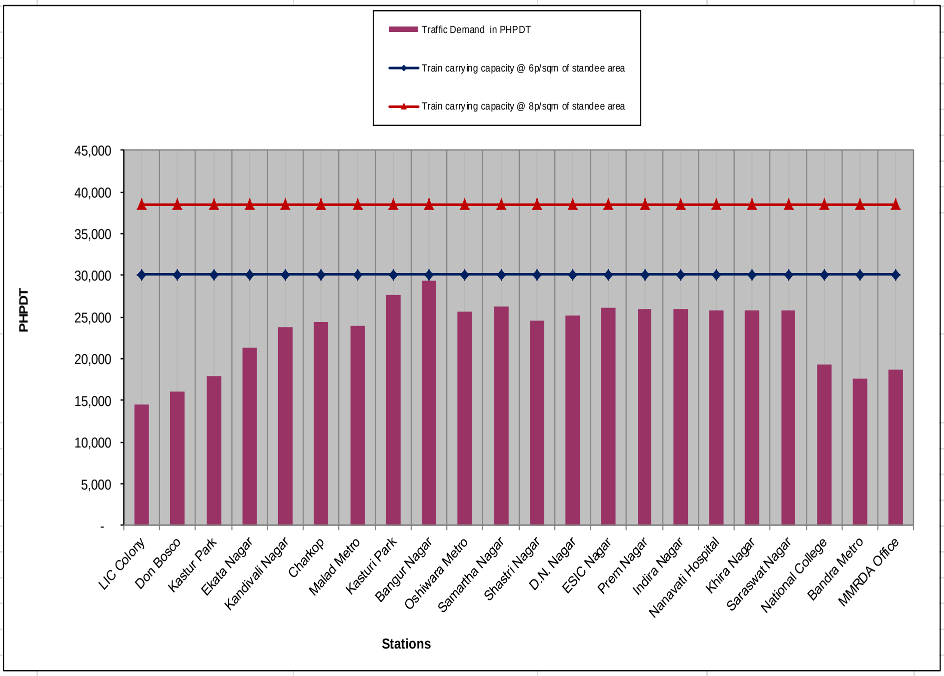
PHPDT Demand and Capacity Chart

Mumbai Metro(LIC to ITO Corridor)

Year:	2019
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	3.50

(LIC to ITO)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	LIC Colony	Don Bosco	14,572	30,103	38,469
2	Don Bosco	Kastur Park	16,101	30,103	38,469
3	Kastur Park	Ekata Nagar	17,931	30,103	38,469
4	Ekata Nagar	Kandivali Nagar	21,316	30,103	38,469
5	Kandivali Nagar	Charkop	23,735	30,103	38,469
6	Charkop	Malad Metro	24,428	30,103	38,469
7	Malad Metro	Kasturi Park	23,976	30,103	38,469
8	Kasturi Park	Bangur Nagar	27,600	30,103	38,469
9	Bangur Nagar	Oshiwara Metro	**29,373**	30,103	38,469
10	Oshiwara Metro	Samartha Nagar	25,583	30,103	38,469
11	Samartha Nagar	Shastri Nagar	26,307	30,103	38,469
12	Shastri Nagar	D.N. Nagar	24,496	30,103	38,469
13	D.N. Nagar	ESIC Nagar	25,157	30,103	38,469
14	ESIC Nagar	Prem Nagar	26,090	30,103	38,469
15	Prem Nagar	Indira Nagar	25,900	30,103	38,469
16	Indira Nagar	Nanavati Hospital	25,971	30,103	38,469
17	Nanavati Hospital	Khira Nagar	25,820	30,103	38,469
18	Khira Nagar	Saraswat Nagar	25,753	30,103	38,469
19	Saraswat Nagar	National College	25,857	30,103	38,469
20	National College	Bandra Metro	19,218	30,103	38,469
21	Bandra Metro	MMRDA Office	17,586	30,103	38,469
22	MMRDA Office	Income Tax Office	18,644	30,103	38,469



NOTE

Train operation has been planned in 2 loops to meet the PHPDT demand. Trains on 7 minute headway will run from Dahisar East to Mandala Metro corridor and LIC to ITO corridor respectively. This would generate more PHPDT capacity on the common section between LIC to ITO section.

Attachment - I/B2

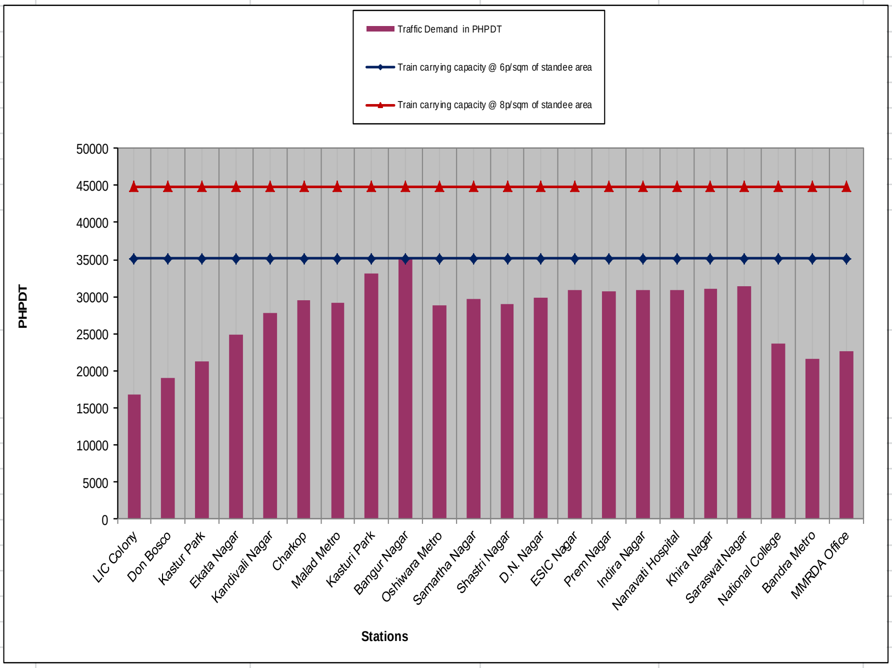
PHPDT Demand and Capacity Chart

Mumbai Metro(LIC to ITO Corridor)

Year:	2021
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	3.00

(LIC to ITO)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
5	LIC Colony	Don Bosco	16859	35,120	44,880
6	Don Bosco	Kastur Park	18986	35,120	44,880
7	Kastur Park	Ekata Nagar	21187	35,120	44,880
8	Ekata Nagar	Kandivali Nagar	24950	35,120	44,880
9	Kandivali Nagar	Charkop	27808	35,120	44,880
10	Charkop	Malad Metro	29582	35,120	44,880
11	Malad Metro	Kasturi Park	29156	35,120	44,880
12	Kasturi Park	Bangur Nagar	33072	35,120	44,880
13	Bangur Nagar	Oshiwara Metro	**35142**	35,120	44,880
14	Oshiwara Metro	Samartha Nagar	28789	35,120	44,880
15	Samartha Nagar	Shastri Nagar	29615	35,120	44,880
16	Shastri Nagar	D.N. Nagar	28922	35,120	44,880
17	D.N. Nagar	ESIC Nagar	29795	35,120	44,880
18	ESIC Nagar	Prem Nagar	30819	35,120	44,880
19	Prem Nagar	Indira Nagar	30758	35,120	44,880
20	Indira Nagar	Nanavati Hospital	30875	35,120	44,880
21	Nanavati Hospital	Khira Nagar	30914	35,120	44,880
22	Khira Nagar	Saraswat Nagar	31088	35,120	44,880
23	Saraswat Nagar	National College	31326	35,120	44,880
24	National College	Bandra Metro	23754	35,120	44,880
25	Bandra Metro	MMRDA Office	21544	35,120	44,880
26	MMRDA Office	Income Tax Office	22720	35,120	44,880



NOTE

Train operation has been planned in 2 loops to meet the PHPDT demand. Trains on 6 minute headway will run from Dahisar East to Mandala Metro corridor and LIC to ITO corridor respectively. This would generate more PHPDT capacity on the common section between LIC to ITO section.

Attachment - I/C2

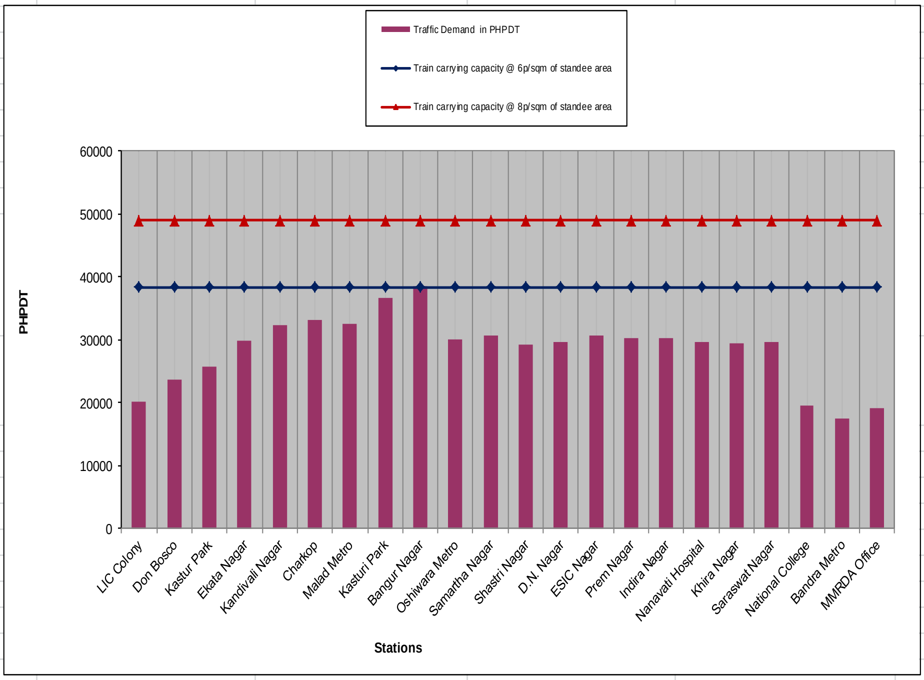
PHPDT Demand and Capacity Chart

Mumbai Metro(LIC to ITO Corridor)

Year:	2031
No. of cars per train	6
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1756
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2244
Headway (min)	2.75

(LIC to ITO)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	LIC Colony	Don Bosco	20252	38,313	48,960
2	Don Bosco	Kastur Park	23759	38,313	48,960
3	Kastur Park	Ekata Nagar	25691	38,313	48,960
4	Ekata Nagar	Kandivali Nagar	29881	38,313	48,960
5	Kandivali Nagar	Charkop	32359	38,313	48,960
6	Charkop	Malad Metro	33061	38,313	48,960
7	Malad Metro	Kasturi Park	32451	38,313	48,960
8	Kasturi Park	Bangur Nagar	36684	38,313	48,960
9	Bangur Nagar	Oshiwara Metro	**38509**	38,313	48,960
10	Oshiwara Metro	Samartha Nagar	29979	38,313	48,960
11	Samartha Nagar	Shastri Nagar	30675	38,313	48,960
12	Shastri Nagar	D.N. Nagar	29221	38,313	48,960
13	D.N. Nagar	ESIC Nagar	29738	38,313	48,960
14	ESIC Nagar	Prem Nagar	30683	38,313	48,960
15	Prem Nagar	Indira Nagar	30209	38,313	48,960
16	Indira Nagar	Nanavati Hospital	30277	38,313	48,960
17	Nanavati Hospital	Khira Nagar	29630	38,313	48,960
18	Khira Nagar	Saraswat Nagar	29494	38,313	48,960
19	Saraswat Nagar	National College	29627	38,313	48,960
20	National College	Bandra Metro	19630	38,313	48,960
21	Bandra Metro	MMRDA Office	17550	38,313	48,960
22	MMRDA Office	Income Tax Office	19110	38,313	48,960



NOTE

Train operation has been planned in 2 loops to meet the PHPDT demand. Trains on 5.50 minute headway will run from Dahisar East to Mandala Metro corridor and LIC to ITO corridor respectively. This would generate more PHPDT capacity on the common section between LIC to ITO section.

Attachment- II A

TABLE 1.1B

Hourly Train Operation Plan

Mumbai Metro(LIC to ITO Corridor)

Year- 2019

7 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**7**	**9**	**9**
9 to 10	**7**	**9**	**9**
10 to 11	**7**	**9**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	2
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**7**	**9**	**9**
18 to 19	**7**	**8**	**8**
19 to 20	**7**	**9**	**9**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**99**	**99**

TABLE 1.2B
Hourly Train Operation Plan
Mumbai Metro(LIC to ITO Corridor)

		Year- 2021	
6 min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	2
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	2
Total No. of train trips per direction per day		**106**	**106**

TABLE 1.3B Hourly Train Operation Plan Mumbai Metro(LIC to ITO Corridor) Year- 2031 5.50 min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	8
8 to 9	**5.5**	**11**	**10**
9 to 10	**5.5**	**11**	**10**
10 to 11	**5.5**	**11**	**10**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.5**	**10**	**11**
18 to 19	**5.5**	**10**	**11**
19 to 20	**5.5**	**10**	**11**
20 to 21	8	8	8
21 to 22	12	5	5
22 to 23	16	4	4
Total No. of train trips per direction per day		**131**	**131**

Attachment-II B

TABLE 1.1B
Hourly Train Operation Plan
Mumbai Metro(LIC to ITO Corridor)
Year -2019

3.5 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	6	6
6 to 7	20	6	6
7 to 8	10	12	12
8 to 9	**7**	18	18
9 to 10	**7**	18	18
10 to 11	**7**	18	18
11 to12	10	12	12
12 to 13	20	6	6
13 to 14	24	4	4
14 to 15	24	6	6
15 to 16	20	6	6
16 to 17	10	12	12
17 to 18	**7**	18	18
18 to 19	**7**	16	16
19 to 20	**7**	18	18
20 to 21	10	12	12
21 to 22	20	6	6
22 to 23	24	4	4
Total No. of train trips per direction per day		**198**	**198**

TABLE 1.2B
Hourly Train Operation Plan
Mumbai Metro(LIC to ITO Corridor)
Year -2021

3 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	6	6
6 to 7	20	6	6
7 to 8	10	12	12
8 to 9	**6**	20	20
9 to 10	**6**	20	20
10 to 11	**6**	20	20
11 to12	10	12	12
12 to 13	20	6	6
13 to 14	24	4	4
14 to 15	24	6	6
15 to 16	20	6	6
16 to 17	10	12	12
17 to 18	**6**	20	20
18 to 19	**6**	20	20
19 to 20	**6**	20	20
20 to 21	10	12	12
21 to 22	20	6	6
22 to 23	24	4	4
Total No. of train trips per direction per day		**212**	**212**

TABLE 1.3B
Hourly Train Operation Plan
Mumbai Metro(LIC to ITO Corridor)
Year -2031

2.75 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DOWN
5 to 6	16	8	8
6 to 7	12	10	10
7 to 8	8	16	16
8 to 9	**5.5**	22	20
9 to 10	**5.5**	22	20
10 to 11	**5.5**	22	20
11 to12	8	16	16
12 to 13	12	10	10
13 to 14	16	8	8
14 to 15	16	8	8
15 to 16	12	10	10
16 to 17	8	16	16
17 to 18	**5.5**	20	22
18 to 19	**5.5**	20	22
19 to 20	**5.5**	20	22
20 to 21	8	16	16
21 to 22	12	10	10
22 to 23	16	8	8
Total No. of train trips per direction per day		**262**	**262**

Attachment III

TABLE 2.2

Mumbai Metro(LIC to ITO Corridor)

PHPDT for the year 2019

S.No	From Station	To Station	Peak hour Load	Directional Split to LIC	Directional Split to ITO
1	LIC Colony	Don Bosco	14,572	50%	50%
2	Don Bosco	Kastur Park	16,101	50%	50%
3	Kastur Park	Ekata Nagar	17,931	50%	50%
4	Ekata Nagar	Kandivali Nagar	21,316	50%	50%
5	Kandivali Nagar	Charkop	23,735	50%	50%
6	Charkop	Malad Metro	24,428	50%	50%
7	Malad Metro	Kasturi Park	23,976	50%	50%
8	Kasturi Park	Bangur Nagar	27,600	50%	50%
9	Bangur Nagar	Oshiwara Metro	**29,373**	50%	50%
10	Oshiwara Metro	Samartha Nagar	25,583	50%	50%
11	Samartha Nagar	Shastri Nagar	26,307	50%	50%
12	Shastri Nagar	D.N. Nagar	24,496	50%	50%
13	D.N. Nagar	ESIC Nagar	25157	50%	50%
14	ESIC Nagar	Prem Nagar	26090	50%	50%
15	Prem Nagar	Indira Nagar	25,900	50%	50%
16	Indira Nagar	Nanavati Hospital	25,971	50%	50%
17	Nanavati Hospital	Khira Nagar	25,820	50%	50%
18	Khira Nagar	Saraswat Nagar	25,753	50%	50%
19	Saraswat Nagar	National College	25,857	50%	50%
20	National College	Bandra Metro	19,218	50%	50%
21	Bandra Metro	MMRDA Office	17,586	50%	50%
22	MMRDA Office	Income Tax Office	18,644	50%	50%

Attachment IV

TABLE 3.2

Mumbai Metro (LIC to ITO Corridor)

Vehicle Kilometer

Year	2019	2021	2031
Section Length	24.72	24.72	24.72
No of cars per train	6	6	6
No of working Days in a year	340	340	340
Number of Trains per day each Way	99	106	131
Daily Train -KM	4895	5241	6477
Annual Train - KM (10^5)	16.64	17.82	22.02
Annual Vehicle - KM (10^5)	99.86	106.92	132.13

Attachment-V

Year-2019

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered * (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement					Total cars
											Bare	Bare	Traffic Reserve	R&M	Total No. Of Rakes(6-car configuration)	
1	Mumbai Metro(Dahisar East to Mandala Corridor)	41.96	35	2019	7.00	71.94	6	0	6	149.88	21.41	22	1	3	26	**156**
	Mumbai Metro(LIC to ITO Corridor)	24.72	35	2019	7.00	42.38	6	0	6	90.76	12.97	13	1	2	16	**96**

Year-2021

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered * (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement					Total cars
											Bare	Bare	Traffic Reserve	R&M	Total No. Of Rakes(6-car configuration)	
1	Mumbai Metro(Dahisar East to Mandala Corridor)	41.96	35	2021	6.00	71.93	6	0	6	149.86	24.98	25	1	3	29	**174**
	Mumbai Metro(LIC to ITO Corridor)	24.72	35	2021	6.00	42.38	6	0	6	90.76	15.13	16	1	2	19	**114**

Year-2031

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered * (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement					Total cars
											Bare	Bare	Traffic Reserve	R&M	Total No. Of Rakes(6-car configuration)	
1	Mumbai Metro(Dahisar East to Mandala Corridor)	41.96	35	2031	5.50	71.93	6	0	6	149.86	27.25	28	1	3	32	**192**
	Mumbai Metro(LIC to ITO Corridor)	24.72	35	2031	5.50	42.38	6	0	6	90.76	16.50	17	1	2	20	**120**

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

Chapter 7 – Maintenance Depot

Chapter - 7

MAINTENANCE DEPOT

7.1 Corridor: Dahisar East-Mandala corridor comprises as below:

Corridor	Route length(Km)
Dahisar East-Mandala corridor	42.232

Train operation has been planned in two loops to meet the PHPDT demand. One train on given headway will run from Dahisar(E) to Mandala section and other train would be run on LIC to Income tax office(ITO) section. This would generate more PHPDT capacity on the common section between LIC to ITO.

Two depots have been planned. Main depot is present at Mandala and satellite depot at Charkop.

7.2 DEPOT- CUM- WORKSHOP AT MANDALA & CHARKOP

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 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 to cater to the required stability facilities.

In broad terms, based on the planned Rolling Stock requirements, this chapter covers conceptual design on following aspects and will work as a guide for detailed design later:

- Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.
- Operational and functional safety requirements.

- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

7.3 MAINTENANCE PHILOSOPHY

- Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, "A" checks, "B" type checks, "IOH" and "POH".
- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation is given due attention.

7.4 ROLLING STOCK MAINTENANCE NEEDS

7.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 232 kms running per train per day, taking in consideration the passenger load of 2019,2021 & 2031 respectively.

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub -systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (approx. 45 days)	Detailed Inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km, (3 and half Years approx.) whichever is earlier	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km, (7 Years approx.) whichever is earlier	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

7.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

S. N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	Automatic washing plant & cleaning & washing shed

7.5 YEAR-WISE PLANNING OF MAINTENANCE FACILITY SETUP AT DEPOT CUM WORKSHOP BASED ON PLANNED ROLLING STOCK REQUIREMENT IN TOP IS TABULATED BELOW:

(i) Planned rakes as per TOP:

TABLE-7.3

Year	No. of Rakes	No. of coaches
2019	42	252
2021	48	288
2031	52	312

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

Year	No. of Rakes	SBLs*	IBLs**	WSLs***
2019	42	36 lines x one train of 8-car length	Two bay, each of 3 lines with one train of 8- car length. One bay is required from the year 2019 and 2nd bay is required from the year 2021 and catering up to year 2031.	Three bays of 2 lines each with one train of 8- car length. Two bays are required from year 2019 and one bay to be required from 2021 and catering up to year 2031. Space to be earmarked for One Workshop bay at Charkop beyond year 2031.
2021	48	42 lines x one train of 8-car length		
2031	52	46 lines x one train of 8-car length		

* Maximum no of stabling lines to be made in main depot at Mandala and balance stabling line to be made at Satellite depot at charkop.

** One inspection bay of three line to be made in main depot at Mandala and balance one bay to be made at Satellite depot, charkop.

*** Two Workshop bay to be made in main depot at Mandala and balance one bay to be made at Satellite depot at charkop. Space to be earmarked for One Workshop bay at Charkop beyond year 2031.

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

Schedule	**Maintenance Requirement (No. of Cars)**	**Lines Needed**
i) Year 2019 - Maximum no. of rake holding is 42 TS x6 (= 252 Cars)		
'A' Checks (5000 km) approx. 15 days	(42X6) Cars = 252 Cars	1 Line x one train of 8- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(42X6) Cars = 252 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		Two bay, each of 3 lines with one train of 8- car length. One bay is required from the year 2019 and 2nd bay is required from the year 2021 and catering upto year 2031.
ii) Year 2021 - Maximum no. of rake holding is 48 TS x6 (= 288 Cars)		
'A' Checks (5000 km) approx. 15 days	(48X6) Cars = 288 Cars	2 Line x one train of 8- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(48X6) Cars = 288 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	2 Line x one train of 8- Cars (with Sunken Floor)
Requirement		Two bay, each of 3 lines with one train of 8- car length. One bay is required from the year 2019 and 2nd bay is required from the year 2021 and catering upto year 2031.
iii) Year 2031 -Maximum no. of rake holding is (52 x6 = 312Cars)		

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
'A' Checks (5000 km) 15 days	(52 X 6) Cars = 312 Cars	2 Line x one train of 8- Cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	(52 X 6) Cars = 312 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	2 Line x one train of 8- Cars (with Sunken Floor)
Requirement		Two bay, each of 3 lines with one train of 8- car length. One bay is required from the year 2019 and 2nd bay is required from the year 2021 and catering upto year 2031.

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
- 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 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates lengths have been taken in consideration:

(i) Length of one 8- Car rake= 184 m
(ii) Pathway in the entry side=11m
(iii) Free length at outer ends (for cross pathway, Signal and Friction buffers)= 11m
(iv) Total length of Stabling lines = 11+184+11= 206 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) Pathway in the entry side = 11 m
(iii) Free length at outer ends (for cross pathway, Signal and Friction buffers)= 11m
(iv) Total length of Inspection lines = 11+184+11= 206m approx

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the lines= 7.5 m
(ii) Centre line of outer lines to column of Shed= 3 m
(iii) Width of a 3 line Inspection Bay= 3+ 7.5+7.5+ 3= 21 meter

a) There shall be one inspection bay of 206 m X 21 m size each with provision of accommodating three inspection lines each having sunken floor and overhead roof inspection platforms at each of the line. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m.

b) Roof Inspection platforms of 1.2m width and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. The inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

7.8.3 Workshop Shed at Depot:

Requirement of workshop lines is planned as under:

Year	IOH & POH	Major Overhauling	Unschedule repairs /lifting	Total	Remarks
2019	2 lines of 8-Car train and free space for storage of other equipment.		2 lines each of 8 Car train length.	Two bays are required from year 2019 and one bay to be required from 2021 and catering up to year 2031. Space to be earmarked for One Workshop bay at Charkop beyond year 2031.	The size of one workshop bay shall be 206 X 21 m comprising of two lines capable of accommodating one train of 8- Car each with Bogie turn table facility, with free space for storage of wheel/ bogie/ equipments etc.
2021	4 lines of 8-Car train and free space for storage of other equipment.		2 lines each of 8 Car train length		
2031	-do-	-do-	-do-		

(a) There shall be two bay comprising of two lines (as detailed in 'Remarks' above). Size of the one workshop bay is proposed to be 206m x 21m. The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 3- Car unit simultaneously for quick change of bogie, thereby saving down time of Rolling Stock. The arrangement of jack system shall be such that lifting of any coach in train formation for replacement of bogie/equipments is also individually possible. Space on one line shall be available for stocking of Bogies and wheels. These lines are to be provided with pits at regular intervals for inspection of undercarriage and lines are to be interconnected by turn tables. Each workshop bay shall be equipped with two 15T and 5T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be space provided for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AWo (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 206 x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor
10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs
16. Couplers/Gangways
17. Coach Painting (Applicable only for Aluminum coaches, if any)

7.9 CAR DELIVERY AREA

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum-Workshop by rail.

However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

7.10 OPERATIONAL FEATURES

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

7.11 INFRASTRUCTURE FACILITIES

I. Inspection and Workshop facilities:
As indicated in 10.8.2 & 10.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 10.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Annexure I.

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 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 and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

i) Close to the depot entry.

ii) Close to the stabling lines.

iii) Close to the Workshop/IBL.

b) Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated at Para 10.12.1. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given at Paras 10.12.1 & 10.12.2.

7.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.
b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is 'Live'.
c) Multi level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.
d) Pillars in the inspection bay & workshop should have provision for power sockets.
e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.
f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.
g) Control Centre, PPIO & store depot must be close to Workshop.
h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.
i) Provision of water hydrants should be done in workshops & stabling yards also.
j) Compressed air points along with water taps should be available in interior of buildings for cleaning.
k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

7.12 LIST OF BUILDINGS & LIST OF PLANTS & EQUIPMENTS AT DEPOT-CUM-WORKSHOP:

7.12.1 List of Buildings at Depot-cum-workshop:

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	206m x 21m	Servicing of Cars for 15 days & 45 days inspection.
	Workshop Shed	206 x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.

S.No	Name of Building	Size	Remarks
	Associated Sections	206m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	206m x ----m	Maximum stabling line available in Mandala Depot ,balance stabling lines to made at Charkop.
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	60m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	206m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
12.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
13.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
14.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
15.	a)Traction	a)120m x 80m	Traction Power Supply

S.No	Name of Building	Size	Remarks
	25/33kV/66kV sub station b) Feeding Post	b) 15m x30m	
16.	Waste Collection Bin	10m x 10m	Garbage dumping
17.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
18.	Work shop Manager Office	30m x 20m	Office of Depot in charge
19.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
20.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
21.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
22.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

7.12.2 List of Plants & Equipments at Depot-cum-Workshop at Mandala:

S. No.	Description	Unit	Depot	Approximate procurement cost (INR Lac)
			Inspection Lines	Depot M&P
			3	
			Workshop Lines	
			4	
1	Under floor Pit Wheel lathe	No.	**1**	**621**
2	RRM for wheel lathe	No.	**1**	**184**
3	Battery Shunting Loco	No.	**1**	**318**
4	Electric Tractors (RRM)	No.	**1**	**200**
5	Pit Jacks-for 4 car unit	No.	**1**	**521**
6	Mobile Jacks for Lifting cars (4 car unit)	No.	**2**	**250**
7	Automatic Train Washing Plant	No.	**1**	**268**
8	Bogie Test Stand	No.	**1**	**360**
9	CNC Wheel Press	No.	1	**600**
10	Rel Fed Bogie Wash Plant	No.	1	**278**
11	CNC Vertical Turret Lathe	No.	1	**600**
12	Coach Underframe/Blow Down Plant	No.	1	**218**

S. No.	Description	Unit	Depot	Approximate procurement cost (INR Lac)
			Inspection Lines	Depot M&P
			3	
			Workshop Lines	
			4	
13	Mobile jib Cranes(1T Manual)	No.	**1**	**1**
14	Mobile Lifting Table(1T for Insp)	No.	**1**	**3**
15	Mobile Lifting Table (3T for WS)	No.	**1**	**3**
16	Work Lift Platform	No.	**1**	**7**
17	Bogie Turn table (25T roll over capacity)	No.	**4**	**97**
18	High Pressure Wash Pumps	No.	**2**	**23**
19	High capacity vacuum cleaner	No.	**1**	**5**
20	AC Filter cleaning machine	No.	**1**	**21**
21	Mobile Compressor(10bar at 20 CFM)	No.	**1**	**4**
22	Air Compressor	No.	**1**	**5**
23	EMU Battery Charger	No.	**2**	**13**
24	Rerailling equipment (set)	No.	**1**	**75**
25	Road cum rail vehicles with crane for rerailing equipment	No.	**1**	**42**
26	container for rerailing equipment	No.	**1**	**4**
27	Truck	No.	**1**	**2**
28	Welding and Cutting Equipments	No.	**1**	**2**
29	Work Test Benches	No.	**LS**	**10**
30	Weighing scales(5T)	No.	**1**	**1**
31	Storage Bins and pallets	No.	**1**	**8**
32	Pallet Trucks	No.	**4**	**5**
33	Fork Lift Truck-3T(Elect)	No.	**2**	**19**
34	Stackers (1T for DCOS)	No.	**1**	**10**
35	Mobile Safety Steps	No.	**5**	**1**
36	Set of Pallets	No.	**LS**	**7**
37	Storage racks (W/shop & DCOS stores)	No.	**1**	**85**
38	Electric and Pneumatic Tools	No.	**LS**	**25**
39	Measuring and calibration equipment Instruments	No.	**LS**	**25**
40	Special Jigs and Fixtures	No.	**LS**	**25**

S. No.	Description	Unit	Depot	Approximate procurement cost (INR Lac)
			Inspection Lines	Depot M&P
			3	
			Workshop Lines	
			4	
41	Industrial Furniture	No.	**LS**	**55**
42	Miscellaneous	No.	**LS**	**40**
43	Minor diagnostic equipment/ Electronic equipment	No.	**LS**	**15**
44	Induction heater	No.	**1**	**8**
45	Bearing puller	No.	**1**	**8**
46	Training equipment/ diagnostic software/computer equipment/laptop etc.	No.	**LS**	**10**
47	Auto wheel profile meter	No.	**1**	**20**
48	High Rise Work lift Platform (HRWP)	No.	**1**	**35**
49	Video diagnostic equipment for TM	No.	1	**15**
50	Impluse Tester for TMs	No.	1	**18**
51	Pentograph checking fixture	No.	1	**30**
	Total			**5200**

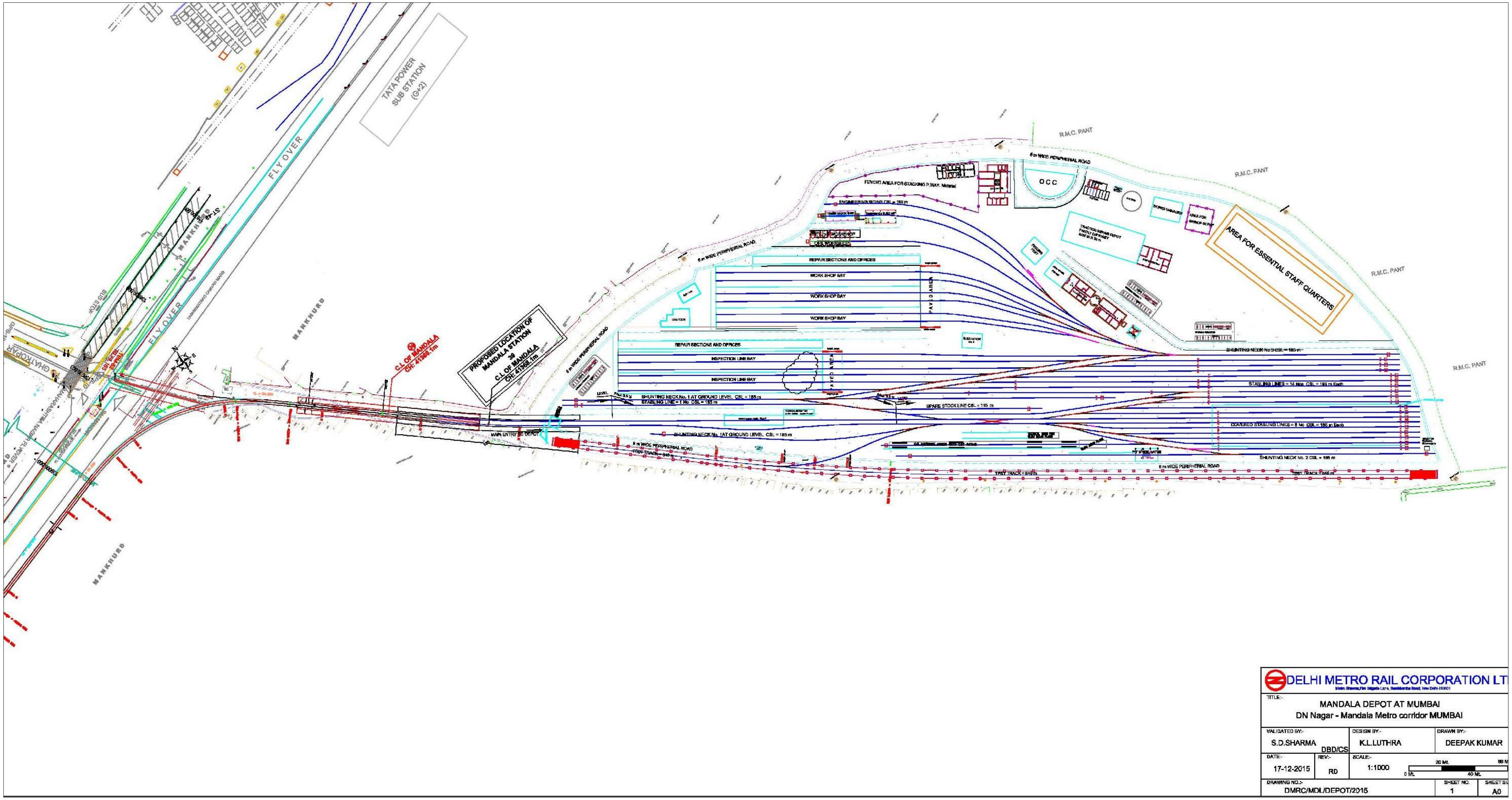
7.12.3 List of Plants & Equipments at Depot-cum-Workshop at Charkop:

S. No.	Description	Unit	Depot	Approximate procurement cost (INR Lac)
			Inspection Lines	Depot M&P
			2	
			Workshop Lines	
			2	
1	Under floor Pit Wheel lathe	No.	**1**	**621**
2	RRM for wheel lathe	No.	**1**	**184**
3	Electric Tractors (RRM)	No.	**1**	**200**
4	Pit Jacks-for 4 car unit	No.	**1**	**521**
5	Mobile Jacks for Lifting cars (4 car unit)	No.	**2**	**250**
6	Automatic Train Washing Plant	No.	**1**	**268**
7	Mobile jib Cranes(1T Manual)	No.	**1**	**1**
8	Mobile Lifting Table(1T for Insp)	No.	**1**	**3**

S. No.	Description	Unit	Depot	Approximate procurement cost (INR Lac)
			Inspection Lines	Depot M&P
			2	
			Workshop Lines	
			2	
9	Mobile Lifting Table (3T for WS)	No.	**1**	**3**
10	Work Lift Platform	No.	**1**	**7**
11	Bogie Turn table (25T roll over capacity)	No.	**2**	**97**
12	High Pressure Wash Pumps	No.	**2**	**23**
13	High capacity vacuum cleaner	No.	**1**	**5**
14	AC Filter cleaning machine	No.	**1**	**21**
15	Mobile Compressor(10bar at 20 CFM)	No.	**1**	**4**
16	Air Compressor	No.	**1**	**5**
17	EMU Battery Charger	No.	**2**	**13**
18	Rerailling equipment (set)	No.	**1**	**75**
19	Road cum rail vehicles with crane for rerailing equipment	No.	**1**	**42**
20	container for rerailing equipment	No.	**1**	**4**
21	Truck	No.	**1**	**2**
22	Welding and Cutting Equipments	No.	**1**	**2**
23	Work Test Benches	No.	**LS**	**10**
24	Weighing scales(5T)	No.	**1**	**1**
25	Storage Bins and pallets	No.	**1**	**8**
26	Pallet Trucks	No.	**4**	**5**
27	Fork Lift Truck-3T(Elect)	No.	**2**	**19**
28	Stackers (1T for DCOS)	No.	**1**	**10**
29	Mobile Safety Steps	No.	**5**	**1**
30	Set of Pallets	No.	**LS**	**7**
31	Storage racks (W/shop & DCOS stores)	No.	**1**	**85**
32	Electric and Pneumatic Tools	No.	**LS**	**25**
33	Measuring and calibration equipment Instruments	No.	**LS**	**25**
34	Special Jigs and Fixtures	No.	**LS**	**25**
35	Industrial Furniture	No.	**LS**	**55**
36	Miscellaneous	No.	**LS**	**40**

S. No.	Description	Unit	Depot	Approximate procurement cost (INR Lac)
			Inspection Lines	Depot M&P
			2	
			Workshop Lines	
			2	
37	Minor diagnostic equipment/ Electronic equipment	No.	**LS**	**15**
38	Induction heater	No.	**1**	**8**
39	Bearing puller	No.	**1**	**8**
40	Training equipment/ diagnostic software/computer equipment/laptop etc.	No.	**LS**	**10**
41	Auto wheel profile meter	No.	**1**	**20**
42	High Rise Work lift Platform (HRWP)	No.	**1**	**35**
43	Video diagnostic equipment for TM	No.	**1**	**15**
44	Impluse Tester for TMs	No.	**1**	**18**
45	Pantograph checking fixture	No.	**1**	**30**
	Total			**2826**

Depot Plan


TATA POWER SUB STATION (G+2)
FLYOVER
R.M.C. PANT
OCC
AREA FOR ESSENTIAL STAFF QUARTERS
MANKHURD
PROPOSED LOCATION OF MANDALA STATION
C.L OF MANDALA
REPAIR SECTIONS AND OFFICES
WORK SHOP BAY
INSPECTION LINE BAY
PAVED AREA
MAIN ENTRY TO DEPOT
DELHI METRO RAIL CORPORATION LTD
TITLE:-
MANDALA DEPOT AT MUMBAI
DN Nagar - Mandala Metro corridor MUMBAI
VALIDATED BY:-
S.D.SHARMA
DBD/CS
DESIGN BY:-
K.L.LUTHRA
DRAWN BY:-
DEEPAK KUMAR
DATE:-
17-12-2015
REV:-
R0
SCALE:-
1:1000
DRAWING NO.:-
DMRC/MDL/DEPOT/2015
SHEET NO.
1
A0

Chapter 8 – Power Supply Arrangements

Chapter - 8

POWER SUPPLY ARRANGEMENTS

Power supply is the lifeline of Metro System

8.1 POWER REQUIREMENTS

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 80 KWh/1000 GTKM
(ii) Regeneration by rolling stock – 30%
(iii) Elevated/at –grade station load – initially 250 kW, which will increase to 500 kW in the year 2031
(iv) Depot auxiliary load - initially 2000 kW, which will increase to 2500 kW in the year 2031.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2019, 2021 and 2031 are summarized in table 8.1 below:

Table 8.1 Power Demand Estimation (MVA)

Corridor	Load	Year		
		2019	**2021**	**2031**
D N Nagar to Mandala Metro 22 Stations (23.643 km)	Traction	16.84	19.65	21.53
	Auxiliary	8.96	11.86	16.06
	Total	**25.80**	**31.51**	**37.59**

The detailed calculations of power demand estimation are attached at annexure 8.1

8.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed Mumbai metro system is being designed to handle about 38,509 passengers per direction during peak hours when trains are expected to run at 2.75 minutes intervals. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220 kV, 110 kV or 66 kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

8.3 SOURCES OF POWER SUPPLY

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

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

Table 8.2 Sources of Power Supply

S. No.	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length cables from GSS to RSS
1.	**D N Nagar to Mandala Metro** 22 Stations (23.643 km)	110 kV Grid Sub Station (GSS) Near MMRDA Office	RSS at MMRDA Office Station	To be confirmed by TATA Power
		110 kV Grid Sub Station (GSS) Near Mankhurd	RSS at Mandala Depot	To be confirmed by TATA Power

For Supply of RSS Near MMRDA Office Station and Mandala Depot, a letter No. DMRC/Elect/Mumbai/2015, dated 12.11.2015 has been sent to TATA Power Company for confirmation of source of power supply (Annexure – 8.2). In view of this, during the detail design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 8.3.

Table 8.3 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand** – Emergency (MVA)	
		Year (2019)	Year (2031)	Year (2019)	Year (2031)
D N Nagar to Mandala Metro 22 Stations (23.643 km)	**RSS Near MMRDA Office Station**				
	Traction	7.67	9.765	16.84	21.53
	Auxiliary	3.48	6.78	8.96	16.06
	Sub-total (A)	**11.15**	**16.545**	**25.80**	**37.59**
	RSS at Mandala Depot				
	Traction	9.17	11.765	16.84	21.53
	Auxiliary	5.48	9.28	8.96	16.06
	Sub-total (B)	**14.65**	**21.045**	**25.80**	**37.59**

** Incase of failure of other source of power

The 110 kV power supply will be stepped down to 33 kV level at the RSS's of metro authority. The 33 kV power will be distributed along the alignment through 33 kV Ring main cable network for feeding traction and auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of One RSS of the line on fault or input supply failure, train services can be maintained from stand-by source of the same line. But if one more RSS fails, only curtailed services can be catered to. However, in case of total grid failure, all trains may come to a halt but station lighting, fire and hydraulics & other essential services can be catered to by stand-by DG sets. However, no train services can be run with power supply received from DG Sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well, except for the train running.

Typical High Voltage Receiving Sub-station

The 110 kV cables will be laid through public pathways from TATA Power Sub-stations to RSS of Metro Authority. RSS Near MMRDA Office station shall be provided with 2 Nos. (One as standby) 110 / 25 kV, 21.6/30 MVA (ONAN / ONAF) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 110 / 33 kV, 20 MVA (ONAN) three phase Transformers for feeding auxiliary loads and RSS at Mandala Depot shall also be provided with 2 Nos. (One as standby) 110 / 25 kV, 21.6/30 MVA (ONAN / ONAF) Traction Transformers for feeding Traction load and 2 Nos. (One as standby) 110 / 33 kV, 20 MVA (ONAN) three phase Transformers for feeding auxiliary loads. The capacity of transformers may be reviewed considering the load requirement/distribution of D N Nagar to Mandala corridor also at the time of detailed design.

Gas Insulated Switchgear (GIS) type 110 kV Switchgear is proposed for all the RSS to be located in approx. 80 X 50 m (4000 sq. m).

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** – The system can cater to traffic needs even in excess of 75000 PHPDT, which, however, is restricted on account of other constraints.

- **Easy of capacity enhancement** – Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation.

- **Higher efficiency of operation** – The efficiency of regeneration is substantially more than DC systems and line losses are very less of the order of 5%. 100% recovery of regenerated energy is possible in the case of 25 kV AC traction compared to a figure of 75% in the case of 1500 V DC systems and 60% in the case of 750 V DC systems.

- **Less Fire hazards**-AC system poses lesser fire hazards as current levels are much lower than DC system.

- **Stray current** - There are no problem of stray currents and hence nearby metallic structures are not affected by corrosion. However there are problems of EMC / EMI which can be controlled by using return conductor & screened cables in signaling applications & fiber optic cable in telecommunication system without using booster transformer as per recent developments. This also helps in avoiding use of booster transformer which causes 2% line loss and excessive voltage drops besides involving maintenance & reliability issues.

- Traction equipments in 25 kV AC system are standardized & mostly indigenously available.
- Though in underground section higher side tunnel diameter because an issue but this is not the case here.

b) 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-** 60% of re-generated energy in a 750 V DC system is possible to be retrieved.

- **Safety hazards with use of high voltage at ground level-** Due to existence of the “live” third rail at ground level, this system can be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.

- **Line losses-** Line losses are more due to higher current. Transmission line losses on 750 V DC traction system are around 21% as against 5% of 25 kV AC traction system.

- **Phenomenon of stray current-** In a third rail system, where the running rails are used as a return path, a part of the return current leaks into track structure. This current is called stray current. It is necessary to manage the stray current to ensure minimal corrosion effect and consequent damages to metallic components in the track structure as well as metallic reinforcement and metal pipes of building of metro and public areas adjacent to the Metro alignment.

c) 1500 V dc system with Overhead Catenary System:-Demerits

- Higher maintenance requirement and costs as compared to 750V DC third rail system.

- Theoretical traffic capacity with 1500 V traction system is less as compared to 25 kV AC system.

- Line losses are more due to higher current as compared to 25 kV AC. It may be in the range of 10 to 12% as against 5% of 25 kV AC system.

d) 2x25 kV a c single phase ac traction system

The following are the benefit of 2x25 kV ac traction system used for **Dahisar to Mandala (42 km)** corridor are:

- **Reduced no. of RSS** – only two RSS (Dahisar depot RSS and Mandala depot RSS) are sufficient to cater total power requirement instead of four RSS. However two RSS can meet normal load requirement which can be reviewed at the design stage.

- Do away with the BT/RC system as the electromagnetic interference reduce in 2x25 kV system, however space for autotransformer shall be required.

- Reduced transmission losses in the system.

- In the event of 2 x 25 kV traction systems being adopted no of neutral section shall reduce.

- Load balancing will be better on all the three phase using Scott connected transformer.

With the use of 2x25 kV system return conductor shall be replaced by feeder wire and the design shall be finalized accordingly.

In view of above techno-economic considerations, 2x25 kV AC traction system is suggested for Dahisar to Mandala (42 km) corridor, otherwise 25 kV ac system is preferred.

8.5 ELECTROMAGNETIC INTERFERENCE (EMI) AND ELECTROMAGNETIC COMPATIBILITY (EMC)

25 kV AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors –Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated via duct and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25 kV OHE and the elevated viaduct.

Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/EMC plan will be required to be developed during project implementation stage.

8.6 AUXILIARY SUPPLY ARRANGEMENTS FOR ELEVATED STATIONS

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 500 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415 kV) of 630 kVA capacity are proposed to be installed at the stations (one transformer as standby).

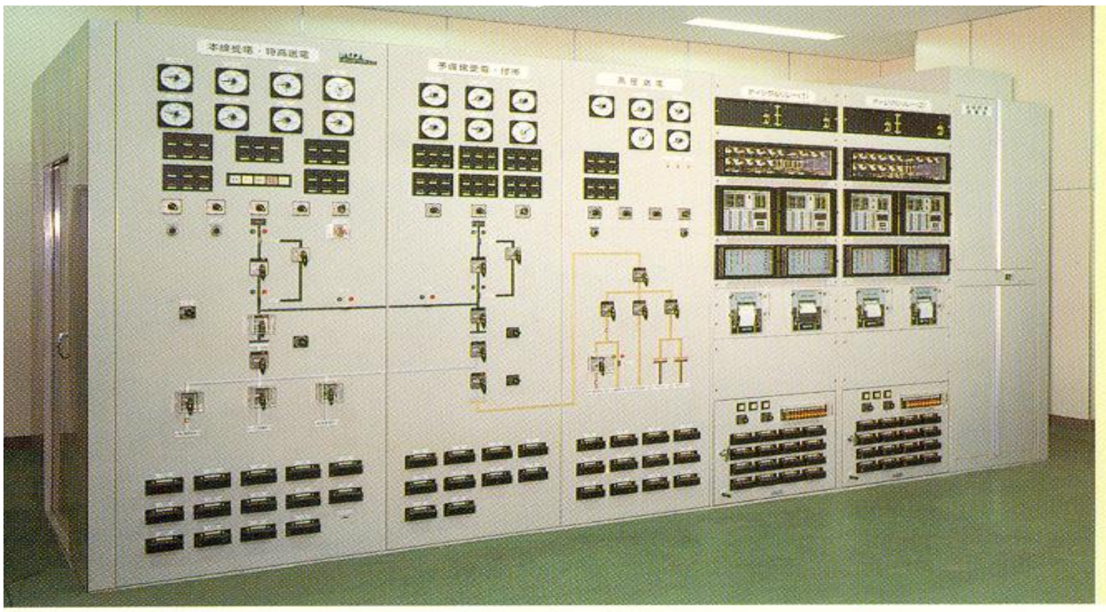
8.7 AUXILIARY SUPPLY ARRANGEMENTS FOR DEPOT

The Following major plant and machinery are to be provided in Depot:-

- RRV for carrying re railing equipments
- Road vehicles (pick up van/ truck)
- Flat wagon for carrying material.

- Diesel/Electric battery powered locomotive with traction battery charger.
- Under floor Pit wheel lathe, chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe.
- Travelling O/H crane workshop 15T/3T,1.5T capacity(IBL),ETU shed 5T crane
- Mobile Jib crane

A separate ASS is required at the depot. The Depot ASSs will also be provided with 2x2500 kVA auxiliary transformers.



Typical Indoor Auxiliary Sub-station

8.8 25 KV AC FLEXIBLE OVERHEAD EQUIPMENT (OHE) SYSTEM

25 kV AC flexible OHE system shall comprise 150 sqmm silver copper contact wire and 65 sq.mm Cd-copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be All Aluminum Conductor (AAC) of 93.3 sq.mm cross section. For tensioning of OHE, ATD shall be a mix of spring ATD (50%) and 5 pulley ATD (balance 50%) spring ATD shall not be having counterweight and shall be provided at critical location like road crossing etc. Proven catenary fittings are proposed similar to DMRC system.

8.9 RATING OF MAJOR EQUIPMENT

Based on emergency demand expected at each RSS as shown in Table 8.3, and expected power demand during emergency, RSS near MMRDA Office Station shall be provided with 2 Nos. of (One to be in service and one as standby) 110 / 25 kV, 21.6 / 30 MVA (ONAN / ONAF) Traction Transformers for feeding traction load and 2 Nos. of (One to be in service and one as standby) 110 / 33 kV, 20 MVA three phase transformers for feeding auxiliary loads. RSS at Mandala Depot shall also be provided with 2 Nos. of (One to be in service and one as standby) 110 / 25 kV, 21.6 / 30 MVA (ONAN / ONAF) Traction Transformers for feeding traction load and 2 Nos. of (One to be in service and one as standby) 110 / 33 kV, 20 MVA three phase transformers for feeding auxiliary loads. The incoming cable shall be 3-phase single core XLPE insulated with 630 mm^2 Aluminum conductors to meet the normal & emergency loading requirements and fault level of the 110 kV supply.

33 kV and 25 kV switchgear shall be rated for 1250 A being standard design. 33 kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of Single core 300 mm^2 FRLSH Aluminum conductor cable XLPE insulated 33 kV cable is proposed for ring main network.

Adequate no. of cables are required for transfer of traction power from Metro's RSS to 25 kV OHE. Single-phase XLPE insulated cables with 240 mm^2 copper conductor are proposed for traction power. Based on current requirements, 2 cables are required for each of the two circuits to feed power to OHE.

The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised for better accuracy during design stage of project implementation.

8.10 MV/LV SYSTEM

Following major E&M Equipments/system shall be required for elevated stations:-

- MV/LV panels
- DG set
- UPS & Battery system
- Lifts
- Escalators
- Fire suppression and detection system
- Lights & fans
- Air conditioning system
- BMS system
- Lightning protection system
- Earthing system

Panels shall be front operated front access cubical type indoor duty floor mounted totally enclosed dust and vermin proof with neoprene gaskets fabricated from CRCA sheet with powder coated finish suitable for 415 V 3 Phase 4 wire 50 Hz system.

8.11 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 180 kVA capacity at the elevated stations to cater to the following essential services:

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

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

8.12 SOLAR PHOTO VOLTAIC (PV) POWER SYSTEM

In DMRC solar PV power system are installed at various sites in RESCO (Renewable Energy Service Company) model. In Dwarka sector-21 station 500KWp solar PV power system has been installed in RESCO model.

Solar PV Power panel

"RESCO Model" means where the developers intend to provide solar power system on rooftop/sites owned by DMRC on mutually agreed terms and conditions from DMRC and enters into the PPA (Power purchase agreement) with DMRC for supply of Solar power for 25 years from the date of Commissioning of project.

In elevated stations about 50KWp to 100KWp capacity of Solar PV power system can be provided depending upon type of roof availability, shadow free roof area, orientation of stations. In DMRC receiving sub-station 50KWp capacity Solar PV system are generally provided. In DMRC Depot area, approx.1000KWp Solar PV can be provided. Solar PV system in station parking area can also be planned.

8.13 SEWAGE TREATMENT SYSTEM USING INTEGRATED CONSTRUCTED WETLANDS (ICW)

Following are the objectives for providing Sewage Treatment System using Integrated Constructed Wetlands (ICW):-

1) To establish an effective option for treatment of wastewater that is generated from campus.
2) Establish an onsite treatment solution which is effective and cost effective option without producing any by products.
3) To establish a sustainable and environmental friendly solution with minimal maintenance.
4) The treated water can be reused for various non-portable applications landscaping, flushing and cleaning.

The objective of Constructed Wetlands is to utilize the decomposable organic matter present in sewage, which can be disposed of into the environment without causing health hazards or nuisance. The degree of treatment to be adopted would meet the regulatory agencies (surface water discharge standards).

Constructed wetlands (CW) are complex and modular system provides an efficient and sustainable purification treatment method that is applicable to practically all pollutant sources and in all climate and environmental conditions. CW relies on Constructed Wetlands, and is based on the activity of plants together with microorganism communities in the root zone. Together they degrade, accumulate, extract, and volatilize contaminants of all kinds in water, soil and the air, resulting in clean and purified outflow. In DMRC Faridabad RSS 1 KLD capacity Sewage Treatment System provided through integrated constructed wetland method.

8.14 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fiber provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33 kV AC switchgear, transformers, 25 kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

8.15 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Mumbai Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefit of low specific energy consumption and almost unity power factor.

(ii) Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25 kV AC OHE to be consumed by nearby trains.

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) has been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

(viii) LED lights to be used in the station area and Depot area.

8.16 ELECTRIC POWER TARIFF

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25-35% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 80.14 million units in initial years 2019, which will be about 116.49 Million Units in the year 2031. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for Mumbai Metro should be at effective rate of purchase price (at 110 kV voltage level) plus nominal administrative Charges i.e. on a no profit no loss basis. The power tariff of Maharashtra Electricity Regulatory Commission for TATA power Company, FY 2015 – 16 demand charges Rs 200/ kVA per month and energy charges Rs 7.63/ kWh. Therefore it will be in the range of **Rs 7.91 to Rs 8.00 per unit**. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro.

Sheet 1 of 2

MUMBAI METRO ANNEXURE - 8.1

D N NAGAR TO MANDALE CORRIDOR 25kV AC Traction System

POWER REQUIREMENT		**D N Nagar to ITO**						**ITO to Mandale**						**D N Nagar to Mandale**					
S.No.	**Particulars**	**Year 2019**		**Year 2021**		**Year 2031**		**Year 2019**		**Year 2021**		**Year 2031**		**Year 2019**		**Year 2021**		**Year 2031**	
A	**Traction Power Requirements**	1	2	3	4	5	6	7	8	9	10	11	12	13=1+7	14	15=3+9	16	17=5+11	18
1	No. of cars	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)						
2	Passenger Weight	145.86	T	145.86	T	145.86	T	145.86	T	145.86	T	145.86	T						
3	Train Tare Weight	251.68	T	251.68	T	251.68	T	251.68	T	251.68	T	251.68	T						
4	Total Train Weight	397.54	T	397.54	T	397.54	T	397.54	T	397.54	T	397.54	T						
5	Section Length	11.61	KM	11.61	KM	11.61	KM	12.78	KM	12.78	KM	12.78	KM						
6	Headway	3.5	mts	3.0	mts	2.8	mts	7.0	mts	6.0	mts	5.5	mts						
7	Specific Energy Consumption	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM						
8	No. of Trains/hr in both directions	34	Nos.	40	Nos.	44	Nos.	17	Nos.	20	Nos.	22	Nos.						
9	Peak Traction Power Requirement	12.66	MW	14.77	MW	16.11	MW	6.97	MW	8.13	MW	8.86	MW						
10	Less Regeneration @ 30%	3.80	MW	4.43	MW	4.83	MW	2.09	MW	2.44	MW	2.66	MW						
11	Depot Power Requirements	0	MW	0	MW	0	MW	1.50	MW	1.75	MW	2.00	MW						
12	Total Traction Power Requirement	8.86	MW	10.34	MW	11.28	MW	6.38	MW	7.44	MW	8.21	MW	15.24	MW	17.78	MW	19.48	MW
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**9.79**	**MVA**	**11.43**	**MVA**	**12.46**	**MVA**	**7.05**	**MVA**	**8.22**	**MVA**	**9.07**	**MVA**	**16.84**	**MVA**	**19.65**	**MVA**	**21.53**	**MVA**
B	**Aux. Power Requirements**																		
1	Elevated/at-grade Station Power Consumption	0.25	MW	0.35	MW	0.50	MW	0.25	MW	0.35	MW	0.50	MW						
2	Underground station Power Consumption	2.00	MW	2.25	MW	2.50	MW	2.00	MW	2.25	MW	2.50	MW						
3	No. of Elevated/at-grade Stations	10	Nos.	10	Nos.	10	Nos.	11	Nos.	11	Nos.	11	Nos.						
4	No. of Underground stations	0	No.	0	No.	0	No.	0	No.	0	No.	0	No.						
5	Total Station Aux Power Requirement	2.50	MW	3.50	MW	5.00	MW	2.75	MW	3.85	MW	5.50	MW						
6	Depot Aux Power Requirement	0	MW	0	MW	0	MW	2.00	MW	2.25	MW	2.50	MW						
7	Total Aux Power Requirement	2.50	MW	3.50	MW	5.00	MW	4.75	MW	6.10	MW	8.00	MW	7.25	MW	9.60	MW	13.00	MW
	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for aux loads	**3.09**	**MVA**	**4.32**	**MVA**	**6.18**	**MVA**	**5.87**	**MVA**	**7.54**	**MVA**	**9.88**	**MVA**	**8.96**	**MVA**	**11.86**	**MVA**	**16.06**	**MVA**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**12.88**	**MVA**	**15.75**	**MVA**	**18.64**	**MVA**	**12.91**	**MVA**	**15.76**	**MVA**	**18.95**	**MVA**	**25.80**	**MVA**	**31.51**	**MVA**	**37.59**	**MVA**

Note: The requirement of PD load is not consided in estimation of power calculation.

Sheet 2 of 2

MUMBAI METRO ANNEXURE - 8.1

D N NAGAR TO MANDALE CORRIDOR

25kV AC Traction System

ENERGY CONSUMPTION		**D N Nagar to ITO**						**ITO to Mandale**						**D N Nagar to Mandale**					
S.No.	**Year**	**Year 2019**		**Year 2021**		**Year 2031**		**Year 2019**		**Year 2021**		**Year 2031**		**Year 2019**		**Year 2021**		**Year 2031**	
A	**Traction Energy**	1	2	3	4	5	6	7	8	9	10	11	12	13=1+7	14	15=3+9	16	17=5+11	18
1	Section Length	11.61	KM	11.61	KM	11.61	KM	12.78	KM	12.78	KM	12.78	KM						
2	No. of Trains per direction in a day*	198	Nos.	212	Nos.	262	Nos.	99	Nos.	106	Nos.	131	Nos.						
3	Weight of Train & Passenger	397.5	T	397.5	T	397.5	T	397.5	T	397.5	T	397.5	T						
4	SFC (NET) with 30% regen	56	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM	56.0	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM	56	KWH/ 1000 GTKM						
	Yearly Traction Energy consumption with 365 days working with 30% regen	**37.36**	**million units**	**40.00**	**million units**	**49.43**	**million units**	**20.55**	**million units**	**22.01**	**million units**	**27.20**	**million units**	**57.91**	**million units**	**62.01**	**million units**	**76.63**	**million units**
B	**Station Aux. Energy**																		
1	Elevated/at-grade Station	0.25	MW	0.35	MW	0.50	MW	0.25	MW	0.35	MW	0.50	MW						
2	Underground Station	2.00	MW	2.25	MW	2.50	MW	2.00	MW	2.25	MW	2.50	MW						
3	No. of Eevated/at-grade Stations	10	Nos.	10	Nos.	10	Nos.	11	Nos.	11	Nos.	11	Nos.						
4	No. of Underground Stations	0	No.	0	No.	0	No.	0	No.	0	No.	0	No.						
5	Total Station Aux. Power Requirement	2.50	MW	3.50	MW	5.00	MW	2.75	MW	3.85	MW	5.50	MW						
6	Depot Aux power requirement	0.00	MW	0.00	MW	0.00	MW	2.00	MW	2.25	MW	2.50	MW						
7	Total Aux. Power Requirement	2.50	MW	3.50	MW	5.00	MW	4.75	MW	6.10	MW	8.00	MW						
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	**3.09**	**MVA**	**4.32**	**MVA**	**6.18**	**MVA**	**5.87**	**MVA**	**7.54**	**MVA**	**9.88**	**MVA**						
9	Diversity Factor of Aux. loads	0.40		0.40		0.40		0.40		0.40		0.40							
	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**7.67**	**million units**	**10.73**	**million units**	**15.33**	**million units**	**14.56**	**million units**	**18.70**	**million units**	**24.53**	**million units**	**22.23**	**million units**	**29.43**	**million units**	**39.86**	**million units**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**45.02**	**million units**	**50.73**	**million units**	**64.76**	**million units**	**35.12**	**million units**	**40.71**	**million units**	**51.73**	**million units**	**80.14**	**million units**	**91.44**	**million units**	**116.49**	**million units**

Note: The requirement of PD load is not consided in energy calculation.

ANNEXURE – 8.2

CIN No. U74899DL 1995G0I068150

दूरभाष Tel. : 23417910/12
फैक्स Fax : 23417921

दिल्ली मेट्रो रेल कॉर्पोरेशन लि०
DELHI METRO RAIL CORPORATION LTD.
(भारत सरकार एंव दिल्ली सरकार का संयुक्त उपक्रम)
(A JOINT VENTURE OF GOVERNMENT OF INDIA AND GOVT. OF DELHI)

No. DMRC/Elect/Mumbai/2015

Date: 12.11.2015

To

Chief Manager,
Tata power Company Limited
Consumer Development and Engineering Department
Technopolis Knowledge Park
Mahakali Caves Road, Andheri East
Mumbai 400 001
Fax: 91 22 5668 8363

Sub: Power Supply Requirement for New Metro Corridor from D N Nagar to Mandale Corridor (24.385 Km length).

Dear Sir,

In reference to above, Mumbai Metropolitan Region Development Authority (MMRDA) has requested to Delhi Metro Rail Corporation for preparing DPR for extension of Dahisar to D N Nagar Corridor i.e. from D N Nagar to Mandale with 24.385 Km length, 21 stations.

In view of the above, it is required to provide the power (66kV or above) from grid Sub – Station along the route where the metro authority will lay their own feeders up to Receiving Sub – Station (RSS), and step it down to 33 kV for auxiliary Load which will be distributed along the alignment through 33 kV Ring main cable network and step it down to 25 kV for traction purpose.

For this purpose, two bays for each Receiving Sub – Station (RSS) of 66 kV or above will be required for the corridor close to the alignment.

S. No.	Corridor	Receiving Sub-station	Power Demand in MVA (Tentatively)		
			2019	2021	2031
01	**D N Nagar to Mandale Metro** 21 Stations (24.385 km)	Near Mankhurd Depot	26	32	38
		Near MMRDA Station	26	32	38

Page 1 of 2

(मेट्रो भवन, फायर ब्रिग्रेड लेन, बाराखम्बा रोड, नई दिल्ली-110001)
Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001

In view of above, it is requested that source locations close to alignment along the route may please be allocated at the earliest. Need be a meeting/survey may kindly be arranged as per your convenience to finalize the issue tentatively on 30th November and 1st December, 2015.

Thanking you,

Yours- faithfully

Encl: Index Plan

(A K Singh)
Executive Director/ Electrical – II
Fax No. 23417920

Copy to:-

1. Dy. Metropolitan Commissioner (project Coordinator), MMRDA Mumbai Metropolitan Region Development Authority, Bandra-Kurla Complex, Bandra (E), Mumbai-400051
   Tel: 2659 0001/4000, Fax: 2659 1264, Email: dmrc.pc@gmail.com

N.O.O.

1. DBD/ DMRC
2. CEE/~~UD~~/DMRC

CC:
DE For kind information please.

Page 2 of 2

Chapter 9 – Environmental Impact Assessment

Chapter - 9

ENVIRONMENTAL IMPACT ASSESSMENT

9.1 ENVIRONMENTAL BASELINE DATA

The main aim of the EIA study is to ascertain the existing baseline conditions and to assess the impacts of all the factors as a result of the proposed corridor during its construction and operation phases. The changes likely to occur in different components of the environment viz. Natural Physical Resources, Natural Ecological (or Biological) Resources, Human/Economic Development Resources (Human use values), Quality of life values (socio-economics), would be studied and assessed to a reasonable accuracy. The environment includes Water Quality, Air Quality, Soils, Noise, ecology, Socio-economic issues, archaeological /historical monuments etc.

The information presented in this section stems from various sources such as reports, field surveys and monitoring. Majority of data on soil, water quality, air and noise quality, flora and fauna was collected during field studies in 2006 and 2010 and 2015. This data have been further utilized to assess the incremental impact, if any, due to the project. The development/compilation of environmental baseline data is essential to assess the impact on environment due to the project. The study area is the Metro corridor from DN Nagar to Mankhurd via Kurla and Bandra.

9.1.1 General Environment

Mumbai (Bombay) is located at (Latitude 18.54^{o}N, Longitude 72.49^{o}E) in Maharashtra State and is the principal Indian port on the Arabian Sea. The original city is confined by its island location. Mumbai's central business district, comprising most of the commercial and business centres and government offices, is located in the extreme southern part of the city. Mumbai harbour is to the east of the city. The commercial Fort area lies to the south of the island while the commercial, residential and industrial areas are located north of the Fort area. The mean elevation of Mumbai is 11 m above mean sea level. The metropolitan region covers an area of 4500 km^2 of which Greater Mumbai covers 437.71 km^2.

Mumbai has a tropical savanna climate; mean humidity ranges between 57-87 per cent. The annual mean temperature is 25.3^{o}C rising to a monthly maximum of 34.5^{o}C in June and with a minimum of 14.3^{o}C in January. Total annual mean precipitation is 2,078 mm with 34 per cent (709 mm) falling in the month of July. Due to the summer monsoons, maximum sunshine occurs in winter (291 hours in January). In the winter the predominant wind direction is northerly (NW-NE). However, in the monsoon season westernly and southernly winds predominate. There is virtually always a sea breeze during the day with mean wind speeds between 5-8 km/hour.

9.1.2 Water and Soil

Water and soil samples have been analysed. The results so obtained are given in **Tables 9.1** and **9.2**. All the parameters of soil and water samples collected from 5 locations of the alignment are within permissible limits except TDS and BOD at Kurla and Mankhurd, Total hardness and sulphate at Kurla. The texture of soil is mainly sandy. The higher concentration of phosphate and organic matter is an indication of good fertility value.

Table 9.1

CHEMICAL ANALYSIS OF WATER SAMPLE (Year 2006)

Sl. No.	Parameters	Bandra (Near Rly Stn.)	Survey Chowk, Kurla (W)	Mankhurd (Near Rly Stn.)	Cosmopolitan Education Society Marg near Juhu	Dr. Ambedkar Chowk, near Charkop
1	Total Suspended Solids (mg/l)	30.9	10	15.7	10.6	1.1
2	BOD (mg/l)	<2	7	3	<2.0	<2.0
3	pH	7.9	7.6	7.8	8.3	7.92
4	Chloride, Cl (mg/l)	31.9	133	52	3.9	3.99
5	Total Dissolved Solids (mg/l)	199.7	1215	545	66.3	63.4
6	Sulphate, SO4 (mg/l)	53.7	319	75.7	3.7	53.7
7	Fluorides (asF) (mg/l)	1.1	0.81	0.92	0.037	0.14
8	Nitrates as NO3 mg/l	2.05	21	7.9	2.1	2.05
9	Alkalinity, mg/L	71.9	204	103.2	27.9	27.9
10	Total Hardness, mg/L	79.9	642	205.1	35.9	35.9
11	Turbidity	10	4	6	3	1
12	COD, mg/L	3.9	10	8	7.9	3.9
13	DO, mg/L	5.8	2.5	3.7	5.8	5.7
14	Arsenic, mg/L	ND*	ND*(0.05)	ND*	ND	ND

Note:* Not Detectable

Table 9.1 A Ground Water Quality at Project Site (2015)

Physical Parameters	Results		*Limits*
Sample	Bandra	Kurla East	
Colour, Hazen	Colourless	Colourless	5 (15) Max
Odour	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Agreeable	Agreeable	Agreeable
Turbidity, NTU	1.58	1.47	1 (5) Max
PH	7.89	7.83	6.5-8.5 Max
Total Hardness as	316	269	200 (600) Max

Physical Parameters	Results		*Limits*
Sample	**Bandra**	**Kurla East**	
Caco3, Mg/l			
Chloride as Cl, Mg/l	116	114.2	250 (1000) Max
Total Iron as Fe, Mg/l	0.17	0.15	0.3 Max
Total Dissolved Solids, Mg/l	1871	1573	500 (2000) Max
Sulphates as So4, Mg/l	105.3	94.2	200 (400) Max
Nitrates as No3, Mg/l	38.5	39.4	45 Max
Fluorides as F, Mg/l	2.59	2.19	1.0 (1.5) Max
Lead as Pb, Mg/l	BDL	BDL	0.01 Max
Copper as Cu,Mg/l	BDL	BDL	0.05 (1.5) Max
Manganese as Mn,Mg/l	BDL	BDL	0.1 (0.3) Max
Phenolic Compound as C6H5OH,Mg/l	BDL	BDL	0.001 (0.002) Max
Mercury as Hg,Mg/l	BDL	BDL	0.001 Max
Cadmium as Cd,Mg/l	BDL	BDL	0.01 Max
Selenium as Se, Mg/l	BDL	BDL	0.01 Max
Arsenic as As,Mg/l	BDL	BDL	0.05 Max
Cyanide as Cn,Mg/l	BDL	BDL	0.05 Max
Zinc as Zn, Mg/l	1.13	1.05	5 (15) Max
Detergent as MBAS, Mg/l	BDL	BDL	0.2 (1.0) Max
Chromium as Cr+6 ,Mg/l	BDL	BDL	0.05 Max
Total Alkalinity as Caco3,Mg/l	118.2	139.6	200 (600) Max
Aluminum as Al,Mg/l	BDL	BDL	0.03(2) Max
Boron as B, Mg/l	BDL	BDL	0.5(1) Max
Bacteriological Analysis Coliform,MPN/100Ml E-Coli/Ml	Nil Negative	Nil Negative	10 Max Negative

Table 9.2

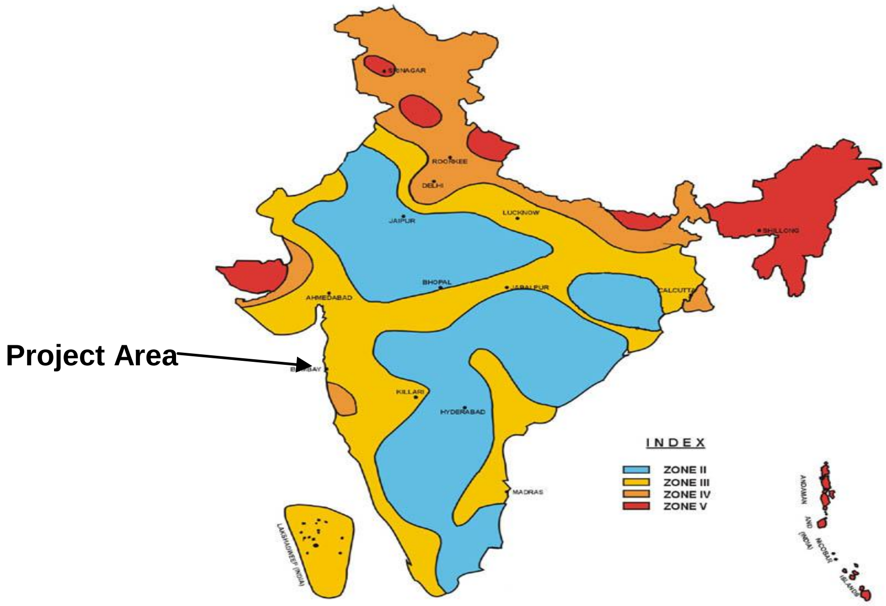
PHYSICO-CHEMICAL CHARACTERISTICS OF SOILS (Year 2006)

S. No.	Parameters	Bandra (Near Rly Stn.)	Survey Chowk, Kurla (W)	Mankhurd (Near Rly Stn.)	Cosmopolitan Education Society Marg(Near Juhu	Dr.Ambedkar Chowk, Charkop
1	pH	7.81	8.14	7.9	8.58	7.81
2	Texture					
	i) Sand (%)	79.21	10.7	81.0	88.97	85.57
	ii) Silt (%)	15.44	9.3	14.51	6.01	7.15
	iii) Clay (%)	5.35	80	4.49	5.02	7.28

3	Nitrogen (kg/hectare)	3014	874.0	1475.0	1610.89	2117
4	Phosphorus (kg/ha)	203	268.8	198.9	15.73	11.78
5	K (meq/100gm)	2.72	5.88	4.78	0.36	1.17
6	Ca (meq/100gm)	24.19	0.6	3.64	35.65	31.14
7	Mg (meq/100gm)	3.03	0.3	2.59	8.81	32.7
8	Na (meq/100gm)	2.22	6.08	4.50	1.6	2.91
9	Organic matter (%)	303	2.32	2.72	1.97	1.82

9.1.3 Seismicity

Mumbai falls in Zone-III (however very near to Zone –IV) of Seismic Zoning Map of India. Suitable seismic factor of recommended Civil Engineering designs structures need to be appropriately incorporated while finalising civil structures. Seismic Zoning Map of India is given in the following figure.



Seismic Zoning Map of India

9.1.4 Air Quality

As a part of this study, in order to establish the base line data, Ambient Air Quality Monitoring (AAQM) has been carried out by setting up ambient air quality monitoring stations through mobile van at four locations for the parameters SPM, RSPM, NOx, and SO_2, CO and HC. The results so obtained are reported in **Table 9.3**. The ambient air quality data indicates that the values of Suspended Particulate Matter (SPM) is higher at all locations except Children Home, Mankhurd. Value Repairable Suspended Particulate Matter (RSPM) is higher than CPCB limits at all locations except at Children Home, Mankhurd (E) and Dr. Ambedkar Road, Charkop, Kandivali. This may be due to heavy traffic area. Values of NOx, SO_2 and CO are within the permissible limits.

Table 9.3
AIR QUALITY AT PROJECT SITE (Year 2006)

Sl. No.	Location	SPM µg/m^3	RSPM µg/m^3	NOx µg/m^3	SO_2 µg/m^3	HC mg/m^3	CO mg/m^3
1	BKJ Mosque, Bandra(W)	250-290	210-230	65-80	21-38	1.02-3.48	1.32-5.48
	Average (24 hour)	270	220	73.16	30.5	1.97	3.29
2	Kamgar Nagar, Barve road, Kurla(W)	190-230	165-200	35-70	14-23	0.01-3.03	1.0-4.23

Sl. No.	Location	SPM µg/m³	RSPM µg/m³	NOx µg/m³	SO_2 µg/m³	HC mg/m³	CO mg/m³
	Average (24 hour)	210	180	54.33	18.66	1.06	2.64
3.	Children Home, Mankhurd(E)	90-100	66-70	21.6-39.8	6-14	0.01-2.91	0.01-1.98
	Average (24 hour)	96	68	29.09	9.6	0.41	0.63
4.	Dr. Ambedkar Road, Charkop, Kandivali	300-324	140-156	41-49	20-29	Traces-0.5	Traces-1.2
	Average (24 hour)	312	151	43	27	0.25	0.7
	Permissible limit	200	100	80	80	-	4.00

Table 9.3A

Ambient Air Quality monitoring at selected locations along Charkop-Dahisar Alignment (Year 2010)

Parameter	Result at different Locations				National AAQM Std.	Unit	Method
	Kantha pada Charkop	Hindustan Naka (DB Realty)	John Bosco School &	Dahisar (Police Chowky)			
Total Suspended Particulate Matter (SPM)	232	218	192	244	500	µg/m3	IS-5182 (part- 4)
Respirable Particulate Matter (RSPM)	84	64	68	78	150	µg/m3	IS-5182 (part- 4)
SO_2 Conc.	14	16	08	19	120	µg/m3	IS-5182 (part- 2)
NOx Conc.	76	56	46	48	120	µg/m3	IS-5182 (part- 6)

Table 9.3 (B) Ambient Air Quality Results (2015) µg/m3

Sl. No.	Parameter	D.N. Nagar	Nanavati Hospital	National College	Kurla East	Shivaji Chowk	Mankhurd	Regulatory Standards (NAAQS) Residential/ Sensitive 24 hourly
Date of Monitoring		4/5-12	4/5-12	4/5-12	5/6-12	5/6-12	6/7-12	
1	RSPM PM-10	263	184	198	218	219	239	100
2	Oxides of Sulphur - SO_2	46.5	32.3	34.7	52.6	57.2	46.1	80
3	Oxides of Nitrogen – NOx	67.2	43.1	48.6	65.7	49.6	67.8	80
4	Carbon Monoxide CO	1840	1570	1620	1810	1720	1450	2000

RSPM= Respirable Suspended Particulate Matter.

The results show that the concentration of all parameters is within permissible limits except respirable suspended particulates (PM_{10}).

9.1.5 Noise Levels

Noise levels were measured at 4 locations along the project alignment at 2.0-m distance from source as per standard practice. The noise levels measured are summarised in **Table 9.4.** It is observed that the noise levels recorded at all locations are higher than prescribed permissible levels of 55-dBA (day) and 45dBA (night) for residential area as prescribed by the Central Pollution Control Board (CPCB).

Table 9.4

NOISE LEVELS ALONG THE ALIGNMENT DB(A) (Year 2006)

Location	L_{eq}	L_{max}	L_{10}	L_{50}	L_{90}	L_{min}	L_{day}	L_{night}	L_{DN}
BKJ Mosque, Bandra(W)	73.35	90	84.33	78.41	74.23	64	76.31	50.25	78.88
Kamgar nagar, Barve road, Kurla(E)	65.5	78	76.33	71.91	66.36	56	69.38	57.75	67.77
Children Home, Mankhurd(E)	62.33	70	69.33	66	63.0	54	62.93	55.2	68.88
Apna Bazar, Dr. Ambedkar Road, Charkop	69	78	75	72	69.59	60	70	67	77

Note: L_{10}, L_{50} and L_{90} are the sound level, which is exceeded 10%, 50% & 90% of the total time

Table 9.4 (A)

Noise Level at different locations along the Charkop-Dahisar Alignment, dBA

Location	06-08 hrs	08-10 hrs	10-12hrs	12-14 hrs	14-16hrs	16-18hrs	18-20hrs	20-22hrs	22-24hrs
Station No-1 Charkop Junction	75	78	79	78	76	80	80	75	74
Station No-2	70	75	77	77	78	80	73	74	75
Station No-3	70	76	75	75	77	82	74	75	70
Station No-4	76	76	78	78	80	84	72	70	70
Station No-5	70	73	77	75	74	70	71	70	65
Station No-6 Charkop side of ROB	68	70	70	68	70	75	65	66	65
Station No-7 ROB	65	66	69	68	70	70	77	65	62
Station No-8 Dahisar Police Chowky	65	75	76	75	73	72	80	75	72

Table 9.4 (B) Noise Levels at different Locations (2015)

Location		L Max	L Min	Leq	L_{10}	L_{50}	L_{90}
D.N.Nagar	Day	77.6	53.0	72.4	75.4	65.4	62.7
	Night	66.7	42.6	58.9	62.1	56.3	51.2
Prem Nagar	Day	85.3	54.0	72.8	78.1	66.1	61.0
	Night	71.8	44.9	63.7	66.5	52.9	47.9
Nanavati Hospital	Day	78.6	53.1	70.5	73.4	64.7	56.6
	Night	69.9	43.5	61.2	66.4	53.0	49.3
National College	Day	81.8	54.9	71.2	74.6	66.8	61.7
	Night	73.2	50.1	63.7	69.2	61.6	56.8
Bandra	Day	88.5	51.4	72.9	76.1	69.6	65.0
	Night	79.7	44.2	70.4	74.4	65.8	53.2
MTNL Station	Day	80.3	64.1	72.2	76.0	70.4	67.2
	Night	76.3	53.6	71.7	73.4	68.0	60.9
Kurla East	Day	81.9	54.8	73.3	76.1	67.6	61.8
	Night	78.7	48.6	62.1	71.2	58.5	51.4
Eastern Express Highway	Day	82.1	50.8	71.7	74.4	70.7	66.5
	Night	78.8	46.1	64.4	71.5	61.0	57.1
Shivaji Chowk	Day	83.7	56.3	72.4	75.6	71.2	64.2
	Night	77.4	47.1	64.9	67.8	63.5	52.7
Mankhurd	Day	87.4	65.9	81.3	84.9	80.3	74.6
	Night	82.0	56.3	68.5	72.4	65.1	64.6

9.1.6 Flora

Separate Environmental Impact Assessment Study is being carried out and report will be ready within a month.

9.2 SOCIO-ECONOMIC ASSESSMENT

Development of proposed Mumbai metro rail project in Charcop-Bandra-Kurla-Mankhurd corridor involve acquisition of land for entry, exit and for other facilities of station and running section. For different components of this corridor, out of total requirement of land, 0.5 ha of private land shall be acquired. Acquisition of this private land may cause social disruption and economic loss for the project affected families/people. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimise any negative impacts. Governed by this consideration, a Socio-Economic Survey (SES) was undertaken in order to assess the socio-economic condition of project-affected families/people and to examine the impacts of the proposed MRTS on their conditions.

9.2.1 Socio Economic Survey

This survey is being done separately. However, prime facie, it is noticed that land acquisition and PAPs are located in patches at different locations. Data has been incorporated in SIA report being prepared separately.

9.3 POSITIVE ENVIRONMENTAL IMPACTS

9.3.1 Based on project particulars and existing environmental conditions, potential impacts have been identified that are likely to result from the proposed MRTS project. The positive environmental impacts are listed below:

1 Traffic congestion reduction,
2 Quick service and safety,
3 Less fuel consumption,
4 Reduction in Air Pollution,
5 Improvement in roads
6 Reduction in number of busses, private vehicles on road etc.,
7 Greenery through compensatory afforestation,
8 Improvement of Quality of Life,
9 Better transport facilities to masses.

9.4 NEGATIVE ENVIRONMENTAL IMPACTS

9.4.1 Based on project particulars and existing environmental conditions, potential negative impacts likely to result from the proposed development have been identified. Negative impacts have been listed under the following headings:

1 Impacts due to project location,
2 Impacts due to construction works, and
3 Impacts due to project operation.

9.4.2 Impacts Due to Project Location

a) Land acquisition: About 30.6176 ha of land will have to be permanently acquired for the proposed project. Out of this 30.6176 ha of land, about 27.1246 ha of land is the government land and 3.4930 ha is estimated to be private land. Socio Economic Survey is being done separately.

b) Loss of Historical and Cultural Monuments: No historical/cultural monuments will be affected as a result of the proposed development..

c) Impacts on sea: Since the proposed Metro alignment is far from the sea coast, hence no impact on sea due to the proposed project is anticipated.

d) CRZ: The alignment does not enter CRZ area.

9.4.3 Impacts Due to Project Construction

a) **Soil Erosion:** Though the project may not have significant impact on soil erosion, however, minor impact on soil erosion due to runoff from unprotected excavated areas may result in soil erosion, especially when erodibility of soil is high. Mitigation measures include careful planning, timing of cut-and-fill operations and re-vegetation. Problems could arise from dumping of construction soils (concrete, bricks), waste materials (from contractor's camp) etc. causing surface and ground water pollution. Hence, it is proposed to have ready mix concrete directly from batching plant for use at site. Batching plants should be located away from the site preferably**,** away from the human settlements.

b) Health Risk at Construction Site: Health risks during construction activity include disease hazards to workers due to lack of sanitary facilities like safe disposal of human waste and garbage clearance and disposal facility. In order to avoid such a situation, proper mitigation measures should be incorporated, which should include proper water supply, sanitation, drainage, healthcare and human waste disposal facilities in labour camps. In addition reduced contaminated water spillage and adoption of disease control measures should be adopted to reduce the health risks.

c) Traffic Diversions and Risk to Existing Buildings: During construction, traffic diversions on roads will be essentially required. As most of the construction activities will be confined to centre of the road and most of the roads are double lane, it will be appropriate that the side lanes may also be utilised for traffic and also for smooth progress of construction activities. Advance information on communication systems will be an advantage to users of any particular road. The proposed section is elevated and located in the middle of the road with deck width being less than the existing road width, hence risk to the existing buildings all along the route may be negligible.

d) Impact on Water Quality: Construction activities may have impact on water bodies due to disposal of waste. The waste could be due to: the spillage of construction materials, dumping of used water from the stone crusher, oils and greases, and labour camp. But the quantities of such spills are very negligible. Care, however, needs to be taken to provide adequate sanitary facilities and drainage in the temporary colonies of the construction workers. Provision of adequate washing and toilet facilities with septic tanks and appropriate refuse collection and disposal system should be made obligatory. Contamination of ground water can take place, if the dump containing above substances gets leached and percolate into the ground water table. This is not the case with the present project, as the activity does not involve usage of any harmful ingredients. Moreover, activities are of short duration. Hence, in overall, the impact on either ground or surface water quality is anticipated to be minimum due to the present project.

9.4.4 Impacts due to Project Operation

a) **Noise:** Noise and Vibration is of similar phenomenon. Noise is a random vibration. It can be broken down into a set of unrelated, elementary components. The main sources of noise from the operation of trains include: engine noise, cooling fan noise, wheel-rail interaction, electric generator and miscellaneous noise like passenger's chatting. The roughness of the contact surfaces of rail and wheel and train speed are the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. The maximum noise level is estimated as 64dB(A). However, due to reduction of vehicular traffic, the road traffic noise as compared with existing levels may come down.

b) **Accidental Hazards:** In view of the hazards potential involved due to failure of system and accident the on-site and off- site emergency measures need to be formulated and shall be implemented by the construction agency during construction and operational phases.

c) **Water Supply:** CPHEEO (Central Public Health Environmental Engineering Organisation) has recommended 45-litres/day, water supply to persons working at railway stations. Water requirement at all Metro stations has various components, viz. Personal use of Staff, Fire demand, Make up water for air conditioning and ventilation, and wastage. The water demand at each Metro station would be about 100m^3 per day. Adequate provision of drinking water has to be made for passengers at the railway stations. Platform washing requirement has been worked out at the rate of 2-lit per sqm.

d) **Railway Station Refuse:** The refuse from metro stations includes; garbage, rubbish, and floor sweepings. The collection and removal of refuse in a sanitary manner from the station is of importance for effective vector control, aesthetic improvement, and nuisance and pollution abatement. There is no shop/ facilities for cooking at MRTS stations hence there is no generation of garbage. RITES has assumed about 3 gm/ person/ day of refuse generation at Metro Stations. The average refuse generated at each station will thus be about 72 kg/day. For the maintenance of adequate sanitary facilities, containers/collection bins not exceeding 50-litres and equipped with side handles will be appropriately designed and installed at stations and platforms.

e) **Visual Impacts:** The construction of DN Nagar-Bandra-Kurla-Mankhurd - Mandala corridor will bring about a change in visual look of the streets through which it will operate. An architecturally well-designed structure, which could be aesthetically pleasing and able to reduce impact due to visual disfiguration, may be incorporated in present corridor.

9.5 CHECKLIST OF IMPACTS

9.5.1 A typical checklist identifying anticipated environmental impacts is shown in **Table 9.5.**

Table 9.5
CHECKLIST OF IMPACTS

Parameter		Negative Impact	Positive Impact	No Impact
A)	**Impacts Due To Project Location**			
i)	Displacement of people	□□		
ii)	Change of Land Use and Ecology	□□		
iii)	Impact on Historical/Cultural Monument			NIL
iv)	Impact on sea			NIL
B)	**Impact Due To Project Construction**			
i)	Soil Erosion,	□□		
ii)	Health Risk at Construction Site	□□		
iii)	Traffic Diversions and Risk to Existing Buildings	□□		
iv)	Impact on Water Quality	□□		
C)	**Impact Due To Project Operation**			
i)	Oil Pollution	□□		
ii)	Noise and Vibration	□□		
iii)	Accidental Hazards	□□		
iv)	Water Supply	□□□		
v)	Railway Station Refuse	□□□		
vi)	Visual Impacts	□□□		
D)	**Positive Impacts**			
i)	Traffic Congestion Reduction,		□□□	
	Quick Service and Safety,		□□□	
ii)	Less Fuel Consumption,		□□□	
iii)	Reduction in Air Pollution,		□□□	
iv)	Reduction in number of busses		□□□	
v)	Improvement in roads		□□ □	

9.6 ENVIRONMENTAL MANAGEMENT PLAN

Based on environmental baseline conditions, planned project activities and its impacts assessed, the set of measures to be taken during implementation and operation to avoid or offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which needs to be taken to implement them are enumerated in this section.

9.6.1 Mitigation Measures: Based on project description, Environmental Baseline Data and Environmental Impacts, it is proposed to prepare the Environmental Management Plan for the following:

- 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

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 23 trees are likely to be lost due to the project. Ten saplings are to be planted for felling a single tree. Hence 230 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.

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 covered trucks. All the material would be stored in a manner to avoid multiple handling for use in construction activities.

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.

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.

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.

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.

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.

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 insignificant 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.

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.

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.

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 both corridors. 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, acquisition of service lanes, 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.

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 araea 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.

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 borewells may be installed with due permission from statuatory authority prior to installation of borewell.

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.

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 artifical recharge. The total length of the proposed alignment is about 18.175 km and there would be 16 stations. The estimated cost of rain water harvesting for elevated corridor is about 11 lakhs per km and 3.5 lakhs per station. The total cost of rainwater harvesting would be Rs. 256.00 Lakh.

Tree Protection

There is requirement of felling 23 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 10 trees for each tree felled. Moreover MMRDA would chalk out the plantation program in close coordination with Tree Authority, 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 metre surrounding the tree. Scope of transplantation of trees would also be explored with discussion with the Tree Authority, MCGM.

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 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**.** The estimated cost of sewage treatment plant is about Rs 78.00 Lakh.

Expectedly about 63 KLD effluent would be generated at each 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). The estimated cost of effluent treatment plant is about Rs 88.50 Lakh.

Surface Drainage: The 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 30.00 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 25.00 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.

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.

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.

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.

9.7 ENVIRONMENTAL MONITORING PLAN

9.7.1 Environmental Monitoring: The environmental monitoring will be required for the construction and operational phases. The parameters need to be monitored are: Water Quality, Air quality and Noise levels etc.

a) Water Quality: Though it is expected that, no impact on water quality is anticipated, monitoring of water quality may be required to assess the impact of the project before and after construction. Water quality parameters shall be monitored one year before the construction, during the construction phase and also for at least three years after the completion of the project (total 7 years). Monitoring shall be carried out at least four times a year to cover seasonal variations. The parameters for monitoring would be: pH, Dissolved Oxygen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids, Chlorides, Nitrates, Sulphates, Total Nitrogen, Total Phosphates, oils and grease etc (about ten parameters as essential depending on the site conditions). The main monitoring stations could be about three locations. The cost for water quality analysis works out to be **Rs. 4.2 lakhs** (Once in a season(1) X 4 season in a year X (3) locations X 7 (years) X cost =1X4X3X7X5000)**.**

b) **Air Quality and Noise Levels:** Ambient air quality and Noise levels should be monitored one year before the construction, during the construction phase and for at least three years after the completion of the project (total 7 years). It is proposed to have the monitoring programme at three locations.

c) Noise Level Monitoring

As the negative impact of the project (during the construction and operation) on the Noise Level (without remedial measures is significant monitoring of Noise level at 3 locations at a frequency of once in a month for 12 months for a period of 7 years is suggested.

9.7.1.2 Total cost of Environmental Monitoring = Rs20.00 lacs

9.8 ENVIRONMENTAL MANAGEMENT SYSTEM

The Environmental Management System constitutes provision of an Environmental Division, which should be staffed by an Environmental Engineer/Officer, an Environmental Assistant and two other assistants (miscellaneous works). The task assigned should include supervision and co-ordination of studies, monitoring and implementation of environmental mitigation measures. An Environmental Advisor shall review progress of the division every year.

9.9 ENVIRONMENT MANAGEMENT COSTS

Table 9.6 Environmental Management Costs

S. No.	ITEM	COST Rs. lakh
1.	Rain Water Harvesting at stations and along alignment	332.12
2.	Air, Noise, vibration, Water, Waste Water, Solid waste, during construction and operation	15.00
3.	Ecological monitoring	5.00
4.	Tree Plantation 850trees @ Rs.2000/- per tree	17.00
5.	Water Treatment Plant	120.50
6.	Sewage Treatment Plant	78.00
7.	Effluent Treatment Plant	88.50
8.	Green Belt at Depot	30.00
9.	Rain water harvesting at Depot	25.00
10.	Recycling of treated waste water	41.00
	Total	**752.12**

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.

9.10 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. Hence the current project is classified as Category 'A' as per the ADB Guidelines. Based on these 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.

Chapter 10 - Multi-Modal Traffic Integration

Chapter - 10

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

10.1 INTRODUCTION

The Metro Rail System in Mumbai D.N. Nagar to Madal Corridor will cover a length of approximately 23.591km. It will be augmented through enhanced flexibility of criss-cross interchanges to other modes and reduce the travel time of commuters. While Metro is a high capacity mode of transport, the need for integration with other secondary/intermediate transport mode is getting highlighted more than ever to ensure a seamless journey. This concept is to provide first mile and last mile connectivity to the commuters with their places of stay. With top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Rail Systems. (Ref: MoUD (Urban Transport Wing) Advisory Circular No. K-14011/1/2007-UT-IV dated 30.08.2013).

The share of various modes of secondary/intermediary mode of travel is complex and debatable issue which is dependent on a large number of variables like available road width, penetration in the residential areas, Road condition, distance from the Metro Stations, availability of parking and lay out and availability of circulating areas at the Metro Rail Stations, Business centre or Market & existing traffic densities. These factors relate with each other and evolve with development of new model mix of transport, infrastructure and changes with the passage of time. Even though for a given urban transport scenario, optimal mode share may be determined from computer based models but actual **optimal mode share** is never achievable on the road due to dynamic nature of demand and supply of transport modes.

10.2 PRESENT CONDITION OF TRANSPORT ON CITY ROADS

At present the various modes coming to Metro Stations comprise of State Transport buses, 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 the Road length on main & arterial Roads may not be seen significant increase and relieve the congestive/chaotic/slow moving road traffic, a divergent policy of linking commuters directly through E-Rickshaw using the service/inner road length to supplement the main road traffic will impact the congestion and provide relief to the Metro commuters in reaching out to Metro Stations.

10.3 IMPACT OF BUS/CLUSTERS IN MODE SHARE

Primary reasons for using personal vehicle (for buying vehicle) is **to save travel time** during journey. On the other hand, Government has tried to increase number of public buses on the road in many different ways.

Government has tried hard to popularise public buses by subsidising the fare but could not bring higher (and middle) income group to use public bus simply because it is slow. Therefore objective of achieving optimal mode share remained elusive than reality.

10.4 BALANCING ACT OF METRO

After introduction of Metro Rail System in the city, Traffic and Transportation scenario will significantly change. People will no longer be afraid to travel a much longer distance. With Metro in place, longer distances can be travelled in shortest time.

10.5 WAY FORWARD

In view of above deliberations in back ground, along with planning for Metro System in any city, there is a need for providing a transportation system which is seamlessly integrated across all modes and provides first mile as well as last mile connectivity. It is also necessary that various public transportation modes including Inter-mediate Public Transport (IPT) and feeder buses etc. work together in order to facilitate increase in ridership to the Metro/Metro system and provide ease of using Metro system by the public at large.

Therefore, there is a need for doing more scientific study exclusively for this. To achieve this goal, Metro Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. Detailed Study is required to be done in this influenced zone of a Metro station for following aspects mainly:

i) Availability and review of existing public and IPT facilities, in terms of motorized and non-motorised mode with main consideration of the streets/roads adjoining to the stations and also to examine adequacy of availability of pedestrians/cycle paths in the influenced zone.

ii) Analysis and identification of gaps between supply and demand in terms of feeder facilities and other requirements for better first and last mile connectivity.

iii) Proposal for introduction/enhancement of feeder buses and cycle/pedestrians tracks, bike sharing arrangement for each Metro station to be finalised.

iv) Proposal for better integration of Metro station with other mode of transport, such as relocation of existing bus stop, introduction of new bus stop, bus base etc.

v) Cost of the requirements namely road widening including roads for pedestrian/cycle paths, feeder buses based on the outcome of the study.

The detailed study and requirement for providing first mile as well as last mile connectivity to the Metro users will be carried out separately and the same should be in place before the commercial operation of the Metro services for the benefit of the users as well as for better ridership and the financial viability of the project.

Since, it is envisaged that detailed study for provision of feeder buses, public bike sharing and pedestrianisation in the influence zone of Metro stations will be done and put in place by the time commercial operation of the Metro services, a lump-sum cost of Rs. 2.31 crores per station has been considered sufficient and included in the project cost of proposed Metro System. If at any stage more feeder services etc will be required, same can be augmented by concerned city transportation authorities.

Chapter 11-Friendly Features For Differently Abled

Chapter - 11

FRIENDLY FEATURES FOR DIFFERENTLY ABLED

11.1 INTRODUCTION

The objective of making this chapter is to create a user-friendly mass transport system in India which can ensure accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems (e.g. a leg in plaster) and the elderly persons.

The design standards for universal access to Public Transport Infrastructure including related facilities and services, information, etc. would benefit people using public transport.

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons", 1998 and 2013 edition (under revision by MoUD), and international best practices / standards

Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around Metro stations.

11.2 CONTENT

1. Rail Transport
2. Light Metro Station
   - Way finding
   - Signage
   - Automated Kiosks
   - Public Dealing Counters
   - Audio-visual Displays
   - Public Telephones
   - Rest Areas/Seating
   - Tactile Paving - Guiding & Warning
   - Doors
   - Steps & Stairs
   - Handrails

- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

3. Street Design
    - Footpath (Sidewalk)
    - Kerb Ramp
    - Road Intersection
    - Median/Pedestrian Refuge
    - Traffic Signals
    - Subway and Foot Over Bridge

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

11.3 RAIL TRANSPORT

1. General
    - Whether over-ground or underground, rail travels is a highly effective mode of transport.
    - Every train should contain fully accessible carriages.
    - Staff should be trained in methods of assistance and be at hand on request.
    - Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways
    - Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
    - All new railway stations should be designed to be fully accessible.
    - For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
    - For persons with visual impairments audio system announcing the station names and door location should be available.

2. Accessible Railway Cars

    The railway cars should have the following features:
    - Railway car doors should be at least 900 mm wide;
    - The gap between the car doors and the platform should preferably be less than 12 mm;

- Identification signage should be provided on the doors of wheelchair accessible coach.
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

3. Wheel Chair Space
   - Space for a wheel chair should be available at the side of the door:-
   - The space should be indicated inside and outside the car by using the international symbol of access; and
   - Wheel stoppers and ring-strap or other appropriate safety grip should be provided for wheelchair users.

4. Seats
   - An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles
   - Aisles should be at least 900 mm wide.

11.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

11.5 METRO STATIONS

1. LEVEL APPROACH
   - Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should have a ramp.
   - Walkway surfaces should be non-slip.
   - Approach walkway should have tactile pavements for persons with visual impairments.

2. STATION ENTRANCES AND EXITS
   - These should have a minimum width of 1800mm and is level or ramped.

3. RESERVATION AND INFORMATION COUNTERS
   - Should have clear floor space of at least 900 mm x 1200 mm in front of the counters;
   - There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
   - At least one of the counters should have an induction loop unit to aid people with hearing impairments; and

- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

4. TOILET FACILITIES
   - There should be at least one unisex accessible toilet
   - Ticket Gates

   At least one of the ticket gates should:
   - Be minimum 900 mm wide to allow a wheelchair user through; and
   - Have a continuous line of guiding paver for people with visual impairments.

5. PLATFORMS

   The Platforms should:
   - Have a row of warning paver installed 600mm before the track edge (photo 6);
   - Have non-slip and level flooring;
   - Have seating areas for people with ambulatory disabilities;
   - Be well illuminated lux level 35 to 40;
   - There should be no gap or difference in level between the train entry door and the platform.
   - All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING
   - Way finding references should be available at decision points.
   - Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
   - Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
   - Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
   - In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
   - Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
   - Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travellers.
   - Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE
   - Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille)

8. SIGN DESIGN SPECIFICATIONS
   - The sign should be in a prominent position.
   - The face of the sign should be well-illuminated by natural or artificial light.
   - Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
   - The colour of the text should be in a colour that contrasts with the sign board.
   - The sign board should also contrast with the wall on which it is mounted.
   - The surface of the sign should not be reflective.
   - Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
   - Illuminated signs should not use red text on a dark background.
   - Signs should be supplemented by Braille where possible.

Fig. 11.1 - Way finding signage

Fig. 11.2 - International Symbol of Accessibility

9. AUTOMATED KIOSKS
   - Automated kiosks should be accessible for wheelchair users.
   - Should be clearly marked with international symbol of accessibility.
   - Should have Braille buttons and audio announcement system for persons with vision impairments.
   - Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. PUBLIC DEALING COUNTERS
  - Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.
  - Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
  - It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.
  - Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
  - Staff manning the counters should know sign language.
  - Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
  - Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
  - Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
  - There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
  - One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep.

11. AUDIO-VISUAL DISPLAYS
  - Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
  - Enable captioning at all times on all televisions and other audio-visual displays that are capable of displaying captions and that are located in any portion of the terminal.
  - The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING
  - Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
  - Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
  - Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.

- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. TACTILE PAVING- GUIDING & WARNING

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. PLACES TO INSTALL WARNING PAVER

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

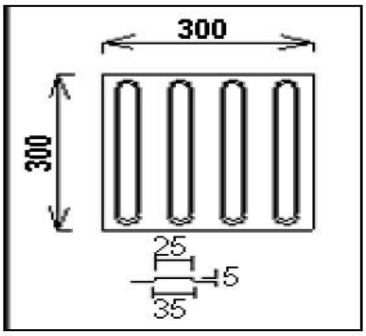


Fig. 11.3 - Guiding paver

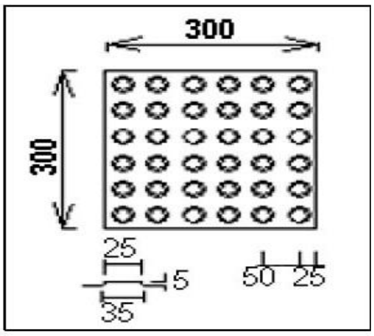


Fig. 11.4 - Warning paver

15. DOORS

Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.

- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).

  - Also be fitted with vision panels at least between 900mm and 1500mm from floor level.
  - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
  - Lever handles and push type mechanisms are recommended. When a sliding door is fully open, handles should be usable from both sides.

- Where revolving doors or turnstiles are used, an alternative wheelchair-
- Accessible entrance must also be provided.
- A distance of 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, colour (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor (figure 28).
- Operable devices such as handles, pulls, latches and locks should:
  - Be operable by one hand
  - Not require fine finger control, tight grasping, pinching or twisting to operate

- Glazed doors and fixed glazed areas should be made visible by use of a clear, colour and tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

16. STEPS & STAIRS
    - Steps should be uniform with the tread not less than 300mm and the risers 150mm.
    - The risers should not be open.
    - The steps should have an unobstructed width of 1200mm minimum.
    - All steps should be fitted with a permanent colour and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both tread and riser.
    - Have continuous handrails on both sides including the wall (if any) at two levels
    - Warning paver to be placed 300mm at the beginning and at the end of all stairs.
    - Nosing to be avoided.
    - The staircase should be adequately and uniformly illuminated during day and night (when in use). The level of illumination should preferably fall between 100-150 lux.
    - The rise of a flight between landings must be no more than 1200mm.
    - There should be no more than 12 risers in one flight run.
    - The stair covering and nosing should be slip-resistant, non-reflective, firmly-fixed and easy to maintain.
    - Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

17. HANDRAILS
    - Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
    - The handrail should contrast in colour (preferably yellow/orange) with surrounding surfaces.
    - At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
    - The handrail should be positioned at two levels- 760mm and 900mm above the pitch-line of a flight of stairs.
    - Handrail at foot of the flight of stairs should extend 300mm beyond the stairs in the line of travel and returning to the wall or floor or rounded off, with a positive end that does not project into the route of travel.

18. RAMPS
    - Ramps gradient should ideally be 1 in 20 and no greater than 1 in 12.
    - Width of the ramp should not be less than 1200mm and preferred width is 1800mm.
    - The steeper the gradient, the shorter the length of ramp between landings.
    - On long ramps, a horizontal resting space should be provided every 6 meters.

- Surface materials should be slip-resistant, non-reflective, firmly-fixed and easily maintained
- The edge of the ramp should have an edge protection with a minimum height of 100mm.
- Landings every 750mm of vertical rise.
- A tapping or lower rail should be positioned so that its bottom edge is no higher than 200mm above ground level.
- Handrails on the ramps should be on both sides at two levels: upper at 900mm and lower at 760mm; both end to be rounded and grouted; extend 300 mm beyond top and bottom of ramp .
- A row of tactile warning paver should be placed 300mm beginning and end of each run.
- Landings should be provided at regular intervals as indicated in the table (Table 11.1).

Table 11.1 - Specifications for Ramps

Level difference	Minimum Gradient.of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	√	
≥ 300 mm ≤ 750 mm	1:12	1500 mm	√	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	√	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	√	Landings every 9 meters of ramp run.

19. LIFTS/ELEVATORS

- A carefully designed lift makes a huge contribution to the accessibility of a multi-storied terminal building for persons with disabilities.
- Lift locations should be clearly signposted from the main pedestrian route and recognizable through design and location.
- The colour and tone of the lift doors should contrast with the surrounding wall finish to assist in their location. Lift doors with metallic finishes such as steel grey and silver should be avoided as they are difficult to identify by persons with low vision.
- The lift lobby shall be of an inside measurement of 1800mm X 2000mm or more. A clear landing area in front of the lift doors of minimum dimensions 1500mm x 1500mm should be provided.
- By making the landing area distinguishable by floor surface and contrast, it will aid location and recognition of core areas. This could comprise a change in floor finish from thin carpet to vinyl/PVC, or cement/mosaic floor to carpet.
- Changes in floor finish must be flushed. There should be no level difference between lift door and the floor surface at each level; the gap if unavoidable should not be more than 12mm.
- The floor level/location should be indicated on the wall adjacent to or just above the call buttons, and opposite the lift doors where possible.

20. Lift Dimensions
- Provisions of at least one lift shall be made for people using wheelchairs with the following car dimensions:
  - Clear internal depth -1500 mm minimum
  - Clear internal width - 1500 mm minimum
  - Entrance door width - 900 mm minimum

21. LIFT CONTROLS
- The lift call button should be wall-mounted adjacent to the lift and should contrast with wall finish, either by using a contrasting panel, or a contrasting border around the button panel.
- The call buttons should be located within the range 800-1000mm above floor finish.
- Buttons should not be touch sensitive, but should require a light positive pressure and should ideally be large enough to be operable by the palm of the hand if required.
- The control buttons inside the lift should be positioned on the side wall rather than front wall to allow access from the back and front of the lift car, by mobility aid users like wheelchair users.
- The control buttons should contrast with their surroundings and illuminate when pressed and should incorporate highly visible tactile embossed (NOT engraved) characters and in Braille.
- Time of closing of an automatic door should be more than 5 seconds and the closing speed should not exceed 25 meters per second. There should be a provision of censor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

22. CAR DESIGN
- Internal walls should have a non-reflective, matt finish in a colour and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.
- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, in order to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

11.6 INFORMATION SYSTEMS

- Lifts should have both visual and audible floor level indicators
- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 50 decibel.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

11.7 GENERAL ACCESSIBLE TOILETS

1. SIGNAGES
   - All signage of general toilets should be in bold and contrasting colors.
   - For persons with low vision and vision impairments: male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
   - Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.
   - Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.

2. ACCESSIBLE TOILETS
   - Should have the international symbol of accessibility displayed outside for wheelchair access.
   - The toilet door should be an outward opening door or two way opening or a sliding type and should provide a clear opening width of at least 900mm.
   - It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.

3. WC COMPARTMENT DIMENSIONS
   - The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
   - Layout of the fixtures in the toilet should be such that a clearing maneuvering space of 1500mm x 1500mm in front of the WC and washbasin.

4. WATER CLOSET (WC) FITTINGS
   - Top of the WC seat should be 450-480mm above finished floor level, preferably be of wall hung or corbel type as it provides additional space at the toe level.
   - An unobstructed space 900mm wide should be provided to one side of the WC for transfer, together with a clear space 1200mm deep in front of the WC.
   - WC should be centred 500mm away from the side wall, with the front edge of the pan 750mm away from the back wall. Have a back support. The WC with

a back support should not incorporate a lid, since this can hinder transfer.
- L-shape grab bar at the adjacent wall and on the transfer side (open side) swing up grab bar shall be provided.
- The cistern should have a lever flush mechanism, located on the transfer side and not on the wall side and not more than 1000mm from the floor.

5. GRAB BARS
   - Grab bars should be manufactured from a material which contrasts with the wall finish (or use dark tiles behind light colored rails), be warm to touch and provide good grip.
   - It is essential that all grab rails are adequately fixed, since considerable pressure will be placed on the rail during maneuvering. Grab bars should sustain weight of 200kgs minimum.
   - A hinged type moveable grab bar should be installed adjacent to the WC on the transfer side. This rail can incorporate a toilet tissue holder. A distance of 320mm from the centre line of the WC between heights of 200-250mm from the top of the WC seat. It should extend 100-150mm beyond the front of the WC.
   - A fixed wall-mounted L- shape grab bar (600mm long horizontal and 700mm long vertical) on the wall side should be provided. It should be placed at a height of 200-250mm above the WC seat level.

6. WASHBASINS
   - Hand washbasins should be fitted on cantilevered brackets fixed to the wall.
   - The basin should be fixed no higher than 750mm above the finished floor level.
   - Be of dimensions 520mm and 410mm, mounted such that the top edge is between 800- 900mm from the floor; have a knee space of at least 760mm wide by 200mm deep by 650-680mm high.
   - The position of the basin should not restrict access to the WC i.e. it should be located 900mm away from the WC.
   - A lever operated mixer tap fitted on the side of the basin closest to the WC is useful as it allows hot and cold water to be used from a seated position on the WC.
   - The hand drying facilities should be located close to the hand washbasin between 1000-1200mm.
   - Lever type handles for taps are recommended.
   - Mirror's bottom edge to be 1000mm from the floor and may be inclined at an angle.

7. FIXTURES AND FITTINGS

- Contrast between fittings and fixtures and wall or floor finishes will assist in their location. For example, using contrasting fittings, or dark tiles behind white hand washbasins and urinals, contrasting soap dispensers and toilet roll holders.
- Contrast between critical surfaces, e.g. floors, walls and ceilings helps to define the dimensions of the room.
- Towel rails, rings and handrails should be securely fixed to the walls and positioned at 800-1000mm from the floor.

- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights-1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.
- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish

8. SIGNAGE OF ACCESSIBLE TOILETS

- All unisex accessible toilets to have access symbol in contrast colours. A distinct audio sound (beeper/clapper) may be installed above the entrance door for identification of the toilets.

Fig. 11.5 - Signage for accessible washroom

9. ACCESSIBLE URINAL

   - At least one of the urinals should have grab bars to support ambulant persons with disabilities (for example, people using mobility aids like crutches).
   - A stall-type urinal is recommended.
   - Urinals shall be stall-type or wall-hung, with an elongated rim at a maximum of 430mm above the finish floor. This is usable by children, short stature persons and wheelchair users.
   - Urinal shields (that do not extend beyond the front edge of the urinal rim) should be provided with 735mm clearance between them.
   - Grab bars to be installed on each side, and in the front, of the urinal.
   - The front bar is to provide chest support; the sidebars are for the user to hold on to while standing.

11.8 DRINKING WATER UNITS

- Drinking water fountains or water coolers shall have up front spouts and control.
- Drinking water fountains or water coolers shall be hand-operated or hand and foot-operated.

- Conventional floor mounted water coolers may be convenient to individuals in wheelchairs if a small fountain is mounted on the side of the cooler 800mm above the floor.
- Fully recessed drinking water fountains are not recommended.
- Leg and knee space to be provided with basin to avoid spilling of water. This allows both front and parallel access to taps for persons using mobility aids like wheel chair, crutches etc.

11.9 VISUAL CONTRASTS

- Visual contrasts means adequate contrast created by difference of at least 30 LRV (Light Reflectance Value) of the two surfaces/ objects and it helps everyone especially persons with vision impairments.
- Visual contrast should be provided between:
    - Critical Surfaces (walls, ceiling and floor),
    - Signage and background sign frame/ wall,
    - Step edges and risers/ treads on steps,
    - Handrails and background walls,
    - Doors and surrounding walls,
    - Switches/ sockets and background wall,
    - Toilet fixtures and critical surfaces in toilet.

- Barriers and hazards should be highlighted by incorporating colours and luminance contrast.

11.10 EMERGENCY EGRESS/EVACUATION

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.
- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a ‘hotkey’ on the phone keypad. This ‘hotkey’ should be distinct from the rest of the keypad.

11.11 ALERTING SYSTEMS

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.
- Consider having audible alarms with ‘voice instructions’ that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.
- Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).

Non-auditory alarms include:

- Flashing beacons
- Vibrating pillows and vibrating beds.
- Pagers or mobile phones that give out a vibrating alarm along with a flashing light (these may be issued to persons with vision or hearing impairments at the time of check-in or boarding the vehicle.)

11.12 WRITTEN EVACUATION PROCEDURE

A written evacuation procedure that details the egress plan for people with disability should be installed behind the entrance door in the accessible rest rooms. The evacuation procedure should be detailed in large print letters that contrast strongly against the background. Where possible, it should also incorporate raised letters and Braille. The evacuation route should be displayed on a high contrast tactile map for benefit of persons with vision impairments.

11.13 EMERGENCY EVACUATION ROUTE

- Designate routes that are at least 1200mm wide, to ensure that a person using a wheelchair and a non-disabled person are able to pass each other along the route. The route should be free of any steps or sudden changes in level and should be kept free from obstacles such as furniture, coolers, AC units and flower pots.

- Use Exit signage along the route. Orientation and direction signs should be installed frequently along the evacuation route and these should preferably be internally illuminated. The exit door signage should also be internally illuminated.

- A ‘way guidance lighting system’ consisting of low mounted LED strips to outline the exit route (with frequent illuminated direction indicators along the route) should be installed along the entire length of the evacuation route. Way guidance systems allow persons with vision impairments to walk significantly faster than traditional overhead emergency lighting. Moreover, emergency exit lights in green color and directional signals mounted near the floor have been found to be useful for all people in cases where a lot of smoke is present.

11.14 WAY GUIDENCE SYSTEM

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.

- Install clear illuminated sign above exit and also directional signage along the route.

- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

11.15 Fire Resistant Doors

- Fire resistant doors and doors used along the emergency evacuation route are generally heavy and the force required to open these is much higher than 25 Newton, making it difficult for people with disability to negotiate these doors independently. There are, however, magnetic and other types of door holders available that can be connected to fire alarms so that they will hold the doors open normally but will release the doors when the fire alarm is activated.

11.16 STREET DESIGN

(a) Footpath (Sidewalk)

Footpaths should be regarded as a transportation system which is connected and continuous, just like roadways and railways. They should not be sporadically placed where ever convenient, but instead should be provided consistently between all major attractions, trip generators, and other locations where people walk.

Footpath should

- Be along the entire length of the road;
- Have height of a standard public step riser i.e. 150 mm maximum;
- Be at least 1800 mm wide;
- Have non-slip surface;
- Have tactile guiding paver for persons with visual impairments;
- Preferably have well defined edges of paths and routes by use of different colours and textures;
- Have no obstacles or projections along the pathway. If this is unavoidable, there should be clear headroom of at least 2200 mm from the floor level;
- The minimum 1.8m (width) x 2.2m (Height) Walking Zone should be clear of all obstructions – both horizontally and vertically.

Footpath should have:

- Have kerb ramps where ever a person is expected to walk into or off the pathway; and
- Have tactile warning paver installed next to all entry and exit points from the footpath.

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.
- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

(c) Road Intersections

- Pedestrian crossings should be equipped with traffic control signal.
- Traffic islands to reduce the length of the crossing are recommended for the safety of all road users.
- Warning pavers should be provided to indicate the position of pedestrian crossings for the benefit of people with visual impairments.
- Table tops (raised road level to the sidewalk height) are helpful in reducing the speed of traffic approaching the intersection.

(d) Median/Pedestrian Refuge

Raised islands in crossings should:

- Cut through and level with the street; or
- Have kerb ramps on both the sides and have a level area of not less than 1500 mm long in the middle; and
- A colored tactile marking strip at least 600 mm wide should mark the beginning and end of a median/ pedestrian refuge to guide pedestrian with visual impairments to its location.

11.17 TRAFFIC SIGNALS

- Pedestrian traffic lights should be provided with clearly audible signals for the benefit of pedestrians with visual impairments;
- Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination;
- The installation of two adjacent acoustic devices such as beepers is not recommended in order to avoid disorientation;
- The time interval allowed for crossing should be programmed according to the slowest crossing persons; and
- Acoustical signals encourage safer crossing behavior among children as well.

11.18 SUBWAY AND FOOT OVER BRIDGE

Subways and foot over bridges should be accessible for people with disabilities. This may be achieved by:

- Provision of signage at strategic location;
- Provision of slope ramps or lifts at both the ends to enable wheelchair accessibility ;
- Ensuring that the walkway is at least 1500 mm wide;
- Provision of tactile guiding and warning paver along the length of the walkway;
- Keeping the walkway; free from any obstructions and projections; and
- Providing for seats for people with ambulatory disabilities at regular intervals along the walkway and at landings.

11.19 ALIGHTING AND BOARDING AREAS

- All areas and services provided in the Mass Rapid Transit System (Metro/subway), bus terminuses, etc. that are open to the public should be accessible.

11.19.1 APPROACH

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.
- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions or areas requiring maintenance should be white cane detectable1.
- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

11.19.2 CAR PARK

(A) SIGNAGE

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be at a minimum height of 2100 mm.

(B) SYMBOL

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the centre of the lot; and
- The colour of the symbol should be white on a blue background.

(C) CAR PARK ENTRANCE

The car park entrance should have a height clearance of at least 2400 mm.

LOCATION

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.
- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) ACCESSIBLE CAR PARKING LOT

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm;
- Have a firm, level surface without aeration slabs;
- Wherever possible, be sheltered;
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings;
- Two accessible parking lots shall be provided for every 25 no of car spaces.

(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

Chapter 12 - Security Measures for a Metro Rail System

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 Measures

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

Chapter – 14

COST ESTIMATES

14.1 INTRODUCTION

Project Cost estimates for the D. N. Nagar (excluding D. N. Nagar Station) - Mandala Metro Corridor has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction at July 2015 price level.

While preparing cost estimates, various items have generally been grouped under three major heads on the basis of:-

(i) Route km. Length of alignment
(ii) No. of units of that item and
(iii) Item being an independent entity.

All items related with alignment, permanent way, OHE, 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-II, Phase-III. A suitable escalation factor has been applied to bring these costs to July 2015 price level. In addition the rates of Civil works have been escalated by 10% to compensate the higher costs in Mumbai compared to Delhi. Taxes & Duties such as Customs Duty, Excise Duty, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the D. N. Nagar (excluding D. N. Nagar Station) - Mandala Metro Corridor of Mumbai at July 2015 price level works out to **Rs. 6947 Crores** excluding applicable Taxes & Duties of **Rs. 1314 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.	D. N. Nagar - Mandala Metro Corridor (23.643 Km, 22 stations)	6947	1314	8261

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 lands with their costs have been shown in corridor 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 July 2015 price level and enhanced by 10% for the higher cost at Mumbai as compared to Delhi.

14.2.3 Stations

Elevated Stations: Rates adopted for elevated stations cover works of station structures, platforms, architectural finishes, covering, etc. Provisions for Electrical and Mechanical works have been made separately. Also provisions for Lifts and Escalators, Viaduct, P-way, O.H.E., Signalling & Telecommunication works, Automatic fare collection installations, etc, have been summed up in the cost estimates.

Mainly three types of stations are proposed for elevated alignment & rates are proposed accordingly.

Type A: Wayside station
Type B: Wayside with Signalling
Type C: Terminal Station

Rates for stations have also been arrived based on Delhi Phase-II and Phase-III accepted rates added by 10% more for higher cost at Mumbai compared to Delhi

14.2.4 Permanent way

For elevated alignment ballastless track and for depot, ballasted track is proposed. Rates adopted are based on similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.3 DEPOT

Depot has been planned near Mandala Station.

14.4 UTILITY DIVERSIONS, ENVIRONMENTAL PROTECTION, MISCELLANEOUS OTHER WORKS

Provisions have been made to cover the cost of utility diversions, miscellaneous road works involved, road diversions, road signages etc. and environmental protection works on route km basis, based on the experience gained from the works done in Phase- II and III of Delhi Metro.

14.5 REHABILITATION AND RESETTLEMENT

Provisions have been made on fair assessment basis, to cover cost of relocation of Jhuggies, shops, residential Houses on private land etc.

Provisions for barracks and security equipment for CISF and Staff Quarters for O&M Wing have been made in the cost estimates on the basis of average cost involved per km length in the recent past.

14.6 TRACTION AND POWER SUPPLY

Provisions have been made to cover the cost of O.H.E., Auxiliary sub stations, receiving substations, service connection charges, SCADA and miscellaneous items, on route km basis separately for 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 July 2015 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 July 2015 price level.

14.9 ROLLING STOCK

Adopted rates are based on awarded rates of similar works of Phase-II and ongoing Phase-III works duly updated to July 2015 price level considering likely indigenization.

14.10 SECURITY

A lump sum provision for providing security infrastructure in the station premises has been made on running kilometre basis. Adopted rates are as taken in phase III DPR suitably escalated to current price level.

14.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 2.31 Crore per station has been made to have seamless integration of metro stations with other modes of transport. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

14.12 GENERAL CHARGES AND CONTINGENCES

Provision @ 7% has been made towards general charges on all items, except cost of land, which also includes the charges towards Detailed Design Charges (DDC), etc. Provision for contingencies @ 3 % has been made on all items including general charges.

14.13 CAPITAL COST ESTIMATES

14.13.1 D. N. Nagar (excluding D. N. Nagar Station) to Mandala Corridor

The overall Capital Cost for this corridor estimated at July 2015 price level, based on the above considerations works out to **Rs. 6947 Crores** without Taxes & Duties. Taxes & Duties such as Customs Duty (CD), Excise Duty (ED), VAT, etc, have been worked out as **Rs. 1314 Crores.**

Table 14.2 - Capital Cost Estimate

Total length = 23.643 km (Entirely Elevated)
Total Station (All Elevated) = 22 Nos

July 2015 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.) Without taxes
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	27.12	542.40
b	Private	ha	100.00	3.49	349.00
1.2	Temporary Land (@5% pa for 4 years)	Ha.	4.00	11.00	44.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.874	23.643	91.59
	Subtotal (1)				**1026.99**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	23.643	872.83
2.2	Depot entry connection	R. Km.	36.92	0.80	29.53
	Subtotal (2)				**902.36**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	16	465.39
b	Type (A) way side- EM works etc	Each	8.06	16	128.99
c	Type (B) Way side with signalling-civil works	Each	28.48	5	142.38

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.) Without taxes
d	Type (B) Way side with signalling-EM works etc	Each	8.06	5	40.31
e	Type (C), Terminal station -civil works	Each	32.45	1	32.45
f	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	1	8.06
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	44	107.80
3.3	Metro Bhawan, OCC bldg. (Cost already considered in Dahisar to D.N. Nagar Corridor)				
a	civil works	LS			0.00
b	EM works etc	LS			0.00
	Subtotal (3)				**925.38**
4.0	**Depot at Mandala**	LS			
4.1	Depot				
a	Civil works	LS			80.00
b	EM works etc	LS			120.00
	Subtotal (4)				**200.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	8.58	24.443	209.72
5.2	Ballasted track for Depot	R. Km.	4.72	5.00	23.60
	Subtotal (5)				**233.32**
6.0	**Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R.Km.	10.50	24.443	256.65
	Subtotal (6)				**256.65**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	24.443	390.94
7.2	Automatic fare collection	Stn.			

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.) Without taxes
	a) Elevated stations	Each	5.50	22	121.00
	Subtotal (7)				**511.94**
8.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.5 cr/km)** + EM works (3.5 cr/km)	R. Km.	8.00	24.443	195.54
	Subtotal (8)				**195.54**
9.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	204	1999.20
	Subtotal (9)				**1999.20**
10.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.07	24.443	1.71
b	EM works etc	R.Km.	0.29	24.443	7.09
	Subtotal (10)				**8.80**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.74	24.443	42.53
b	EM works etc	R.Km.	0.44	24.443	10.75
	Sub Total (11)				**53.29**
12.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	22	50.82
	Sub Total (12)				**50.82**
13.0	**Total of all items except Land**				**5428.88**
14.0	**General Charges incl. Design charges @ 7 % on all items except land**				**380.02**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.) Without taxes
15.0	Total of all items including G. Charges except land				5808.91
16.0	Contingencies @ 3 %				174.27
17.0	Gross Total				5983.17
	Cost without land			=	5983
	Cost with land including contingencies on land			=	6947

Table 14.3 - Details of Taxes and Duties

Customs duty = 23.4155 %

Excise duty = 12.50 %

VAT = **12.5 %**

Octroi = **4 %**

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT(Cr.)		
1	**Alignment & Formation**						
	Elevated, at grade & entry to Depot	902.36		78.96	88.83	19.63	**187.41**
2	**Station Buildings**						
	Elevated station - civil works	748.02		65.45	73.63	16.27	**155.35**
	Elevated station-EM works	177.36	8.31	15.08	16.96	5.62	**45.96**
	OCC bldg-civil works	0.00		0.00	0.00	0.00	**0.00**
	OCC bldg-EM works	0.00	0.00	0.00	0.00	0.00	**0.00**
3	**Depot**						
	Civil works	80.00	5.62	4.90	5.51	1.81	**17.84**
	EM works	120.00	5.62	10.20	11.48	3.80	**31.10**
4	**P-Way**	233.32	43.71	4.96	5.58	7.90	**62.14**
5	**Traction & power supply**						
	Traction and power supply	256.65	24.04	16.36	18.41	8.32	**67.12**
6	**S and T Works**						
	S & T	390.94	73.23	9.77	11.00	13.27	**107.27**
	AFC	121.00	21.25	3.78	4.25	4.09	**33.37**
7	**R & R hutments**	91.59			5.72	1.83	**7.56**
8	**Misc.**						
	Civil works	229.01		20.04	22.54	4.98	**47.56**
	EM works	79.43		8.44	9.49	2.46	**20.40**
9	**Rolling stock**	1999.20	411.95	19.49	21.93	77.78	**531.15**
	Total	**5428.88**	**593.72**	**257.43**	**295.33**	**167.76**	**1314.24**
	Total taxes & Duties						**1314**

Chapter 15 - Financing Options, Fare Structure and Financial Viability

Chapter - 15

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

15.1 INTRODUCTION

The Mumbai Metro Rail Project (DN Nagar to Mandala) is proposed to be constructed at an estimated cost of Rs. 7798.00 Crore with central taxes and land cost. The route length of the proposed metro rail system and estimated cost at July-2015 price level without central taxes, with central taxes and with all taxes are placed in table 15.1 as under:

Table 15.1 Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)	Estimated cost with all taxes, Octroi & land cost (Rs/Crore)
1	D N Nagar to Mandala	23.643	6947.00	7798.00	8261.00

The estimated cost at July-2015 price level includes an amount of Rs.8.80 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 taxes has been calculated by taking escalation factor @7.5% per annum. The taxes and duties consists of Custom Duty (CD), Excise Duty (ED), State Value Added Tax (VAT) and Octroi levied by the Brihanmumbai Municipal Corporation (BMC). Mumbai Metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective CD works out to 23.4155% (Basic CD (5%), Countervail Duty (CVD) + Additional Custom Duty (ACD)) on the imported portions, ED @ 12.50% and VAT @ 12.50% on indigenously manufactured items and Octroi @ 4% on supply items, which have been considered for working out the estimated taxes and duties. Service Tax on "Works Contract Services" on new construction pertaining to Metro and Mono Rail Projects is exempted from the Service Tax on date and therefore the same has been considered as Nil in the estimated cost. It has been assumed that Maharashtra

State Government will exempt the local taxes or reimburse the same (Sate VAT, Octroi etc) and provide the land worth Rs. Rs.1274 crore on completion cost basis free of cost or shall provide Interest Free Subordinate Debt. The impact of proposed GST Act has not been considered in the FIRR calculation.

It is assumed that the construction work will start on 01.04.2016 and is expected to be completed on 31.03.2020 with Revenue Opening Date (ROD) as 01.04.2020 for the corridor. The total completion costs duly escalated and shown in the table 15.2 have been taken as the initial investment. The cash flow of investments separately is placed in Table –15.2 as below.

Table 15.2 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost including land cost and central taxes	Completion Cost including land cost and all taxes
2015-16	132.00	139.00	146.00
2016-17	1005.00	1134.00	1205.00
2017-18	1949.00	2364.00	2534.00
2018-19	2016.00	2628.00	2805.00
2019-20	1348.00	1889.00	2031.00
2020-21	674.00	1015.00	1086.00
2021-22	674.00	1092.00	1163.00
Total	**7798.00**	**10261.00**	**10970.00**

15.2.1.2 Although the construction is expected to get over by 31^{st} March 2020, the cash flow spill over up to March 2022 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

15.2.1.3 The cost of Land of Rs. 1274 crore included in the above completion cost will be provided free of cost by the Maharashtra Government.

15.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 15.3 as under: -

Table 15.3 Additional Investment towards Rolling Stock

(Rs/Crore)

Financial Year	No. of Cars	Amount
2021-22	30	524.00
2031-32	6	171.00
TOTAL	**36**	**695.00**

15.2.3 Operation & Maintenance (O&M) Costs

The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs
(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables
(iii) Energy costs

The requirement of staff has been assumed @ 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 7.50% per annum. The O&M costs have been tabulated in Table 15.4.1as below:

Table 15.4 Operation and Maintenance Costs

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2020	-	2021	45.80	35.46	97.37	178.63
2021	-	2022	49.92	38.12	119.43	207.48
2022	-	2023	54.41	40.98	128.39	223.79
2023	-	2024	59.31	44.06	138.02	241.39
2024	-	2025	64.65	47.36	148.37	260.38
2025	-	2026	70.47	50.91	159.50	280.88
2026	-	2027	76.81	54.73	171.46	303.00
2027	-	2028	83.72	58.84	184.32	326.88
2028	-	2029	91.26	63.25	198.14	352.65
2029	-	2030	99.47	67.99	213.00	380.47
2030	-	2031	108.43	73.09	228.98	410.50
2031	-	2032	118.18	78.58	313.59	510.35
2032	-	2033	128.82	84.47	337.11	550.39
2033	-	2034	140.41	90.80	362.39	593.61
2034	-	2035	153.05	97.61	389.57	640.23
2035	-	2036	166.83	104.94	418.79	690.55
2036	-	2037	181.84	112.81	450.19	744.84
2037	-	2038	198.21	121.27	483.96	803.43
2038	-	2039	216.04	130.36	520.26	866.66
2039	-	2040	235.49	140.14	559.28	934.90
2040	-	2041	256.68	150.65	601.22	1008.55
2041	-	2042	279.78	161.95	646.31	1088.04
2042	-	2043	304.96	174.09	694.79	1173.84
2043	-	2044	332.41	187.15	746.90	1266.46
2044	-	2045	362.33	201.19	802.91	1366.43

YEAR			Staff	Maintenance Expenses	Energy	Total
2045	-	2046	394.94	216.27	863.13	1474.34
2046	-	2047	430.48	232.50	927.87	1590.84

15.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

15.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years.

15.3 REVENUES

The Revenue of Mumbai Metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

15.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on trip distribution at different distance zones.

15.3.2 Traffic

15.3.2.1 **(a)** The projected ridership figures years as provided by MMRDA are as indicated in table 15.5 below: -

Table 15.5 Projected Ridership

Financial Year	Trips per day (lakhs)
2020-21	8.21
2021-22	8.90
2031-32	10.50
2041-42	12.80

(b) The growth rate for traffic is assumed @8.40% Per Annum upto 2021-22, and @ 1.67% per annum upto 2031-32, @2.00% per annum upto 2041-42 thereafter 1% per annum.

15.3.2.2 Trip Distribution

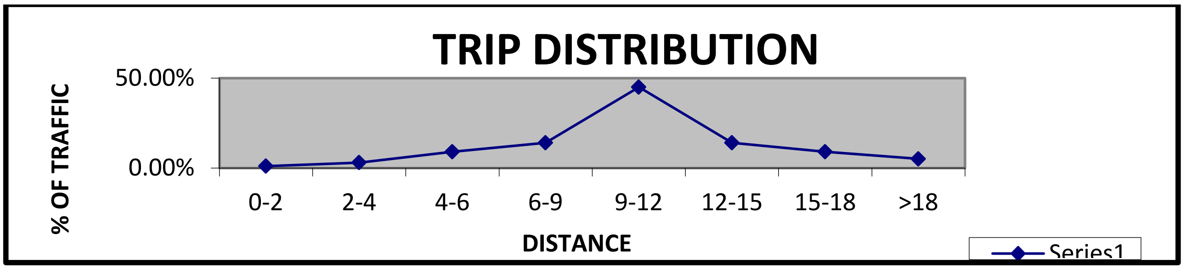
The trip distribution has been worked out for the fare structure proposed by MMRDA by taking an average lead of 10.60 KM which is shown in Table 15.6 below: -

Table 15.6 Trip Distribution

Distance in km	Percent distribution
0-2	1.00%
2-4	3.00%
4-6	9.00%
6-9	14.00%
9-12	45.00%
12-15	14.00%
15-18	9.00%
>18	5.00%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-15.1.

Figure 15.1 –Trip Distribution



Fare Structure

The fare structure for the FY 2020-21 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 15.7 below:

Table 15.7 Fare Structure in 2020-21

Sr. No.	Distance	Proposed Fare
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 since it has been approved by 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.

Year 2020-21	
SLAB	**FARE (Rs)**
0-3 Kms	10.00
3-12 Kms	20.00
12 Kms and More	30.00

The proposed Fare Structure will have convenience in making use of ticket vending machine and eliminate the problems of non-availability of changes for tendering changes to the passengers.

15.3.2.3 Other Sources of Revenues

Other revenues from Property Development and advertisement have been assumed @ 10% of the fare box revenues during 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 10.78%. The FIRR with central taxes & duties is produced in Table 15.9:-

Table 15.9 – 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
2016	-	2017	139				139			0	-139
2017	-	2018	1134				1134			0	-1134
2018	-	2019	2364				2364			0	-2364
2019	-	2020	2628				2628			0	-2628
2020	-	2021	1889		179		2068	609	61	670	-1398
2021	-	2022	1015	524	207		1746	660	66	726	-1020
2022	-	2023	1092	0	224		1316	770	77	847	-469
2023	-	2024	0	0	241		241	783	78	861	620
2024	-	2025	0	0	260		260	915	92	1007	747
2025	-	2026	0	0	281		281	931	186	1117	836
2026	-	2027	0	0	303		303	1086	217	1303	1000
2027	-	2028	0	0	327		327	1105	221	1326	999
2028	-	2029	0	0	353		353	1288	258	1546	1193

Year			Outflow					Cash Flow			
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2029	-	2030	0	0	380		380	1310	262	1572	1192
2030	-	2031	0	0	411		411	1534	307	1841	1430
2031	-	2032	0	171	510		681	1559	312	1871	1190
2032	-	2033	0	0	550		550	1841	368	2209	1659
2033	-	2034	0	0	594		594	1878	376	2254	1660
2034	-	2035	0	0	640		640	2210	442	2652	2012
2035	-	2036	0	0	691		691	2255	451	2706	2015
2036	-	2037	0	0	745		745	2628	526	3154	2409
2037	-	2038	0	0	803		803	2680	536	3216	2413
2038	-	2039	0	0	867		867	3137	627	3764	2897
2039	-	2040	0	0	935		935	3201	640	3841	2906
2040	-	2041	0	0	1009		1009	3770	754	4524	3515
2041	-	2042	0	0	1088	935	2023	3845	769	4614	2591
2042	-	2043	0	0	1174	982	2156	4459	892	5351	3195
2043	-	2044	0	0	1266	0	1266	4504	901	5405	4139
2044	-	2045	0	0	1366	0	1366	5245	1049	6294	4928
2045	-	2046	0	0	1474	0	1474	5298	1060	6358	4884
Total			**10261**	**695**	**16878**	**1917**	**29751**	**59501**	**11528**	**71029**	**10.78%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 15.10 below : -

Table 15.10 –FIRR Sensitivity Analysis

Capital Cost with Central Taxes but without land cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
10.01%	9.32%	11.67%	12.70%
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**
8.19%	9.55%	11.92%	12.97%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
10.49%		**11.07%**	

These sensitivities have been carried out independently for each factor.

15.4 FINANCING OPTIONS

Objectives of Funding: - The objective of funding metro rail systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
    - Low infrastructure maintenance costs
    - Longer life span
    - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai, Bengaluru and Mumbai Line-3 projects are funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

15.5.1 Alternative Models Of Financing

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

(i) Special Purpose Vehicle under the State Government Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC)

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

SPV (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.

MULTILATERAL FUNDING AGENCY LOAN: - Official Development assistance from Inter National funding 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 Multilateral Funding Agency to GOI which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Normally, funding agencies fund for underground civil works, Electrical, Signalling &Telecom and Rolling Stock only. Since the loan will be in fully convertible currency, 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, Multilateral

Funding Agency 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 MULTILATERAL FUNDING AGENCY 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 Multilateral Funding Agency officials, henceforth Multilateral Funding Agency will 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. Multilateral Funding Agency 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 Multilateral Funding Agency agree to fund the project, the full loan i.e., Rs. 5393 crore shall be funded by Multilateral Funding Agency. In that case there will be no need to borrow from Market Borrowing.

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 Multilateral Funding Agency 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 central and state taxes, land & IDC)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	1216.00	13.53%
Equity By GOM	1216.00	13.53%
SD for CT by GOM	581.00	6.47%
SD for CT by GOI	581.00	6.47%
0.30% Loan from Multilateral Funding Agency / 12% Market Borrowings	5393.00	60.00%
Total	8987.00	100.00%
SD for Land by GOM	1274.00	
Total	10261.00	
Interest During Construction	16.00	
State Taxes (State VAT & Octroi etc)	709.00	
Grand Total	10986.00	

(State VAT, Octroi etc) of Rs.709.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

BOT Model: - In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Maharastra 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 funding pattern assumed under this model excluding the cost of land is placed in table 15.12 tabulated as under: -

Table 15.12 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1797.00	20.00%
VGF by GOM	905.00	9.49%
Equity by Concessionaire	2095.00	23.51%
Concessionaire's debt @12% PA	4190.00	47.00%
Total	8987.00	100.00%
Land Free by GOM	1274.00	
Total	10261.00	
IDC	110.00	
State Taxes (State VAT, Octroi etc)	709.00	
Grand Total	**11080.00**	

State Taxes (State VAT, Octroi etc) of Rs.709.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

15.6. RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 10.78%. The pre-tax Equity FIRR to the BOT operator worked out to 16% with total VGF of Rs.3976.00 crore.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 15.13 excluding state taxes.

Table 15.13

Rs. In crore

Particulars	SPV Model	BOT Model
GOI	1797.00	1797.00
GOM	3071.00	2179.00
Total	**4868.00**	**3976.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.709.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Though in case of BOT Model cash out flow from the government is less by Rs. 892/- crore, yet considering other factors such as delay in the implementation, inflation of cost etc. as described in the chapter 17 of the DPR. 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 Funding Agency Loan	15.14
SPV Model with Market Borrowings	15.15
BOT Model	15.16

The funding pattern assumed under SPV model with Multilateral Funding Agency Loan / Market Borrowing and BOT model is depicted in the pie chart i.e., Figure 15.2.2 & 15.2.3 as under: -

Figure 15.2.2
Funding pattern under SPV Model

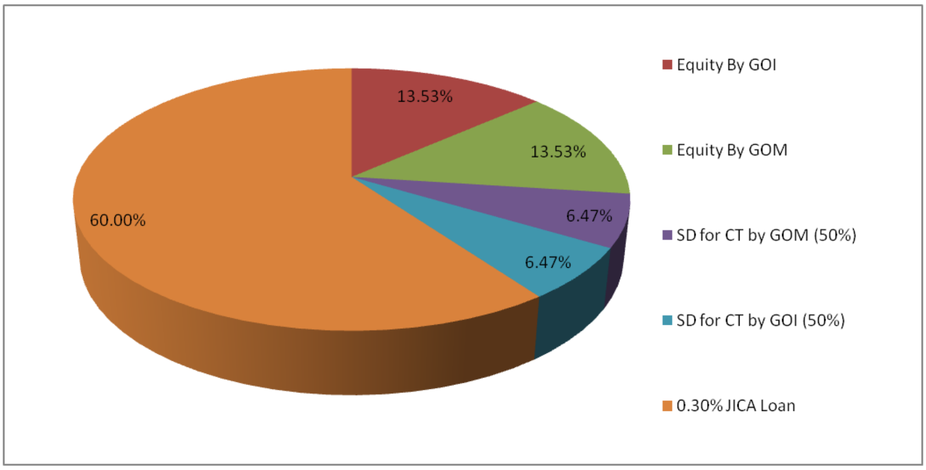


Figure 15.2.3
Funding pattern under BOT Model

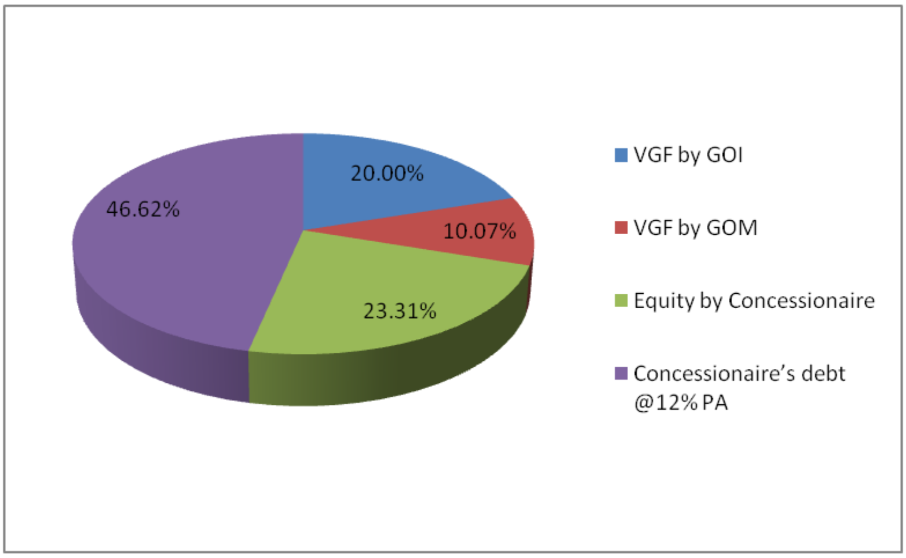


Table 15.14

Mumbai Metro (DN Nagar to Mandala) Corridor

CAPITAL COST-FIXED	7798		MB		0%	0.00%	0.00%	
CAPITAL COST - CURRENT	10261		Multilateral Funding Agency		0.30%	100.00%	0.30%	
DOMESTIC FUNDING - BASE CASE			Front end Fee (one time)		0.20%		0.30%	
			Tenure of JICA Loan		10+30 Years			

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
2016 - 2017	139					139			0	-139	218	79	79	0	0	0	0	0				
2017 - 2018	1134					1134			0	-1134	1272	138	217	0	0	0	0	0				
2018 - 2019	2364					2364			0	-2364	1300	-1064	-847	847	847	0	12	859				
2019 - 2020	2628					2628			0	-2628	1331	-1297	-2144	2144	1297	0	4	2160				
2020 - 2021	1889		179	308		2068	609	61	670	-1398	747	-1142	-3286	3286	1142	0		3302	8	175	483	483
2021 - 2022	1015	524	207	324		1746	660	66	726	-1020	0	-1015	-4301	4301	1015	0		4317	11	184	-16	466
2022 - 2023	1092	0	224	324		1316	770	77	847	-469		-1092	-5393	5393	1092	0		5409	15	284	608	1075
2023 - 2024	0	0	241	324		241	783	78	861	620		0	0	0	0	0		5409	16	280	604	1679
2024 - 2025	0	0	260	324		260	915	92	1007	747		0	0	0	0	0		5409	16	407	731	2409
2025 - 2026	0	0	281	324		281	931	186	1117	836		0	0	0	0	0		5409	16	496	820	3229
2026 - 2027	0	0	303	324		303	1086	217	1303	1000		0	0	0	0	180		5229	16	660	803	4033
2027 - 2028	0	0	327	324		327	1105	221	1326	999		0	0	0	0	180		5048	16	659	803	4836
2028 - 2029	0	0	353	324		353	1288	258	1546	1193		0	0	0	0	180		4868	15	854	998	5833
2029 - 2030	0	0	380	324		380	1310	262	1572	1192		0	0	0	0	180		4688	15	853	997	6830
2030 - 2031	0	0	411	324		411	1534	307	1841	1430		0	0	0	0	180		4508	14	1092	1236	8066
2031 - 2032	0	171	510	329		681	1559	312	1871	1190		0	0	0	0	180		4327	14	1018	996	9062
2032 - 2033	0	0	550	329		550	1841	368	2209	1659		0	0	0	0	180		4147	13	1317	1466	10528
2033 - 2034	0	0	594	329		594	1878	376	2254	1660		0	0	0	0	180		3967	12	1319	1467	11995
2034 - 2035	0	0	640	329		640	2210	442	2652	2012		0	0	0	0	180		3786	12	1671	1820	13815
2035 - 2036	0	0	691	329		691	2255	451	2706	2015		0	0	0	0	180		3606	11	1675	1823	15638
2036 - 2037	0	0	745	329		745	2628	526	3154	2409		0	0	0	0	180		3426	11	2069	2218	17856
2037 - 2038	0	0	803	329		803	2680	536	3216	2413		0	0	0	0	180		3245	10	2074	2222	20078
2038 - 2039	0	0	867	329		867	3137	627	3764	2897		0	0	0	0	180		3065	10	2558	2707	22785
2039 - 2040	0	0	935	329		935	3201	640	3841	2906		0	0	0	0	180		2885	9	2568	2717	25502
2040 - 2041	0	0	1009	329		1009	3770	754	4524	3515		0	0	0	0	180		2705	9	3177	3326	28828
2041 - 2042	0	0	1088	357	935	2023	3845	769	4614	2591		0	0	0	0	180		2524	8	3161	2403	31231
2042 - 2043	0	0	1174	386	982	2156	4459	892	5351	3195		0	0	0	0	180		2344	8	3783	3007	34238
2043 - 2044	0	0	1266	386	0	1266	4504	901	5405	4139		0	0	0	0	180		2164	7	3746	3952	38189
2044 - 2045	0	0	1366	386	0	1366	5245	1049	6294	4928		0	0	0	0	180		1983	6	4536	4741	42931
2045 - 2046	0	0	1474	386	0	1474	5298	1060	6358	4884		0	0	0	0	180		1803	6	4492	4698	47628
	10261	695	16878	8739	1917	29751	59501	11528	71029	10.78%	4868				5393	3606	16		305	45107	47628	
										41278												

Mumbai Metro (DN Nagar to Mandala) Corridor

Table 15.15

CAPITAL COST-FIXED			7798																			
CAPITAL COST - CURRENT			10261												MARKET BORROWING		12.00%					
DOMESTIC FUNDING - BASE CASE																						
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2016 - 2017	139					139			0	-139	218	79	79	0	0	0	0	0				
2017 - 2018	1134					1134			0	-1134	1272	138	217	0	0	0	0	0				
2018 - 2019	2364					2364			0	-2364	1300	-1064	-847	847	847	0	51	898				
2019 - 2020	2628					2628			0	-2628	1331	-1297	-2144	2144	1297	0	179	2374				
2020 - 2021	1889		179	315		2068	609	61	670	-1398	747	-1142	-3286	3286	1142	0		3516	353	-177	138	138
2021 - 2022	1015	524	207	331		1746	660	66	726	-1020	0	-1015	-4301	4301	1015	562		3969	483	-295	-1050	-912
2022 - 2023	1092	0	224	331		1316	770	77	847	-469		-1092	-5393	5393	1092	562		4499	542	-250	-481	-1393
2023 - 2024	0	0	241	331		241	783	78	861	620		0	0	0	0	562		3937	540	-251	-482	-1875
2024 - 2025	0	0	260	331		260	915	92	1007	747		0	0	0	0	562		3375	472	-56	-287	-2162
2025 - 2026	0	0	281	331		281	931	186	1117	836		0	0	0	0	562		2813	405	100	-131	-2293
2026 - 2027	0	0	303	331		303	1086	217	1309	1000		0	0	0	0	562		2251	338	331	100	-2193
2027 - 2028	0	0	327	331		327	1105	221	1326	999		0	0	0	0	562		1689	270	398	167	-2026
2028 - 2029	0	0	353	331		353	1288	258	1546	1193		0	0	0	0	562		1127	203	659	428	-1598
2029 - 2030	0	0	380	331		380	1310	262	1572	1192		0	0	0	0	562		565	135	726	495	-1103
2030 - 2031	0	0	411	331		411	1534	307	1841	1430		0	0	0	0	565		0	68	1031	797	-306
2031 - 2032	0	171	510	336		681	1559	312	1871	1190		0	0	0	0	0		0	0	1025	1190	884
2032 - 2033	0	0	550	336		550	1841	368	2209	1659		0	0	0	0	0		0	0	1323	1659	2543
2033 - 2034	0	0	594	336		594	1878	376	2254	1660		0	0	0	0	0		0	0	1324	1660	4203
2034 - 2035	0	0	640	336		640	2210	442	2652	2012		0	0	0	0	0		0	0	1676	2012	6215
2035 - 2036	0	0	691	336		691	2255	451	2706	2015		0	0	0	0	0		0	0	1679	2015	8230
2036 - 2037	0	0	745	336		745	2628	526	3154	2409		0	0	0	0	0		0	0	2073	2409	10639
2037 - 2038	0	0	803	336		803	2680	536	3216	2413		0	0	0	0	0		0	0	2077	2413	13052
2038 - 2039	0	0	867	336		867	3137	627	3764	2897		0	0	0	0	0		0	0	2561	2897	15949
2039 - 2040	0	0	935	336		935	3201	640	3841	2906		0	0	0	0	0		0	0	2570	2906	18855
2040 - 2041	0	0	1009	336		1009	3770	754	4524	3515		0	0	0	0	0		0	0	3179	3515	22370
2041 - 2042	0	0	1088	364	935	2023	3845	769	4614	2591		0	0	0	0	0		0	0	3162	2591	24961
2042 - 2043	0	0	1174	393	982	2156	4459	892	5351	3195		0	0	0	0	0		0	0	3784	3195	28156
2043 - 2044	0	0	1266	393	0	1266	4504	901	5405	4139		0	0	0	0	0		0	0	3746	4139	32295
2044 - 2045	0	0	1366	393	0	1366	5245	1049	6294	4928		0	0	0	0	0		0	0	4535	4928	37223
2045 - 2046	0	0	1474	393	0	1474	5298	1060	6358	4884		0	0	0	0	0		0	0	4491	4884	42107
	10261	695	16878	8921	1917	29751	59501	11528	71029	10.78%	4868				5393	5623	230		3809	41421	42107	
										41278												

Mumbai Metro (DN Nagar to Mandala) Corridor																							Table 15.16
CAPITAL COST-FIXED			7798														12.00%						
CAPITAL COST - CURRENT			6285																				
DOMESTIC FUNDING - BASE CASE																							
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2016 - 2017	70					70			0	-70	524	454	454	0	0	0	0	0					-524
2017 - 2018	490					490			0	-490	524	34	488	0	0	0	0	0					-524
2018 - 2019	1287					1287			0	-1287	524	-763	-275	275	275	0	17	292					-524
2019 - 2020	1522					1522			0	-1522	523	-999	-1274	1274	999	0	93	1384					-523
2020 - 2021	1214		179	192		1393	609	61	670	-723		-1214	-2488	2488	1214	0		2598	166	133	325	325	325
2021 - 2022	745	524	207	208		1476	660	66	726	-750		-745	-3233	3233	745	430		2913	312	-1	-747	-422	-747
2022 - 2023	957	0	224	208		1181	770	77	847	-334		-957	-4190	4190	957	430		3440	350	65	-157	-578	-157
2023 - 2024	0	0	241	208		241	783	78	861	620		0	0	0	0	430		3010	413	-1	-223	-801	-223
2024 - 2025	0	0	260	208		260	915	92	1007	747		0	0	0	0	430		2580	361	178	-44	-845	-44
2025 - 2026	0	0	281	208		281	931	186	1117	836		0	0	0	0	430		2150	310	318	96	-749	96
2026 - 2027	0	0	303	208		303	1086	217	1303	1000		0	0	0	0	430		1720	258	534	312	-437	312
2027 - 2028	0	0	327	208		327	1105	221	1326	999		0	0	0	0	430		1290	206	585	363	-74	363
2028 - 2029	0	0	353	208		353	1288	258	1546	1193		0	0	0	0	430		860	155	830	608	534	608
2029 - 2030	0	0	380	208		380	1310	262	1572	1192		0	0	0	0	430		430	103	881	659	1193	659
2030 - 2031	0	0	411	208		411	1534	307	1841	1430		0	0	0	0	430		0	52	1170	948	2141	948
2031 - 2032	0	171	510	213		681	1559	312	1871	1190		0	0	0	0	0		0	0	1148	1190	3331	1190
2032 - 2033	0	0	550	213		550	1841	368	2209	1659		0	0	0	0	0		0	0	1446	1659	4990	1659
2033 - 2034	0	0	594	213		594	1878	376	2254	1660		0	0	0	0	0		0	0	1447	1660	6650	1660
2034 - 2035	0	0	640	213		640	2210	442	2652	2012		0	0	0	0	0		0	0	1799	2012	8662	2012
2035 - 2036	0	0	691	213		691	2255	451	2706	2015		0	0	0	0	0		0	0	1802	2015	10677	2015
2036 - 2037	0	0	745	213		745	2628	526	3154	2409		0	0	0	0	0		0	0	2196	2409	13086	2409
2037 - 2038	0	0	803	213		803	2680	536	3216	2413		0	0	0	0	0		0	0	2200	2413	15499	2413
2038 - 2039	0	0	867	213		867	3137	627	3764	2897		0	0	0	0	0		0	0	2684	2897	18396	2897
2039 - 2040	0	0	935	213		935	3201	640	3841	2906		0	0	0	0	0		0	0	2693	2906	21302	2906
2040 - 2041	0	0	1009	213		1009	3770	754	4524	3515		0	0	0	0	0		0	0	3302	3515	24817	3515
2041 - 2042	0	0	1088	241	935	2023	3845	769	4614	2591		0	0	0	0	0		0	0	3285	2591	27408	2591
2042 - 2043	0	0	1174	270	982	2156	4459	892	5351	3195		0	0	0	0	0		0	0	3907	3195	30603	3195
2043 - 2044	0	0	1266	270	0	1266	4504	901	5405	4139		0	0	0	0	0		0	0	3869	4139	34742	4139
2044 - 2045	0	0	1366	270	0	1366	5245	1049	6294	4928		0	0	0	0	0		0	0	4658	4928	39670	4928
2045 - 2046	0	0	1474	270	0	1474	5298	1060	6358	4884		0	0	0	0	0		0	0	4614	4884	44554	4884
	6285	695	16878	5723	1917	25775	59501	11528	71029	15.68%	2095				4190	4300	110		2685	45743	44554		16.04%
										45254													

Chapter 16 - Economic Appraisal

Chapter - 16

ECONOMIC APPRAISAL

16.0 ALIGNMENT DESCRIPTION AND ISSUES

Traffic study was conducted for Dahisar (E) to Mandala Metro Corridor (Mumbai) and ridership was estimated. Revenue earning length of the entire section is 42.232 km which include 39 stations. Competent authority considered the report carefully and thought the section could be divided in to two sections for construction purpose. First stretch is from Dahisar (E) to D.N. Nagar, Length of which is 18.589 km and the second stretch is from D.N.Nagar to Mandala (23.643 km). Under this situation, issues arise for deriving the financial, economic parameters.

Cost is derived which is the sum of different costs such as Civil Construction, Rolling Stock, Electrical Work, Signalling, Electronics and telecommunication equipments etc. Recurring costs include Power consumption, Staff Cost and Other Maintenances. These are distributed year wise known as cost stream.

Present Economic appraisal is done for (option 1) the stretch is Dahisar (E) to D.N. Nagar, (option 2) the stretch is D.N.Nagar to Mandala and (option 3) is for Dahisar (E) to Mandala. Ridership and the cost are to be used separately for the three options.

In Option 1, first stretch is considered as an isolated or stand alone system where trips between Dahisar (E) to D.N.Nagar is taken and the ridership after D.N. Nagar is discarded. Cost is estimated only for first stretch.

In Option 2, second stretch is considered as continuation of the first stretch but only remaining ridership which is full ridership of 39 stations minus inside ridership of first stretch is taken. Cost is estimated accordingly

In Option 3, full stretch ridership is considered and the cost is the sum of cost estimated for option 1 and option 2.

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 fuel and vehicle maintenance cost which are estimated from market cost. Economic factors which are used for each components are also given in table 16.1. Overall economic value of benefit components is 93% of the estimated value.

Table 16.1: Cost/Benefit Components due* to *Metro

	Cost/Benefit Components	Economic Factors
1	Construction Cost	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%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	100%
9	Annual Fuel Cost Saved by Road Passengers	80%
10	Annual Infra Structure Maintenance Cost	100%

16.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in table 16.2.

***Table 16.2*: Values adopted for some important variables**

	Values	Important variables
1	Rs. 0.51/min (2014 value)	Weighted value of Travel Time is derived 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. 0.5/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km
9	3.58 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 charges 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	6	0.5	0.66	0.439
Train	6	0.1	0.05	0.651
Two Wh.	5	2	1.67	0.913
Four Wh.	20	10	5.69	6.346
Three Wh.	20	8	2.60	7.352
Private Bus & Others	6	0.5	0.70	0.399

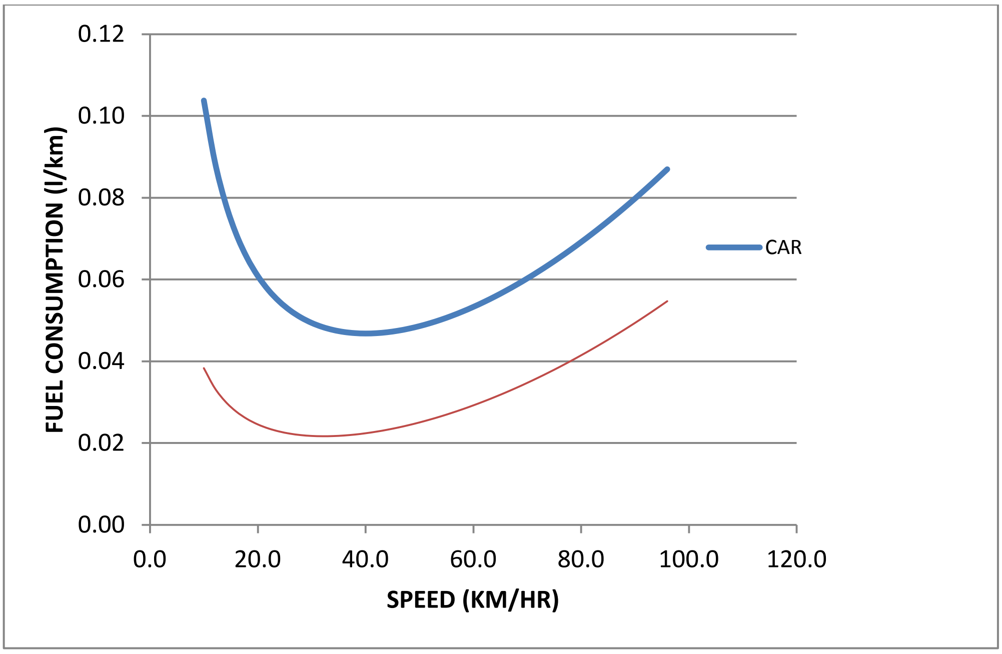
Table 16.5: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

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 16.7A, 16.7B and 16.7C.

Table 16.7A: Summary of the Ridership for Dahisar (E) - D.N. Nagar Option 1

Particulars	2019	2021	2031
Trips/day	358333	407830	609850
Average Trip length (km)	6.22	6.41	6.34
Passenger km	2227039	2614190	3866449
Passenger km/km	126680	148703	219935

Table 16.7B: Summary of the Ridership for D.N.Nagar – Mandala Option 2

Particulars	2019	2021	2031
Trips/day	759194	890430	1049100
Average Trip length (km)	11.05	12.14	11.66
Passenger km	8389091	10805368	12232506
Passenger km/km	477195	614640	695819

Table 16.7C: Summary of the Ridership for Dahisar (E)- – Mandala Option 3

Particulars	2019	2021	2031
Trips/day	1112810	1298260	1658950
Average Trip length (km)	10.41	11.09	9.71
Passenger km	11588456	14397703	16108405
Passenger km/km	659184	818982	916291

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 16.9A, 16.9B AND TABLE 16.9C show components of benefit values (economic) for option1, option2 andd option3 respectively.

Table 16.9A Stream of Economic Benefit Values (Dahisar (E) - D.N. Nagar - Option1)

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Maintenance Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2019	2020	202	126	38	6	1	7	1	5	385
2020	2021	236	150	45	7	1	8	1	6	455
2021	2022	277	179	54	7	2	10	1	6	536
2022	2023	324	214	64	7	2	12	1	7	632
2023	2024	380	254	76	8	3	13	2	8	743
2024	2025	429	289	86	9	3	15	2	8	842
2025	2026	485	327	98	11	4	17	2	9	952
2026	2027	548	371	110	12	4	19	3	9	1078
2027	2028	620	420	125	14	5	22	3	10	1219
2028	2029	700	478	142	15	6	25	4	11	1381
2029	2030	792	540	160	17	7	29	4	11	1561
2030	2031	895	614	181	20	8	34	5	12	1768
2031	2032	1012	852	252	27	9	51	7	16	2225
2032	2033	1143	975	288	31	11	59	8	17	2532
2033	2034	1292	1110	328	36	13	68	9	18	2874
2034	2035	1492	1303	384	42	15	80	11	20	3347
2035	2036	1722	1521	449	49	18	95	13	22	3889
2036	2037	2246	2017	594	65	25	126	17	27	5117
2037	2038	2570	2331	686	75	30	147	20	29	5888
2038	2039	2941	2693	793	86	35	171	24	32	6774
2039	2040	3365	3112	916	100	42	199	28	34	7795
2040	2041	3850	3596	1058	115	49	232	32	37	8970
2041	2042	4406	4154	1223	133	58	271	37	41	10322
2042	2043	5041	4800	1413	154	69	315	43	44	11879
2043	2044	5768	5546	1632	177	82	367	50	48	13671
2044	2045	6600	6408	1886	205	96	428	59	52	15735

Table 16.9B Stream of Economic Benefit Values (D.N. Nagar - Mandala Option2)

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Maintenance Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2019	2020	509	480	145	22	7	19	3	19	1205
2020	2021	606	589	178	27	9	25	4	22	1459
2021	2022	721	722	217	28	11	31	5	25	1760
2022	2023	857	885	266	29	14	39	6	29	2125
2023	2024	1019	1084	325	35	18	42	8	33	2564
2024	2025	1125	1206	360	39	21	48	9	35	2842
2025	2026	1242	1338	399	43	24	54	10	36	3146
2026	2027	1371	1489	443	48	28	60	11	38	3488
2027	2028	1513	1651	491	53	33	68	12	39	3860
2028	2029	1670	1837	545	59	38	77	14	41	4280
2029	2030	1843	2035	604	66	44	87	16	42	4737
2030	2031	2034	2265	670	73	51	98	18	44	5254
2031	2032	2245	3229	956	104	60	152	26	59	6832
2032	2033	2477	3631	1072	116	69	173	30	63	7632
2033	2034	2734	4059	1200	130	81	197	34	66	8501
2034	2035	3018	4595	1354	147	94	224	39	70	9541
2035	2036	3331	5169	1527	166	110	256	45	74	10677
2036	2037	3799	6044	1778	193	133	301	52	81	12382
2037	2038	4155	6729	1980	215	154	338	59	85	13714
2038	2039	4544	7492	2205	240	178	380	66	88	15192
2039	2040	4970	8341	2454	267	206	427	74	92	16830
2040	2041	5436	9286	2733	297	238	479	83	97	18648
2041	2042	5945	10338	3042	331	275	538	93	101	20664
2042	2043	6502	11510	3387	368	318	605	104	106	22900
2043	2044	7111	12815	3771	410	368	679	116	110	25381
2044	2045	7778	14267	4199	456	425	763	131	115	28134

Table 16.9C Stream of Economic Benefit Values (Dahisar-Mandala Option3)

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Maintenance Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2019	2020	651	625	189	29	6	23	4	25	1552
2020	2021	772	782	236	36	8	30	5	29	1899
2021	2022	916	979	294	38	11	39	7	34	2318
2022	2023	1086	1225	367	40	15	50	8	40	2832
2023	2024	1289	1530	458	50	20	55	11	47	3460
2024	2025	1434	1721	514	56	25	63	12	49	3873
2025	2026	1595	1929	576	63	30	72	14	52	4330
2026	2027	1775	2169	645	70	36	81	16	55	4847
2027	2028	1975	2430	723	79	43	93	18	58	5418
2028	2029	2198	2732	810	88	52	106	21	61	6069
2029	2030	2446	3059	908	99	63	122	24	64	6784
2030	2031	2721	3440	1017	111	76	139	28	67	7599
2031	2032	3028	5339	1581	172	92	236	44	98	10590
2032	2033	3369	6084	1795	195	111	273	51	105	11982
2033	2034	3749	6889	2037	221	134	314	58	112	13514
2034	2035	4171	7974	2349	255	164	367	68	121	15469
2035	2036	4641	9169	2708	294	201	427	79	131	17651
2036	2037	5424	11135	3276	356	259	522	96	149	21217
2037	2038	5981	12668	3727	405	315	600	110	159	23965
2038	2039	6595	14412	4241	461	382	688	126	170	27075
2039	2040	7272	16396	4825	524	463	790	145	182	30597
2040	2041	8019	18654	5489	597	561	908	166	194	34588
2041	2042	8843	21222	6245	679	681	1042	190	207	39109
2042	2043	9751	24144	7105	772	826	1197	218	221	44234
2043	2044	10752	27468	8084	879	1002	1374	250	237	50045
2044	2045	11856	31250	9197	1000	1215	1577	286	253	56635

16.4 METRO CONSTRUCTION COST

Total cost of metro construction (**Completion cost**) is derived after considering cost of all major component such as Relocation and Rehabilitation (RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. (**Recurring cost**) includes energy cost, maintenance cost, and operation cost. These costs are inclusive of central tax and yearly escalation cost applied on fixed cost. Analysis period is taken from 2015-16 to 2044-45 out of which 4 years (2015-2019) are marked as construction period. During the years 2021-22, additional capital will again be required for rolling stock and in 2040-41-42 major repairing and replacement cost is envisaged. Operation is expected to start in 2019-20 (4^{th} Year).

To obtain economic cost, escalation factors (7.5%) are removed from the completion cost. Tax is removed from fixed cost which is 10.21%. 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 16.10A, Table 16.10B** and **Table 16.10C** for the three options**.**

Table 16.10A: Completion and Economic Cost stream (Dahisar(E)- D.N.Nagar-Option1)

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2015	2016	247	0	222	0
2016	2017	667	0	557	0
2017	2018	1386	0	1077	0
2018	2019	1286	0	929	0
2019	2020	1106	136	744	91
2020	2021	595	146	372	91
2021	2022	740	174	431	101
2022	2023	0	188	0	102
2023	2024	0	203	0	102
2024	2025	0	219	0	103
2025	2026	0	236	0	103
2026	2027	0	255	0	103
2027	2028	0	275	0	104
2028	2029	0	297	0	104
2029	2030	0	320	0	104
2030	2031	0	346	0	105
2031	2032	496	430	140	121
2032	2033	0	464	0	122
2033	2034	0	501	0	122
2034	2035	0	541	0	123
2035	2036	0	583	0	123
2036	2037	0	630	0	124

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2037	2038	0	679	0	124
2038	2039	0	733	0	125
2039	2040	0	791	0	125
2040	2041	725	854	107	126
2041	2042	761	922	104	126
2042	2043	0	995	0	127
2043	2044	0	1074	0	127
2044	2045	0	1160	0	128

Table 16.10B: Completion and Economic Cost stream (D.N.Nagar-Mandala Option2)

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2015	2016	139	0	125	0
2016	2017	1134	0	947	0
2017	2018	2364	0	1837	0
2018	2019	2628	0	1899	0
2019	2020	1889	182	1270	122
2020	2021	1015	196	0	0
2021	2022	1616	227	940	132
2022	2023	0	245	0	133
2023	2024	0	264	0	133
2024	2025	0	285	0	133
2025	2026	0	308	0	134
2026	2027	0	332	0	135
2027	2028	0	359	0	135
2028	2029	0	387	0	136
2029	2030	0	418	0	136
2030	2031	0	451	0	137
2031	2032	171	555	48	157
2032	2033	0	599	0	157
2033	2034	0	646	0	158
2034	2035	0	697	0	158
2035	2036	0	753	0	159
2036	2037	0	812	0	160
2037	2038	0	877	0	160
2038	2039	0	947	0	161
2039	2040	0	1022	0	162
2040	2041	935	1103	138	162
2041	2042	982	1191	134	163
2042	2043	0	1286	0	164
2043	2044	0	1389	0	165
2044	2045	0	1499	0	165

Table 16.10C: Completion and Economic Cost stream (Dahisar (E)-Mandala Option3)

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2015	2016	386	0	347	0
2016	2017	1801	0	1504	0
2017	2018	3750	0	2914	0
2018	2019	3914	0	2829	0
2019	2020	2995	318	2014	214
2020	2021	1610	342	0	0
2021	2022	2356	401	1371	233
2022	2023	0	433	0	234
2023	2024	0	467	0	235
2024	2025	0	504	0	236
2025	2026	0	544	0	237
2026	2027	0	587	0	238
2027	2028	0	634	0	239
2028	2029	0	684	0	240
2029	2030	0	738	0	241
2030	2031	0	797	0	242
2031	2032	667	985	188	278
2032	2033	0	1063	0	279
2033	2034	0	1147	0	280
2034	2035	0	1238	0	281
2035	2036	0	1336	0	282
2036	2037	0	1442	0	284
2037	2038	0	1556	0	285
2038	2039	0	1680	0	286
2039	2040	0	1813	0	287
2040	2041	1660	1957	244	288
2041	2042	1743	2113	239	289
2042	2043	0	2281	0	291
2043	2044	0	2463	0	292
2044	2045	0	2659	0	293

16.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **Table 16.11A, Table 16.11B** and **Table 16.11C** for option 1, option 2 and option 3 respectively. Project period is 2015-2045,

(1) Option 1: Dahisar(E) - D.N. Nagar:

On the basis of **completion** cost, EIRR is 17.06% B/C Ratio is 5.32 and NPV is 91410, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **21.18%,** B/C ratio as **14.73** and NPV as

104931. With 12 % discount, EIRR (completion cost) is **4.51%** and B/C ratio is **1.66**. NPV is Rs **4068** Cr. and with 12% discount rate, EIRR (economic cost) is **8.20%** and B/C ratio is **2.71**. NPV is Rs **6446** Cr.

Table 16.11A: Economic Indicator Values (DAHISAR- DN NAGAR)

DN NAGAR-DAHISAR	(Completion Cost Basis)		(Economic Cost)	
OPTION 1	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	21161	6142	7640	3765
Cumulative benefit(Cr.)	112571	10211	112571	10211
Benefit Cost Ratio	5.32	1.66	14.73	2.71
NPV(Cr.)	91410	4068	104931	6446
EIRR	17.06%	4.51%	21.18%	8.20%

(2) Option 2: D.N. Nagar - Mandala:

On the basis of **completion** cost, EIRR is **25.20%** B/C Ratio is 9.03 and NPV is 240162, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **31.80%,** B/C ratio as **24.43** and NPV as 259009. With 12 % discount, EIRR (completion cost) is **11.51%** and B/C ratio is **3.04**. NPV is Rs **18677** Cr. and with 12% discount rate, EIRR (economic cost) is **15.89%** and B/C ratio is **4.81**. NPV is Rs **22046** Cr.

Table 16.11B: Economic Indicator Values (DN NAGAR-MANDALA)

DN NAGAR-MANDALA	(Completion Cost Basis)		(Economic Cost)	
OPTION 2	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	29903	9162	11057	5794
Cumulative benefit(Cr.)	270065	27839	270065	27839
Benefit Cost Ratio	9.03	3.04	24.43	4.81
NPV(Cr.)	240162	18677	259009	22046
EIRR	25.20%	11.51%	31.80%	15.89%

(1) Option 3: Dahisar(E) - Mandala:

On the basis of **completion** cost, EIRR is **23.48%** B/C Ratio is 9.16 and NPV is 416641, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **29.22%,** B/C ratio as **25.65** and NPV as 449472. With 12 % discount, EIRR (completion cost) is **10.22%** and B/C ratio is **2.95**. NPV is Rs 29007 Cr. and EIRR (economic cost) is 14.10% B/C ratio is 4.72 and NPV is Rs.**34595** Cr.

Table 16.11C: Economic Indicator Values (DAHISAR-MANDALA)

DAHISAR-MANDALA	(Completion Cost Basis)		(Economic Cost)	
OPTION 3	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	51064	14884	18234	9296
Cumulative benefit(Cr.)	467705	43891	467705	43891
Benefit Cost Ratio	9.16	2.95	25.65	4.72
NPV(Cr.)	416641	29007	449472	34595
EIRR	23.48%	10.22%	29.22%	14.10%

16.6A SENSITIVITY ANALYSIS FOR OPTION 1 (DAHISAR (E) - D.N. NAGAR)

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**. 2044-45 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%	17.06%	5.32	21161	4.51%	1.66	6142
-10%	0%	15.96%	4.79	21161	3.53%	1.50	6142
-20%	0%	14.77%	4.26	21161	2.47%	1.33	6142
0%	10%	16.06%	4.84	23277	3.63%	1.51	6756
0%	20%	15.18%	4.43	25393	2.84%	1.39	7371
-10%	10%	14.99%	4.35	23277	2.67%	1.36	6756
-20%	20%	12.98%	3.55	25393	0.88%	1.11	7371

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 12.98%.

Table 16.12 B Sensitivity of EIRR (Economic Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	21.18%	14.73	7640	8.20%	2.71	3765
-10%	0%	20.04%	13.26	7640	7.18%	2.44	3765
-20%	0%	18.82%	11.79	7640	6.09%	2.17	3765
0%	10%	20.15%	13.39	8404	7.27%	2.47	4141
0%	20%	19.24%	12.28	9168	6.46%	2.26	4518
-10%	10%	19.05%	12.06	8404	6.30%	2.22	4141
-20%	20%	17.05%	9.82	9168	4.51%	1.81	4518

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 17.05%.

16.6B SENSITIVITY ANALYSIS FOR OPTION 2 (D.N. NAGAR - MANDALA)

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 16.13A**. 2044-45 is taken for the year of comparison.

Table 16.13A Sensitivity of EIRR (Completion Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	25.20%	9.03	29903	11.51%	3.04	9162
-10%	0%	23.60%	8.13	29903	10.20%	2.73	9162
-20%	0%	22.18%	7.74	24357	9.09%	2.48	7537
0%	10%	23.75%	8.21	32893	10.32%	2.76	10078
0%	20%	22.48%	7.53	35884	9.29%	2.53	10995
-10%	10%	22.22%	7.39	32893	9.07%	2.49	10078
-20%	20%	19.49%	6.02	35884	6.79%	2.03	10995

Sensitivity analysis in **table 16.13B** 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 19.49%.

Table 16.13B Sensitivity of EIRR (Economic Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	31.80%	24.43	11057	15.89%	4.81	5794
-10%	0%	29.91%	21.98	11057	14.42%	4.32	5794
-20%	0%	27.93%	19.54	11057	12.88%	3.84	5794
0%	10%	30.08%	22.20	12163	14.56%	4.37	6373
0%	20%	28.60%	20.35	13268	13.41%	4.00	6952
-10%	10%	28.30%	19.98	12163	13.17%	3.93	6373
-20%	20%	25.14%	16.28	13268	10.67%	3.20	6952

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 25.14%.

16.6C SENSITIVITY ANALYSIS FOR OPTION 3 (DAHISAR (E)- MANDALA)

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 16.14A**. 2044-45 is taken for the year of comparison.

Table 16.14A Sensitivity of EIRR (Completion Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	23.48%	9.16	51064	10.22%	2.95	14884
-10%	0%	22.09%	8.24	51064	9.06%	2.65	14884

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
-20%	0%	20.62%	7.33	51064	7.82%	2.36	14884
0%	10%	22.22%	8.33	56170	9.17%	2.68	16372
0%	20%	21.12%	7.63	61277	8.25%	2.46	17861
-10%	10%	20.89%	7.49	56170	8.06%	2.41	16372
-20%	20%	18.48%	6.11	61277	6.01%	1.97	17861

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 18.48%.

Table 16.14B Sensitivity of EIRR (Economic Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	29.22%	25.65	18234	14.10%	4.72	9296
-10%	0%	27.62%	23.09	18234	12.83%	4.25	9296
-20%	0%	25.94%	20.52	18234	11.49%	3.78	9296
0%	10%	27.76%	23.32	20057	12.95%	4.29	10225
0%	20%	26.51%	21.38	21880	11.95%	3.93	11155
-10%	10%	26.25%	20.99	20057	11.74%	3.86	10225
-20%	20%	23.54%	17.10	21880	9.55%	3.15	11155

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 23.54%.

16.7 QUANTIFIED BENEFITS

Benefits which are shown in previous tables are money value of the benefits. These benefits are estimated first and the converted into money value. For brevity, only 5 year estimates are shown in **table 16.15** (Reduction of Vehicle gas Emission). It is seen that reduction of CO2 will be 93214 tons in 2019 and particulate matters (PM) is reduced by 56 tons in 2019.

Table 16.15 Environmental Benefits Quantified for option 3

Tons/Year	2019	2020	2021	2022	2023
CO	1297.01	1213.83	1408.85	1468.62	1530.92
HC	577.82	421.03	488.68	509.41	531.02
NOX	472.30	548.70	636.86	663.87	692.04
PM	55.89	53.27	61.83	64.46	67.19
SO2	3.91	4.14	4.81	5.01	5.23
CO2	93214	108191	125573	130900	136454
Total Emission Saved	95621	110432	128174	133612	139280

From **Table 16.16**, it may be seen that in 2021, due to shifting, metro passengers time saving will be 30 Cr. (10 million) hour, fuel saving by metro passengers will be 135.6 thousand tons. Amount of travel in terms of passenger km reduced due to shifting to Metro Rail is equivalent to reduction of 47787 vehicles from the road.

About 29 fatal accidents and 206 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the area.

Table 16.16 Travel Benefits Quantified for option 3

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Time Saved by Metro Passengers in Cr. Hr.	24.67	27.22	30.03	31.08	32.17
Annual Fuel Saved by Metro Passengers in thousand Tons.	99.88	116.56	135.60	142.16	148.30
Daily vehicles reduced (off the road)	35473	41172	47787	49815	51928
CO2 reduced in thousand tons	93.21	108.19	125.57	130.90	136.45
Other gases reduced in thousand tons	2.41	2.24	2.60	2.71	2.83
Reduced No of Fatal Accidents in Year	18.41	23.02	28.77	32.30	36.26
Reduced No of Other Accidents in year	132.17	165.22	206.52	231.85	260.28
Annual Vehicle km Reduced in Cr. Km.	66.22	76.86	89.21	92.99	96.94

Chapter 17 - Implementation Plan

Chapter - 17

IMPLEMENTATION

17.1 INTRODUCTION

The D. N. Nagar (Excluding) to Mandala Corridor is the extension of the corridor from Dahisar(E) to D N Nagar, with route length of 23.643 km and 22 stations. The entire corridor is elevated.

Estimated Cost of the project at July 2015 price level with central taxes and duties only is Rs. 7798 crores exclusive of State taxes and Octroi of Rs 463 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs.10261Crores excluding State taxes and Octroi of Rs 709Crores.

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 D. N. NAGAR TO MANDALA CORRIDOR

The D.N. Nagar to Mandala Corridor is carved out of corridors recommended in Phase-I and Phase-II with route length of 23.643km and completion cost of Rs 10261 Crores. World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for this corridor is 10.78%.

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

Out of the 3 PPP models in the country, Delhi Airport Line has been a total failure since the Concessionaire has voluntarily withdrawn with claims through arbitration. In the case of Bombay Metro Line No.1 which is only 11 Kms length had taken more than 6 years for completion and the cost had gone up 2 times. Concessionaire is representing to government for allowing him to charge very high fare in spite of very good ridership leading to loading the public financially.

In the case of the Hyderabad Metro the PPP Concessionaire withdrew from the project and another Concessionaire namely L&T is implementing the project. The financial performance of this project is yet to be assessed as even one section of the project is still not opened for traffic. Considering the global scenario and the experience in our own country DMRC does not recommend either the BOT model or PPP route for implementing the D.N. Nagar to Mandala Corridor.

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

17.4 INSTITUTIONAL ARRANGEMENTS

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

17.5 IMPLEMENTATION STRATEGY

When the project is taken up as a Government initiative there are two ways the projects can be implemented. One is – Mumbai Metro Rail Corporation Ltd. (MMRC) /MMRDA handling the project directly with the help of General Consultants (G.C.). Further bilateral lending agencies generally insist of international consultants to engage as G.C. for assisting for the implementation of the project. International G.C. is required for planning, design, drawing up specifications, preparation of tender documents, finalization of contract and supervision of the project during execution. To engage the G.C. globally tenders would be necessary. For finalizing such a global contract and positioning the Consultants itself takes about 9 to 12 months. G.C. will generally cost about 3½ to 4% of the project cost. Even if G.C. is engaged, still MMRC/MMRDA will need a fairly big organisation to oversee the G.C. work. It will be difficult for MMRC/MMRDA to mobilize required technical persons with experience and knowledge and the establishment cost of MMRC/MMRDA itself would be about another 3½ to 4%. Thus about 7 to 8% of the project cost will be spent on total establishment alone.

The 2nd option is MMRC/MMRDA for this project can be a very small lean and efficient organization responsible for land acquisition and mobilization of funds. The entire Metro project can be entrusted on turnkey basis and on deposit terms to an experienced organization such as DMRC who has the experience and track record and competency of technical manpower. DMRC is implementing on similar basis Jaipur Metro for Rajasthan Government and Kochi Metro for Kerala Government and Greater Noida Metro project for the Greater Noida Authority. The same way the D.N. Nagar to Mandal Corridor can also be handed over to DMRC on a turnkey basis for implementation. DMRC generally charges 6% of the project cost for the total turnkey implementation. This will be the cheapest and quickest way of completing the project in time.

17.6 CONTRACT PACKAGES FOR IMPLEMENTATION OF THE PROJECT

The project may be implemented in the nine packages as under.

Package –1: Starting from chainage 18.175km (Dead End of DN Nagar Station) and upto Badra Station (Including) proposed metro station.

Package – 2: Starting just after Badra Station and upto Kurla(E) Station(Including).

Package – 3: Starting just after Kurla(E) Station upto Mandala Station Dead end.

Package - 4: Detailed design consultant for corridor including Depot.

Package - 5: Construction of boundary wall for depot, earth work filling and construction of workshop, inspection bay, stabling lines etc.

Package – 6 System Contracts: Supply and installation of traction power system (3rd bay) including sub-station.

Package - 7: Supply and installation of signaling system (CBTC)

Package - 8: Supply and installation of AFC System.

Package - 9: Supply and commissioning of rolling stock.

Any other small package may be decided at the time of implementation of the Project.

17.7 IMPLEMENTATION SCHEDULE

A suggested project implementation schedule for Project Implementation on Turnkey Basis (Deposit Terms) is given in Table 17.1

Table 17.1 Project Implementation on Turnkey basis (Deposit Terms)

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

17.8 High Power Committee

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Maharashtra should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project. This Committee should meet once a month and sort out all problems brought before it by 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.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- Sales Tax on works contracts to be executed for the implementation of the project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

As in the case of Delhi Metro, the State Government should exempt/reimburse the Maharashtra Value Added Tax (VAT) to this Metro project. It should also exempt the following:

As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Maharashtra State Government may pursue the Central government to extend the same benefit to MMRC.

In the case of Delhi Metro project, the Union Government has granted exemption from payment of Custom Duty and Excise Duty while the Delhi Government has agreed to give exemption from payment of Sales Tax and on works contracts. Delhi Metro Rail Corporation is also pursuing with the Government for exemption from tax on electricity being consumed by Delhi Metro for its operation and maintenance.

It is recommended that similar exemptions from taxes and duties be granted by the Central Government/Maharashtra Government for Mumbai Metro. In this connection it may be mentioned that the Central Government has been encouraging infrastructure projects in the country through fiscal and non-fiscal concessions. Cities have emerged as the engines of growth and mass transport systems today are one of the most important pre-requisites for the balanced growth of the city. The Government can demonstrate the importance it attaches to this sector by granting the above concessions which would not only help reduce the initial cost of the project so that Mumbai Metro remains commercially viable during its operation phase but also send strong signals to the effect that it is committed to a safer and pollution free city. Moreover, public transport is employment-friendly and favours social balance in a sustainable way since it allows access to jobs and services to all.

17.10 Legal Cover for Mumbai Metro

Implementation of proposed 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.

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रजिस्ट्री सं॰ डी॰ एल॰-33004/99

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भारत का राजपत्र
The Gazette of India

असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

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शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

विमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/Bhadra 5, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[*26th August*, 2009.]

An Act further to amend the Metro Railways (Construction of Works) Act, 1978 and to amend the Delhi Metro Railway (Operation and Maintenance) Act, 2002.

BE it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

Short title and commencement

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009.

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (*3*), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area".

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

'(*ka*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (*2*), after clause (*b*), the following clauses shall be inserted, namely:— Amendment of section 6.

"(*ba*) develop any metro railway land for commercial use;

(*bb*) provide for carriage of passengers by integrated transport services or any other mode of transport;".

9. Section 7 of the Delhi Metro Railway Act shall be renumbered as sub-section (*1*) thereof and after sub-section (*1*) as so renumbered, the following sub-section shall be inserted, namely:— Amendment of section 7.

"(*2*) The Commissioner shall function under the administrative control of the Chief Commissioner of Railway Safety appointed under section 5 of the Railways Act, 1989.". 24 of 1989.

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:— Substitution of new section for section 12.

"12. The Chief Commissioner of Railway Safety shall, for each financial year, prepare in such form, and within such time, as may be prescribed, an annual report giving a full account of the activities of the Commissioners during the financial year immediately preceding the financial year in which such report is prepared and forward copies thereof to the Central Government.". Annual report.

11. In section 13 of the Delhi Metro Railway Act, for the word "Commissioner", the words "Chief Commissioner of Railway Safety" shall be substituted. Amendment of section 13.

12. In section 23 of the Delhi Metro Railway Act, in sub-section (*1*), for the words "Hindi and English", the words "Hindi, English and official language of the State in which such station is located" shall be substituted. Amendment of section 23.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted. Amendment of section 26.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:— Amendment of section 34.

"(4) The Central Government and the State Government shall nominate one member each to the Fare Fixation Committee:

Provided that a person who is or has been an Additional Secretary to the Government of India or holds or has held an equivalent post in the Central Government or the State Government shall be qualified to be nominated as a member.".

Amendment of section 38.

15. In section 38 of the Delhi Metro Railway Act, in sub-section (2), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted.

Amendment of section 85.

16. In section 85 of the Delhi Metro Railway Act,—

(i) in sub-section (1), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted;

(ii) in sub-section (2), for the words "Government of the National Capital Territory of Delhi in the Delhi Gazette", the words "State Government" shall be substituted.

T.K. VISWANATHAN,
Secretary to the Govt. of India.

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Chapter 18 - Conclusions and Recommendations

Chapter – 18

CONCLUSIONS AND RECOMMENDATIONS

18.1 Mumbai is the Commercial Capital of India and it's fast growth especially in the suburbs is causing heavy stress on all infrastructure, especially the Transport. Being a linear city, the existing suburban rail services are very effective and the modal split in favour of public transport is about 88%, which is very high. Since the existing transport infrastructure has been heavily loaded, it has been observed that the population of private vehicles is increasing and it was also predicted that, the modal split in favour of public transport may also recede. Hence, it is proposed by MMRDA to introduce a rail based Mass Transportation System in Greater Mumbai and a master plan has been prepared for the same. It is proposed to take up the extension of Dahisar (E) - D. N. Nagar Corridor upto Mandala with route length of 23.643km 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.

D.N. Nagar (excluding) – Mandala corridor of Mumbai Metro Project is an extension of corridor from Dahisar (E) to D.N. Nagar. First station on this corridor is ESIC Nagar and last station is Mandala. As this corridor is an extension therefore chainage of Dahisar (E) proposed station is taken as 0.0 for reference. This corridor runs in North to South direction between DN Nagar to Bandra. Hereafter it takes turn and runs West to East direction. It connects heavily populated area of city, market places, Airport, Railway Stations and Central Business District (CBD) of Bandra Kurla Complex. Twenty-two stations have been proposed on the corridor. Names of stations are ESIC Nagar, Prem Nagar, Indra Nagar, Nanawati Hospital, Khira Nagar, Saraswat Nagar, National College, Bandra Metro, MMRDA Office, Income Tax Office, ILFS, MTNL Metro, S G Barve Marg, Kurla Terminal, Kurla (E), EEH, Chembur, Diamond Garden, Shivaji Chowk, BSNL Metro, Mankhurd and Mandala Metro.

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 the project at July 2015 price level with central taxes and duties only is Rs. 7798 crores exclusive of State taxes and Octroi of Rs 463 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs.10261Crores excluding State taxes and Octroi of Rs 709 Crores.

18.2 A study is in progress to assess the Environmental and Social Impact of the proposed Metro corridor. A separate report giving details of the Environmental Impact Assessment as well as Social Impact Assessment will be submitted within a period of one month.

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 15% every two years.

18.5 As in the case of Delhi Metro, the State Government should exempt/reimburse the Maharashtra Value Added Tax (VAT) and Octroi etc 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 **10.78%.** The Economic Internal Rate of Return (EIRR) works out to **25.20%**.

18.8 It is recommended to hand over the project to an agency like DMRC on turnkey basis as was done by Rajasthan and Kerala Governments in regard to Jaipur and Kochi Metro projects respectively to complete it within the time period of about three and half year

18.9 Meanwhile the State Government should freeze all future developments along the proposed route of D. N. Nagar - Mandala Metro 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

Appendix

MMRDA's Comments & DMRC's Responses on D.N. Nagar-Mandala Metro Corridor

General Comments:-

- **Diversion Plan chapter/Drawing is not submitted** – Traffic Diversion plan will be prepared at the time of implementation of the corridor.
- **A separate Chapter on underground v/s Elevated metro system in Mumbai Scenario is not submitted** – it is felt that there is no need of separate chapter for underground v/s elevated. However, Annexure 5.1 gives the comparison of two types of alignment.
- **Grammatically errors and spelling needs to be correct for entire DPR** - Corrected

Chapter No	Page No.	Point No.	Particulars	Remarks	DMRC's response
Salient Features	2	6.iii	Schedule (Booked) Speed	**32kmph** speed is considered wheras in TOP schedule speed is considered as **35kmph.**	Corrected as 35kmph
Executive Summary	10	Table 0.4 Station Location	Stations Name	MMRDA, Kurla Railway should be corrected as MMRDA office, Kurla Terminal**.** R.C. Marg station should change as Diamond garden.	Corrected
	12	Table 0.6	Daily Trips & Average Lead	Average Lead in KM is not Mentioned in Table.	Para details are changed.
	22	0.5.9	Geo-technical Investigation	No fresh Geotechnical data provided in DPR. Wherever new alignment taken.	The strata is likely to be same as in other lengths where data is available. However, DMRC will furnish the data for the alignment on new stretch which could not be done due to urgency.
	25	Table 0.12	PHPDT Capacity	D.N. Nagar To Mandala Corridor PHPDT should be mentioned.	This corridor is extension of corridor from Dahisar to D N Nagar. Therefore, PHPDT of whole corridor will be governing. However, peak sectional load of all the sections is available in table 3.4.
	38	Table 0.18	Capital cost Estimate	Land Cost Is not mentioned. Calculation needs to be checked.	Corrected
1	50	1.1.4		Avoid quoting articles without stating source	Deleted.
	51	1.2.3		Table 1.1 and 1.2 not clear	These are the growth rates of three areas of Mumbai in table 1.1 and details of gross density in various areas of the city in table

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					1.2.
	52	1.2.5		CTS were done by MMRDA and the planning parameters should quote CTS study by MMRDA as source.	Corrected
	55	1.6		Reference to Metro Line 1 should be included in rail transit.	Included
	57	1.8.1		NMMT should be included in list	included
2	70	Annex 2.1		Map does not seem accurate. What is dashed line? Legend does not match figure.	It is the copy of Master Plan. However, another plan subsequently modified by MMRDA is also put up at Annexure 2.2.
3	71	3.1		Remarks spelling error	Corrected
	72	3.2		Summary spelling mistake	Corrected
	75		Table no 3.5	Remove the last row	Corrected
	77, 78		Table No 3.7, 3.8, 3.9	Mention the ridership for DN Nagar to Mandale corridor as provided by MMRDA.	These details are available in table 3.3 & 3.5 A. The table of Dahisar (E) to D.N. Nagar have inadvertently gone which are now deleted.
	77	3.4		Correct the name of the corridor as DN Nagar to Mandale.	Corrected.
5	115	5.1.1		Line 2A is generally spaced at 25m centres.	It is not necessary to keep length of standard span same throughout the corridor, it may very from contract to contract depending on characteristic of corridor.
	116	5.1.3 (a)		Standardise spelling of centre and metre in entire document.	Corrected
	150			No entry/exit stairs locations provided?	Refer station planning drawing submitted separately.
	151	5.3.3		No mention of security/screening	Separate chapter is provided on security.
	115	5.1.1	General	The Average Inter-station Distance is about 1.08km?	Checked it is correct.
	117	Table 5.2	CANT given	For 150m radius 0 & for 120m-110mm?	Speed for 150m & 120m radius curves has been calculated with and without cant.
	119	5.2.2	Station Location	All stations will be two level stations except ILFS station?	Yes, agreed.
	120	5.2.6.1	Horizontal Alignment	Alignment starts on New Link Road.	The name of road is New Link Road.
	120	5.2.6.1	Horizontal Alignment	Height Restrictions at Juhu airport.	Height of metro in Juhu area will not be more than the structures already

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					existing in the vicinity.
	121	5.2.6.1	Horizontal Alignment	R C Marg Stations name need to be corrected as ovel garden/Maitri Park.	Changed as to diamond garden station, as mentioned in remark no. 02
	122	5.2.6.1	Horizontal Alignment	The last stations are Mandale at Chainage 41368.1m. It needs to be shifted.	Kindly show the shifted location on map to make necessary change.
	127	5.3.1	Station Planning, General	It should be Mumbai Metro Corridors.	corrected
	128	Table 5.7	Station Types	Stations Name need to be corrected.	Corrected
	146	18. RC Marg		Station name need to be corrected as Diamond Garden/Maitri Park.	Changed as to diamond garden station, as mentioned in remark no. 02
	150	22.Mandala Metro		Station To be shifted.	Kindly show the shifted location on map to make necessary change.
	153	5.3.4	Typical elevated Station	The station is generally located on the road median, is 185m long**?**	Yes, it is true, stations have been designed for 8 coaches.
	153	5.3.4 a	Typical elevated Station	Station can be made as narrow as 19-20m**?**	Corrected as stations minimum width can be kept as 19.4m.
	156	Table 5.8	Passenger Amenity Requirement in Station	Stations name needs to be corrected.	corrected
	158	5.4.1.1	Choice of Superstructure	Need To be Change	Not required to change as for sharp curvature, segmental construction is recommended.
	160	5.4.2 C	Precast, pre-tentioned U-girder with internal Pre-stresing.	Last Para. Need to be corrected.	Not required to change
	160	5.4.3.1	Structural System of Viaduct.	Last Para. Need to be check.	Not required to change
	161	5.4.3.2	Substructure	Last Para. Need to be check.	'Traffic' word is removed.
	161	5.4.5	Grade of Concrete (IV)	Instead of M-45 Grade it should be M-60.	Not required to change
	162	5.4.6	Reinforcement and pre-stressed Steel	It should be CRSHYSD 500	Not required correction.

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	162	5.5	Geotechnical Investigation	No Fresh Geotechnical Investigation is done for this Corridor. Data collected from DPR of Charkop-Bandra-Mankhurd Corridor.	Yes it is correct. GT will however be required to be done again at the time of implementation. It is not required at this stage.
	163	5.5.2	Seismicity	Seismic Zone III is mentioned. It needs to be checked. Design Should include Zone IV.	Mumbai falls in seismic zone III and hence design is also recommended with same seismic factors.
	164	Table 5.9	Details of Boreholes.	When alignment change data for the same need to be mentioned.	The strata is likely to be same as in other lengths where data is available. However, DMRC will furnish the data for the alignment on new stretch which could not be done due to urgency.
	167	5.5.7		Detail soil Investigation needs to be done at the time of implementing the corridor.	Yes, it will be required to be done again at the time of implementation.
	172	5.17	Details of affected Gas (Mahanagar) Pipeline	Fresh investigation of underground utilities needs to be done. Data mentioned in DPR is taken from previous DPR's.	Yes, it will be required to be done again at the time of implementation. It is not required at this stage.
	174	**5.6.7**	Telecom Cables	Above Ground Location of Cables (Utilities) is not Mentioned.	Location can be seen in alignment plans.
	176	5.7.3	Land for Traffic Integration	Need to be clarified.	It is self explanatory.
	181	5.7.8 & 5.7.9	Temporary Office accommodation & Casting Yard.	Location is not mentioned.	Generally these lands are required close to the alignment depending upon availability of the space which is decided by project implementing agency
	182	Table 5.27	Details of Summary of Temporary Land Requirement	Details are not given.	Temporary land are identified at the time of execution of the project.
	190		Drawings	Drawing is not clearly Visible.	corrected
	205		Drawings	Station name mention in drawing need to be correct.	corrected
	208 & 209		Drawings	It should be Kurla Metro Terminal & Kurla(E) Metro.	corrected

Chapter No	Page No.	Point No.	Particulars	Remarks	DMRC's response
	236	Ground Level Plan of Elevated station & Underground Station	Fig1 & Fig.2	Figures are Missing.	Provided.
6	243, 244, 245		Attachment no. 1/A1, 1/B1 & 1/C1	Use the traffic demand PHPDT as provided by MMRDA in column no 3 and accordingly calculate the train operation plan for horizon yr 2021, 2031. Observed that first station and last station ridership is miss-matched.	Agreed. However, TOP will not change.
	254, 255, 256		Attachment no. 1/A2, 1/B2 & 1/C2		
7	**283**			Depot Plan Not Attached.	Corrected (attached now)
9	304	9.1	Data collected from 2006 &2010	Survey need to be done for current year to analysis latest data	Chapter is put up.
	304	9.1.1	Area of Greater Mumbai is incorrect (438sqkm)	Area to be corrected as 437.71 sq km	Rounded off figure has been used.
	305	9.1.2	Data for water sample and soil sample is of 2006 and 2010 Table 9.1 and 9.2	Data needs to be Updated as per Survey for current year	updated
	306	9.1.3	Seismic Zoning Map- Map is not available in the chapter	Seismic Microzonation map needs to be added.	updated
	306	9.1.4	The data of 2006 and 2010 is used for air quality monitoring Table 9.3 and 9.3.7	Data needs to be Updated as per Survey for current year along with the survey date and time. Details regarding Dust pollution needs to be added.	updated
	308	9.1.5	The data of 2006 and 2010 is used for Noise quality monitoring Table 9.4 and 9.4(B)	Data needs to be Updated as per Survey for current year along with the survey date and time Impact of Noise in sensitive areas like hospital, school educational institute etc. if any then what will be measures to be taken.	updated
	309	9.2.1	Socio Economy Survey	Data regarding PAPs need to be added after survey.	It is chapter only for more detail refer SIA & EIA report submitted separately.

Chapter No	Page No.	Point No.	Particulars	Remarks	DMRC's response
	309	9.3	Positive Environmental Impacts	Include reduction in noise, compensatory a forestation, carbon credits, saving in road infra development, health improvements, quality of life improvement Reduce in buses?? It should be reduce in private vehicles. Description for the positive impacts is needed.	It is chapter only for more detail refer SIA & EIA report submitted separately.
	313	9.6	Environment management Plan	• Environmental Impact Identification and Recommended remediation Plan : Measure during Construction, Measures during Operation • Disaster management • Management plan for depot • Emergency measures • Fire protection • Labour camp Environmental monitoring plan: workers health and safety	It is chapter only for more detail refer SIA & EIA report submitted separately.
			Compliance with the coastal regulation Zone (CRZ)	The detail if the alignment passes through the CRZ area …if any it needs to be added. If not then it should be mentioned that the alignment does not pass through h CRZ.	Corrected
			Other Topics to be added	• Waste Management : during construction, operation • Liquid waste • Impact on topography • Impact on climate (GHG) • Impact on water environment: depot and other construction areas • Impact on Land environment • Loss of forest/Trees and Mitigation measures • Impact on Public health and hygiene • Water resources :Ground water and bore wells • Utility drainage problems • Details about ADB format in the chapter • Summary of cost	It is chapter only for more detail refer SIA & EIA report submitted separately.

Chapter No	Page No.	Point No.	Particulars	Remarks	DMRC's response
10	317	Heading		Spelling of Multi Modal is wrong in Chapter heading	corrected
	317	10.2		There are no Mini Buses on road in Mumbai	corrected
	319	10.5		Metro Station Influence zone is proposed to be 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. This is way too much and will overlap on subsequent stations on both directions	In overlapping areas, some service may serve both the stations.
		General		Integration with suburban stations (Western at Bandra, Central at Kurla and Harbour at Mankurd, Govandi, Chembur),Mono Rail at Chembur and Metro Line 3 is not talked about. Integration of Metro Line –I at D.N. Nagar & Metro Line III at ITO?	Chapter on multi modal traffic integration is very generic and not specific. For specific multi modal traffic, integration MMRDA should undertake separate study for this.
		General		Measures to mitigate traffic and pedestrian dispersal under the station is not addressed	Chapter on multi modal traffic integration is very generic and not specific. For specific multi modal traffic, integration MMRDA should undertake separate study for this.
12	340	12.2	Necessity of Security	NECESSSITY OF SECURITY must be replacing with NECESSITY OF SECURITY.	Corrected
	340	12.3	Three Pillars of security.	'Procedure and' should be replace with 'Procedure	Corrected
	343	12.6 / 10and 17	Proposed provision for security system.	Security of women in Metro Train is not considered. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency. Correction: Queue replace with queue.	It is the security of all passengers irrespective of gender. It will be taken care of by metro authority with assistance of state government. -
13	347	13.6	Provisions at metro stations/other installations	(F) DG Sets & UPS replace with DG SETS & UPS.	Corrected

Chapter No	Page No.	Point No.	Particulars	Remarks	DMRC's response
14	349	14.1	INTRODUCTION	Estimates are prepared based on Phase-II & ongoing Phase-III (DPR) of Delhi Metro. Further DMRC escalated to arrive at the July 2015 price level. Added 10% escalation to meet the Mumbai area specific constraints. DMRC required providing back and calculations (Excel formats) for the same for better understanding. Estimates are of July 2015 price level. However estimates may further revised up to Dec 2015/Jan 2016 price levels.	Not required to change datum of costing. It will help in comparing cost of different corridors.
	350	14.2.1	Land	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.	corrected
	351	14.11	Multimodal Traffic Integration	A lump sum provision of Rs. 2.31 Crore per station has been made to have seamless integration of metro stations with other modes of transport. (No Calculation)	Provision has been made based on the unit cost worked out for Delhi metro after conducting a study. It will be equally valid for Mumbai metro.
	353	14.13.1	Table Sr. No 1.1a	Multiplication error 442.4 Cr (542.4) .Subtotal needs to correct.	corrected
	354		3.3	Metro Bhawan, OCC bldg. costs may include in the cost estimates as this line have exclusive depot at Mandala. Also may be operated other than DMRC.	It is already taken into account in the corridor from Dahisar to D.N. Nagar.
	355		13	Total figure not matching. Supporting calculations of excel sheet required to be provided by DMRC.	corrected
	356		Table 14.3 Sr. No 1	Figures not matching based on the factors provided for ED, VAT, OCtroi . Supporting calculations of excel sheet required to be provided by DMRC.	It Is correct. Whole amount is not considered for taxes.
15	**357**	15.1	FIRR Calculation	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.	Yes, agreed.
	358	15.2.1.1	FIRR Calculation	The impact of proposed GST Act has not been considered in the FIRR calculation.	Impact can not be assessed at this point of time as bill is not yet

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					passed by Parliament
	358	Table 15.3	Additional Investment towards Rolling Stock	Calculation in Excel Sheet Need to be provided.	Pls refer attachment-V for TOP chapter on page 265
	359	15.2.3	Staff Requirement	Staffs have been assumed @ 30 persons per kilometre based on DMRC's current practice. It should be based Metro Line-1 Experience.	MMRDA's experience of metro line 1 may please be shared with DMRC.
			FIRR Calculation	Excel sheet is required for verification of all calculation	Noted
16	**387**	16.7 (Table16.15)	Quantified Benefits	Quantified Benefits for Line 2B (D.N Nagar to Mandala) Is not calculated Separately.	It is calculated for whole corridor.
	388	Table 16.16	Travel benefits Quantified	Quantified Travel Benefits for Line 2B (D.N Nagar to Mandala) Is not calculated Separately.	It is calculated for whole corridor as entire corridor has ultimately to be viable.
17	**389**	17.1	Introduction	1st Paragraph Need to be corrected.	Corrected
	391	17.3	RECOMMENDED FINANCIAL MODEL FOR D. N. NAGAR TO MANDALA	Last paragraph in page 391 need to be corrected. It should be D.N. Nagar to Mandala.	Corrected
	394	17.8	High Power Committee	Replace MMRC with MMRDA.	Corrected
18	**403**	18.9	Conclusions & Recommendations	Replace Dahisar (E) - D. N. Nagar Metro to D.N. Nagar to Mandala Metro.	Corrected