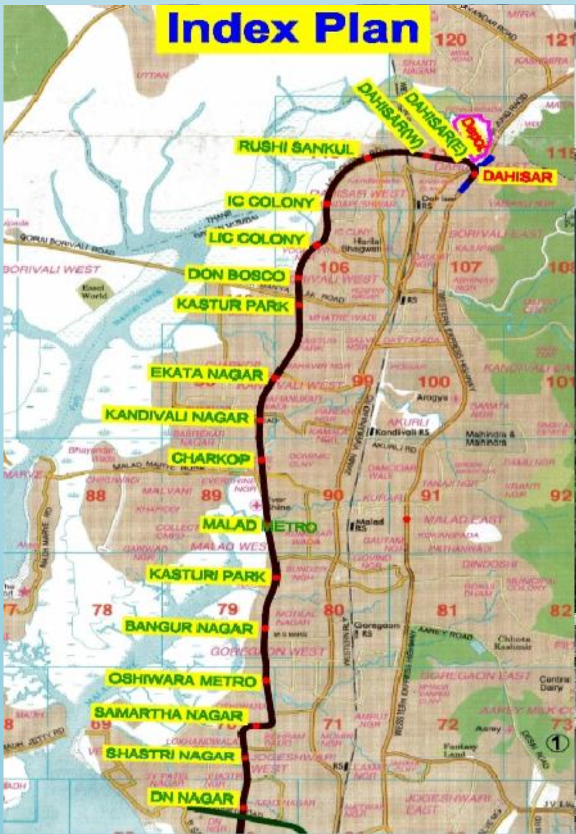
DETAILED PROJECT REPORT(UPDATED)

Dahisar (E) – D.N. Nagar Corridor

CLIENT : MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY (MMRDA)



Prepared By

DELHI METRO RAIL CORPORATION LTD.

September, 2015

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PREFACE

DMRC prepared the Master Plan for Mumbai Metro 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. Now MMRDA has approached to DMRC with the proposal that DPR for Andheri (East) to Dahisar (East) corridor prepared by SPAN Consultants in 2010 be updated by DMRC. This assignment of updation of the DPR has to be completed at the earliest as Government of Maharashtra desires to implement this corridor on priority basis for meeting the heavy traffic needs.

DMRC took up this task and has updated the DPR modifying all the Chapters excluding Environmental Impact Assessment Four more chapters namely Multi Modal Integration, Friendly Features for differently abled, Security Measures and Disaster Management have also been incorporated. Social Impact Assessment is being done and separate report is under preparation.

This DPR gives two options for this stretch between Dahisar (East) and D.N.Nagar. In option-1, Dahisar (East) to D.N. Nagar corridor has been considered as isolated stretch while in option-2 planning has been done considering that entire corridor between Dahisar (East) to Mandale (42.5 kms) will be operational. In option – 2, the PHPDT figure and ridership for this stretch comes much higher than the option – 1. For the above, the under-mentioned Chapters have been put up separately for option-1 and option -2.

1. Salient Features – for option – 1 and option – 2
2. Chapter 6 named as Chapters 6A and 6B respectively for option-1 and option-2
3. Chapter 7 (Maintenance Depot) named as Chapters 7A and 7B respectively for option-1 and option-2
4. Chapter 8 (Power Supply arrangement) named as Chapters 8A and 8B for option -1 and option – 2
5. Chapter 14 (Cost Estimates) named as Chapters 14A and 14B respectively for option – 1 and option -2

6. Chapter 15 (Finance Chapter) named as Chapters 15A and 15B respectively for option – 1 and option – 2
7. Chapter 16 (Economic Analysis) named as Chapters 16A and 16B respectively for option -1 and option -2

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

We thank MMRDA who have made available old Detailed Project Report (DPR) prepared by M/s SPAN Consultants for the stretch between Charkop and Dahisar (East) and also traffic projections for this corridor.

Delhi Metro Rail Corporation

Dated 11.9.2015

SALIENT FEATURES

(Option -1, Considering the proposed Dahisar - D. N. Nagar corridor as isolated Stretch)

1.	**GAUGE (NOMINAL):**	1435 mm
2.	**ROUTE LENGTH:**	18.589 Kms (Completely Elevated)
3.	**NUMBER OF STATIONS:**	17 (All Elevated)

4 TRAFFIC PROJECTION

Year	PHPDT	Daily Trips	Average Lead in KM
2016	8279	270215	6.02
2019	10213	352782	6.25
2021	11560	407826	6.41
2031	15565	609847	6.33

5. TRAIN OPERATION:

	Item	**Horizon Year**		
		2019	**2021**	**2031**
a.	Train composition	3 cars	3 cars	3 cars
b.	Designed Train headway (Peak Hour)	5.25 min	4.5 min	3.5 min
c.	PHPDT demand	10213	11560	15565
d.	**PHPDT Capacity**	10286	12000	15429
		(With 6 standees per sqm.)		
e.	Rakes required	16	18	24
f.	Coaches required	48	54	72

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

7. **Traction Power Supply:**

a.	Traction system voltage	25 kV AC
b.	Current Collection	Over Head Catenary
c.	Receiving Sub Stations	One near Dahisar (E) Station and second in Maintenance Depot at Charkop

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 Charkop station in 20 Ha. land area.

10. **SIGNALLING, TELECOMMUNICATION AND TRAIN CONTROL:**

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

.

11. **FARE COLLECTION** Automatic Fare collection system with POM and Smart card etc.

12. **STRUCTURE:**

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

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

13. **TOTAL ESTIMATED COST:**

i) Estimated cost with central taxes only (At July 2015 prices) — Rs. **4673.00 Crores**.

ii) Estimated completion cost with central taxes only (by April 2019 At 7.5% p.a escalation) — Rs. **5925.00 Crores.**

iii) FIRR

a) without PD income **6.41%**

b) with PD income (from 10 Ha. area) **8.65%**

iv) EIRR **17.19%**

SALIENT FEATURES

(Option -2, considering the entire corridor from Dahisar to Mandale, will be operational)

1. GAUGE (NOMINAL): 1435 mm

2. ROUTE LENGTH: 18.589 Kms (Completely Elevated)

3. NUMBER OF STATIONS: 17 (All Elevated)

4 TRAFFIC PROJECTION

Year	PHPDT	Daily Trips	Average Lead in KM
2016	21346	448800	9.97
2019	29373	597744	10.74
2021	35142	697040	11.26
2031	38509	902050	9.80

5. TRAIN OPERATION:

	Item	Horizon Year		
		2019	**2021**	**2031**
a.	Train composition	6 cars	6 cars	6 cars
b.	Designed Train headway (Peak Hour)	3.5 min	3.0 min	2.75 min
c.	PHPDT demand	29373	35142	38509
d.	**PHPDT Capacity**	30103	35120	38313
		(With 6 standees per sqm.)		
e.	Rakes required	24	27	29
f.	Coaches required	144	162	174

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

7. Traction Power Supply:

a.	Traction system voltage	25 kV AC
b.	Current Collection	Over Head Catenary
c.	Receiving Sub Stations	One near Dahisar (E) Station and second in Maintenance Depot at Charkop

8. ROLLING STOCK

a. 3.20 m wide rolling stock with stainless steel body

b.	Axle load	17 T
c.	Seating arrangement	Longitudinal
d.	Capacity of 6 coach unit With 6 standees / sqm.	1756
e.	Class of accommodation	One (Air conditioned)

9. MAINTENANCE FACILITIES:

Maintenance Depot has been proposed near Charkop station in 20 Ha. land area.

10. SIGNALLING, TELECOMMUNICATION AND TRAIN CONTROL:

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

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11. **FARE COLLECTION** Automatic Fare collection system with POM and Smart card etc.

12. **STRUCTURE:**

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

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

13. **TOTAL ESTIMATED COST:**

i) Estimated cost with central taxes only (At July 2015 prices) Rs. **5913.00 Crores**.

ii) Estimated completion cost with central taxes only (by April 2019 At 7.5% p.a escalation) Rs. **7530.00 Crores.**

iii) FIRR **10.91%**

iv) EIRR **25.33%**

EXECUTIVE SUMMARY

0.1 INTRODUCTION:

0.1.1 Background:

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

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

0.1.2 Population:

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

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

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

0.1.3 Employment:

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

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

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

0.1.4 Land Use Policy:

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

0.1.5 Road Vehicles:

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

0.1.6 Suburban Rail Network:

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

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

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

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

0.1.7 Road Network:

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

0.1.8 Bus Transport System:

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

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

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

0.1.9 Air Pollution:

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

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

0.1.10 Need for Metro:

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

The proposed Dahisar (E) – D. N. Nagar Metro Corridor will basically serve the western parts of Mumbai and the route where this corridor is suggested is heavily loaded. 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 – Mahim – Mankhurd corridor. SPV comprises of Government of Maharashtra, Reliance Infrastructure and SNC Lavalin of Canada. However, the implementation of this Line did not take off.

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

0.2.5.4 MMRDA is intending to implement other corridors by itself.

0.3 TRAFFIC FORECAST:

0.3.1 Proposed Metro Stations on Dahisar - D. N. Nagar Corridor

It is proposed to have seventeen stations on the Dahisar (E) to D. N. Nagar Metro corridor. Dahisar (E) station will be common to both corridors. i.e. Dahisar (E) to D. N. Nagar Corridor and Dahisar (E) to Andheri(E) Corridor. The Index Plan of this corridor is put up at Fig 0.1. The platforms of Dahisar (E) - D. N. Nagar Corridor at Dahisar (E) will be located above the platforms of Dahisar (E) – Andheri (E) Corridor. The locations of proposed stations are as under

Table 0.4 Station Locations

Dahisar(E) to DN Nagar Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G/ ELEVATED**
0	DEAD END	(-) 413.941		
1	DAHISAR (E)	0.0	413.941	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
	DEAD END	18175.0	596.4	

The station to station segment flows, station loading for the entire corridor, i.e. from Dahisar (E) to Mankhurd 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
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	JVPD	18996	10110	30819	17140	30683	21010
20	Ville Parle	18612	10505	30758	17415	30209	21284
21	Nanavati Hospital	18614	10737	30875	17724	30277	21335
22	Arya Samaj Road	18179	10963	30914	17833	29630	21490
23	Khar Metro	17751	11163	31088	17855	29494	21575
24	National College	17653	10988	31326	17651	29627	21329
25	Bandra Metro	12414	10940	23754	17565	19630	21270

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
26	Kala Nagar	11648	8296	21544	14760	17550	16316
27	ITO	12530	7834	22720	13564	19110	15004
28	Baharat Diamond	11173	8552	21167	13926	17426	18386
29	MTNL Metro	11120	8534	21140	13873	17413	18644
30	Budh Nagar	6647	8504	15234	13835	11794	18690
31	Kurla Railway	6431	5360	14677	11217	11481	13625
32	Tilak Nagar	6214	5291	14251	11084	10821	13528
33	Kurla East Metro	6747	4788	14166	10291	11016	12305
34	S.G. Barve Marg	5552	7398	13112	12501	9893	16386
35	R.C. Marg	3247	6961	11436	12307	8845	16098
36	Shivaji Chowk	2475	6156	10816	12483	7988	15777
37	BSNL Metro	1556	2343	9169	7992	6294	10913
38	Mankhurd Metro	252	950	771	6341	3443	8873
39	Mandale Metro	0	329	0	885	0	4819
	PHPDT	**21346**	**11711**	**35142**	**20219**	**38509**	**27376**
	Daily Ridership	**834636**		**1298260**		**1658943**	

0.3.2 Option -1, Considering the proposed corridor as isolated Stretch

However as this DPR is only for Dahisar (E) to D. N. Nagar stretch, the projections for only this stretch as isolated are as under:

The station to station segment flows in both directions during peak hours for the years 2016, 2021 and 2031 are shown in Table no 0.6 and peak hour total boarding and alighting figures in Table 0.7. These figures have been arrived considering the corridor between D. N. Nagar and Dahisar (W) – Dahisar (E) as independent. Once it is extended from D. N. Nagar to Bandra and further to Mankhurd, the PHPDT figures will be much higher.

Table No 0.6

Peak Hour Station to Station Segment Flows

From	To	2016		2019		2021		2031	
		Forward	Reverse	Forward	Reverse	Forward	Reverse	Forward	Reverse
DAHISAR (E)	DAHISAR (W)	1089	0	2980	0	4241	0	6096	0
DAHISAR (W)	RUSHI SANKUL	2986	2076	4231	2795	5061	3275	8161	4593

From	To	2016		2019		2021		2031	
		Forward	Reverse	Forward	Reverse	Forward	Reverse	Forward	Reverse
RUSHI SANKUL	I C COLONY	7258	6721	7582	5511	7797	4705	12198	7528
I C COLONY	LIC COLONY	7209	2680	7547	5231	7773	6931	12154	10515
LIC COLONY	DON BOSCO	7310	2650	7852	5083	8213	6706	12707	9935
DON BOSCO	KASTUR PARK	7251	2873	7975	5424	8457	7125	12958	11092
KASTUR PARK	EKATA NAGAR	7305	2807	8582	5407	9433	7140	13802	11405
EKATA NAGAR	KANDIVALI NAGAR	7750	2734	9031	5554	9885	7435	14034	11768
KANDIVALI NAGAR	CHARKOP	8132	3157	9725	5794	10788	7552	14958	12113
CHARKOP	MALAD METRO	8279	3395	10213	5949	11502	7651	15565	12177
MALAD METRO	KASTURI PARK	6217	3451	9041	6040	10923	7766	14334	12246
KASTURI PARK	BANGUR NAGAR	5540	3280	8330	6196	10190	8141	13377	12962
BANGUR NAGAR	OSHIWAR A METRO	6374	3203	9330	5920	11301	7731	14660	12335
OSHIWARA METRO	SAMARTH A NAGAR	6370	3679	9484	6363	11560	8152	14822	13096
SAMARTHA NAGAR	SHASTRI NAGAR	5649	3642	4307	6214	3412	7928	4651	12756
SHASTRI NAGAR	D N NAGAR	5248	3982	3968	3147	3115	2591	4137	3584
Maximum PHPDT		**8279**	**6721**	**10213**	**6363**	**11560**	**8152**	**15565**	**13096**

Table 0.7 Peak Hour Boarding and Alighting

Station	2016		2019		2021		2031	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
DAHISAR (E)	1089	2076	2980	2795	4241	3275	6096	4593
DAHISAR (W)	1897	4646	1251	2716	820	1429	2066	2935
RUSHI SANKUL	9347	1035	8921	5290	8637	8127	13603	12554
I C COLONY	31	49	147	34	225	24	580	43
LIC COLONY	463	585	816	852	1052	1031	1972	2576
DON BOSCO	468	462	701	561	856	628	1907	1969

Station	2016		2019		2021		2031	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
KASTUR PARK	766	638	1393	933	1811	1129	2816	2334
EKATA NAGAR	1198	1177	1688	1479	2015	1680	2338	2451
KANDIVALI NAGAR	2396	2252	2877	2337	3198	2394	4414	3554
CHARKOP	1141	1050	1553	1157	1827	1227	2182	1644
MALAD METRO	953	2844	2201	3529	3033	3986	3759	5706
KASTURI PARK	560	1161	779	1214	925	1249	1299	1629
BANGUR NAGAR	1349	991	1640	1083	1834	1144	2253	1731
OSHIWARA METRO	908	875	1237	934	1457	974	1782	1280
SAMARTHA NAGAR	422	1484	3756	5868	5979	8791	9964	10964
SHASTRI NAGAR	272	451	401	527	487	578	602	885
D N NAGAR	3760	5248	2935	3968	2386	3115	3353	4137
Total	**27021**	**27021**	**35278**	**35278**	**40783**	**40783**	**60985**	**60985**

0.3.3 Daily Trips and Average Lead (Option -1, Considering the proposed corridor as isolated Stretch)

The projected Daily ridership and average lead in Km for the proposed Corridor from Dahisar (E) to D. N. Nagar for various horizon years are given in Table 0.8

Table No 0.8
Daily Ridership and Average lead in Km

Year	Trips per day (lakhs)	
	Daily Trips	Average Lead in KM
2016	270215	6.02
2019	352782	6.25
2021	407826	6.41
2031	609847	6.33

0.3.4 Daily Trips and Average Lead (Option -2, Considering the proposed corridor as isolated Stretch)

In Option-2, considering that entire corridor will be operational, the ridership for this stretch for different horizon years is given as under:

Daily Trips and Average Lead

Year	Trips per day (lakhs)	
	Daily Trips	Average Lead in KM
2016	448800	9.97
2019	597744	10.74
2021	697040	11.26
2031	902050	9.80

In working out financial viability for option 2, the average length has been taken as calculated for entire corridor.

Considering Dahisar (E) – D. N. Nagar stretch in isolation, sectional load and average lead is very less. However, entire corridor from Dahisar (E) to Mandale is recommended for implementation so that large public is benefited and also project gives High return.

0.4 SYSTEM SELECTION:

0.4.0 General:

0.4.0.1 Dahisar (E) – D.N. Nagar corridor of Mumbai Metro Project is proposed to start at Western Express Highway with its station named as Dahisar (East) and platform located above the already proposed Dahisar (East) metro station for Andheri (E) – Dahisar corridor. The alignment stretches from Dahisar (E) to D.N. Nagar via Dahisar (W), Rushi Sankul, I.C. Colony, Don Bosco, Charkop, Kasturi Park, Oshiwara and runs on link road. D.N. Nagar Metro Station on this corridor is proposed on the median of the road and will be integrated with D.N. Nagar Station of Versova – Ghatkopar corridor

0.4.0.2 Length of Dahisar (E) – D. N. Nagar Metro corridor is 18.589 Kms. The entire corridor will be elevated. Maintenance Depot has been proposed near Charkop station. Depot is about 1.5 km away from the alignment, the cost of which has been provided in the Cost Estimates.

0.4.0.3 Seventeen 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 628.5 metres and farthest 1711.7 metres.

0.4.1 Permanent Way:

0.4.1.1 Choice of Gauge:

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

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

0.4.1.2 Track Structure:

Two types of Track Structure have been proposed. The ballastless track has been proposed for viaduct, while normal ballasted track has been proposed in the maintenance depot. The track will be completely welded and even the turn outs will be incorporated in LWR / CWR. The rails section used will be UIC – 60 (60 kg / mtrs). The grade of rails on main lines will be 1080 Head Hardened as per IRS-T-12-96. As these rails are not manufactured in India at present, these are to be imported. For the

Depot lines, the grade of rails should be 880, which can be easily manufactured indigenously.

0.4.2 Traction System:

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

0.4.3 Signalling:

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

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

0.4.4 Telecommunication:

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

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

The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchange
- Integrated Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- 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. Relative advantages of automatic fare collection system over manual system are as follows.

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

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

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

B. Automatic fare collection systems have the following advantages:

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

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

0.4.5.4 Choice of Control Gates:

Retractable flap type or Turnstile type Control Gates are proposed.

0.4.5.5 Passenger Operated Machines:

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

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

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

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

0.4.6 Rolling Stock:

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

- Proven equipment with high reliability
- Passenger safety features
- Energy efficiency
- Light weight equipment and coach body
- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low life cycle cost
- Flexibility to meet increase in traffic demand

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

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

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

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

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

0.5 CIVIL ENGINEERING:

0.5.1 Geometric Design Norms:

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

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

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

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

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

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

- At scissors crossing — 4.50 m

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

0.5.1.2 Gradients:

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

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 Dahisar (E) – D.N. Nagar corridor of Mumbai Metro Project is proposed to start at Western Express Highway with its station named as Dahisar (East) and platform located above the already proposed Dahisar (East) metro station for Andheri (E) – Dahisar corridor. The alignment stretches from Dahisar (E) to D.N. Nagar via Dahisar (W), Rushi Sankul, I.C. Colony, Don Bosco, Charkop, Kasturi Park, Oshiwara and runs on link road. D.N. Nagar Metro Station on this corridor is proposed on the median of the road and will be integrated with D.N. Nagar Station line.

0.5.2.2 The chainage of Dahisar (E) proposed station is taken as 0.0 and dead end chainage of this station as (-) 413.9 m.

0.5.2.3 Total length of the corridor from dead end to dead end is 18.589 km. The entire corridor proposed is elevated.

0.5.2.4 The corridor starts on W.E.H. and takes left turn to reach Dahisar (W) and thereafter aligns along Link Road.

0.5.2.5 Seventeen stations have been proposed on the corridor. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one Km. distance apart. The maximum and minimum inter station distances are 1711.7 m and 628.5 m respectively.

0.5.2.6 The platform of Dahisar (E) Station of the proposed Dahisar - D. N. Nagar corridor has been planned over the platform of already planned corridor between Andheri (E) – Dahisar (E) along WEH and takes turn towards left to come to Dahisar (W) area. Alignment before reaching Dahisar (W) area traverses on some of the shops and thereafter along the drain. Dahisar (W) station is located at chainage 711.0 on straight alignment. From thereon alignment deviates to the outside Dahisar flyover and to be located between flyover and Group housing. Foundation of the pillars will be so located that pillars will be just butting the edge of the flyover and the height of the viaduct is kept to allow the headway of at least 5.5 m on the flyover. The flyover is located between the chainage 300m and 1300m. From thereon alignment continues to run on the median of link road.

0.5.3 Station Locations:

Stations have been located so as to serve major passenger destinations and enable convenient integration with other modes of transport. Average spacing of stations is close to one km. The platform length of 185 m is proposed to be provided for enabling the lengthening of trains upto 8 coaches, if needed.

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

0.5.3.2 List of stations with chainages and inter station distances are given below in Table 0.9. **An index map showing the alignment and location of stations is given in Fig. 0.1**

Table 0.9 List of Stations

Dahisar(E) to DN Nagar Corridor (Mumbai)				
Sl. No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G/ ELEVATED**
0	DEAD END	(-) 413.941		
1	DAHISAR (E)	0.0	413.941	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
	DEAD END	18175.0	596.4	

0.5.4 Terminals:

- **Dahisar (E) Terminal:**

This terminal station proposed on WEH (S.V & L.R. Junction) near junction of S.V. Road and Link Road at Dahisar (East), the centre line being at Ch.0.0. Station is in the midst of residential and commercial area of Dahisar.

- **D. N. Nagar Terminal:**

This Station is proposed on median of the road by the side of Sewage treatment plant. Scissors cross overs are proposed on both side 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. This Station will be integrated with the D.N. Nagar station of line-1 by providing skywalk

0.5.5 Scissors Crossovers:

Scissors Crossovers will be provided at both the terminal stations viz. Dahisar (E) (S.V. & L.R Junction) and also D.N. Nagar. In between, crossovers are proposed at two intermediate stations 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 the Car maintenance depot at Charkop. The land parcel available is of 20. Ha but of irregular shape. Detailed planning of depot in this area has been done.

0.5.7 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

Twin U Girders are normally economical as compared to segmental U girders and box girders. Twin U girder is recommended for adoption upto the curvature of 300m radius and I girder for sharper curves..

0.5.8 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 in the year 2006 and the borehole done by M/s SPAN Consultants between Charkop and Dahisar (East) has only been relied upon. The details of borehole and type of strata are given in Civil Engineering chapter. There will be need of fresh boreholes at every 100 m distance at the stage of Detailed Design of sub-structure

0.5.9 Utility Diversions:

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

A fresh Utility survey is being done by DMRC as all the above utilities were identified as per the old alignment by SPAN for the stretch between Dahisar(E) and Charkop and by DMRC for the stretch between Charkop and D.N. Nagar. Separate report on the utilities will be made available. However the provision in the cost for handling utilities have been made on per kilometer basis.

0.5.10 Land:

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

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

Entire corridor is planned on the central verge of the Link Road. Stations exit and entry have been designed keeping in view that minimum acquisition of private land will be needed. .

Summary of Permanent land acquisition required is given in Table 0.10.

Table 0.10 Summary of Permanent Land Requirement

		Govt	Private	Total
1	Stations including running sections	**16579.679**	**5005.185**	**21584.864**
2	Depot including one RSS	**200000**	**0**	**200000**
3	Receiving Sub stations (RSS) at Charkop	**Included in Depot Land**	**0**	**0**
	Total	**216579.67**	**5005.185**	**221584.864**

- **Temporary Construction Depot:**

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

0.5.11 Safety & Security Systems:

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

0.5.11.1 Requirements:

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

0.6A TRAIN OPERATION PLAN:

(Option -1, Considering the proposed corridor as isolated Stretch)

0.6.1A 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 A 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
3-car train composition: DMC+TC+DMC

Capacity@ 6 passengers per square meter of standee area

DMC : 300 passengers (Sitting-47, Standing-253)
MC : 300 passengers (Sitting-56, Standing-244)
TC : 300 passengers (Sitting-56, Standing-244)
3 Car Train : 900 Passengers (Sitting-159, Standing-741)

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

Table 0.11 A PHPDT Capacity Provided

YEAR			
	2019	2021	2031
Cars/trains	3	3	3
Head way (Minutes)	5.25	4.50	3.50
Max. PHPDT Demand	10213	11560	15565
PHPDT Capacity Available	10286* (13029**)	12000* (15200**)	15429* (19543**)

* @ 6 persons per square meter of standee area
** @ 8 persons per square meter of standee area

0.6.3A YEARWISE RAKE REQUIREMENT

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

Table 0.12A: Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	No. of car per rake	No. of Coaches
Dahisar (E) to D. N. Nagar	2019	5.25	16	3	48
	2021	4.50	18		54
	2031	3.50	24		72

0.6B TRAIN OPERATION PLAN:

(Option -2, considering the entire corridor from Dahisar to Mandale, will be operational)

0.6.1B 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.

0.6.2B 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 0.11B :

Table 0.11B PHPDT Capacity Provided

	YEAR		
	2019	**2021**	**2031**
Cars/trains	**6**	**6**	**6**
Head way (Minutes)	**3.5**	**3**	**2.75**
Max. PHPDT Demand	**29373**	**35142**	**38509**
PHPDT Capacity Available	**30103* (38469**)**	**35120* (44880**)**	**38313* (48960**)**

* @ 6 persons per square meter of standee area

** @ 8 persons per square meter of standee area

0.6.3B YEARWISE RAKE REQUIREMENT

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

Table 0.12B: Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	No. of car per rake	No. of Coaches
Dahisar (E) to D. N. Nagar	2019	3.5	24	6	144
	2021	3	27		162
	2031	2.75	29		174

0.7A POWER SUPPLY:

(Option -1, Considering the proposed corridor as isolated Stretch)

0.7.1A Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

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

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2016, 2019, 2021 and 2031 are summarized in table 0.13A below:

Table 0.13A Power Demand Estimation (MVA)

Corridor	Load	Year		
		2019	**2021**	**2031**
Dahisar (E) to D. N. Nagar 17 Stations (18.589 km)	Traction	11.95	13.94	17.65
	Auxiliary	7.72	10.13	13.59
	Total	**19.67**	**24.07**	**31.24**

0.7.2 A Sources of Power Supply

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

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

Table 0.14A Sources of Power Supply

S. No.		Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length cables from GSS to RSS
1.	**Dahisar (E) to D. N. Nagar**	110 kV Grid Sub Station (GSS) Near Malad	RSS at Charkop Depot.	To be confirmed by TATA Power
	17 Stations (18.589 km)	110 kV Grid Sub Station (GSS) Near Borivli	*RSS Near Dahisar(E) Depot	To be confirmed by TATA Power

*This RSS already considered in Andheri to Dahisar DPR.

As per Tata Power letter No. CDD/LR-N 4040/13674 dated 04.02.2010 Tata Power Company have assured that reliable power supply from their 110 kV Borivli Sub-station will be provided for Dahisar Depot RSS and 110 kV, Malad Grid Sub Station (GSS) for Supply of Charkop Depot RSS. During the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 0.15A.

Table 0.15A– 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)
Dahisar (E) to D. N. Nagar 17 Stations (18.589 km)	**RSS at Charkop Depot**				
	Traction	6.80	9.93	11.95	17.65
	Auxiliary	5.09	8.34	7.72	13.59
	Sub-total (A)	**11.89**	**18.27**	**19.67**	**31.24**
	RSS Near Dahisar Station*				
	Traction	9.84	14.35	11.95	17.65
	Auxiliary	7.58	13.29	7.72	13.59
	Sub-total (B)	**17.42**	**27.64**	**19.67**	**31.24**

* In Normal Condition Dahisar RSS will also take half load of Andheri to Dahisar Corridor

** Incase of failure of other source of power

0.7B POWER SUPPLY:

(Option -2, considering the entire corridor from Dahisar to Mandale, will be operational)

0.7.1B 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:-

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

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2016, 2019, 2021 and 2031 are summarized in table 0.13 B below:

Table 0.13B Power Demand Estimation (MVA)

Corridor	Load	Year		
		2019	**2021**	**2031**
Dahisar (E) to D. N. Nagar 17 Stations (18.589 km)	Traction	17.09	19.94	21.85
	Auxiliary	7.72	10.13	13.59
	Total	**24.81**	**30.07**	**35.44**

0.7.2B Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in brief. The city has 220, 110 and 33 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 0.14B Sources of Power Supply

S. No.		Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length cables from GSS to RSS
1.	**Dahisar (E) to D. N. Nagar** 17 Stations (18.589 km)	110 kV Grid Sub Station (GSS) Versova	RSS at DN Nagar	1 km approx.
		110 kV Grid Sub Station (GSS) Near Borivli	*RSS Near Dahisar(E) Depot	2 km approx.

*This RSS already considered in Andheri to Dahisar DPR.

M/s TATA Power Company vide their letter No. CDD/LR-N 4040/13674, dated 04.02.2010 has confirmed that they will provide two No, 110 kV bay from their 110 kV Malad Grid Substation to Charkop Receiving Substation (RSS) (Annexure – 8.2). M/s TATA Power Company has shown their inability in the meeting held on 03.09.2015 for providing two No. 110 kV bay from Malad Grid Substation in present situation. They indicated that there is no spare bay & space presently. M/s TATA Power Company has confirmed that they will provide two No. 110 kV bay from their 110 kV Versova Grid Substation to DN Nagar Receiving Substation (RSS). (Annexure–8.3). During the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 0.15B.

Table 0.15B– 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)
Dahisar (E) to D. N. Nagar 17 Stations (18.589 km)	**RSS at D N Nagar**				
	Traction	9.38	12.03	17.09	21.85
	Auxiliary	5.09	8.34	7.72	13.59
	Sub-total (A)	**14.47**	**20.27**	**21.81**	**35.44**
	RSS Near Dahisar Station*				
	Traction	12.42	16.45	17.09	21.85
	Auxiliary	7.57	13.29	7.72	13.59
	Sub-total (B)	**19.99**	**29.64**	**21.81**	**35.44**

* In Normal Condition Dahisar RSS will also take half load of Andheri to Dahisar Corridor

** Incase of failure of other source of power

0.8 Various options of Traction system:-

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

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

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

0.8.1 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.

0.8.2 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.

0.8.3 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.

0.8.4 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 59.01 million units in initial years 2019, which will be about 92.30 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 8.46 per unit**. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro.

0.9 ENVIRONMENTAL SOCIAL IMPACT ASSESSMENT

0.9.1 A study is in progress to assess the Environmental and Social Impact of the proposed Metro corridor from Dahisar (E) to D.N. Nagar 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.

0.10A COST ESTIMATE:
(Option -1, Considering the proposed corridor as isolated Stretch)

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

The overall Capital Cost for the Dahisar (E) – D. N. Nagar Metro Corridor of Mumbai at July 2015 price level works out to Rs. 4226 Crores excluding applicable Taxes & Duties of Rs 768 Crores. as tabulated hereunder in Tables 0.16A and 0.17A.

Table 0.16A
Dahisar(E) to DN Nagar Corridor
Capital Cost Estimate July 2015 level

Total length = 18.589 km **Elevated (including elevated ramp) =18.589 km**					
Total Station (All Elevated) =17					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	21.65	433.00
b	Private	ha	100.00	0.50	50.00
1.2	Temporary Land for Construction Depot	Ha.	5.00	8.00	40.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.52	18.59	65.46
	Subtotal (1)				**588.46**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	18.59	686.25
2.2	Depot entry connection	R. Km.	36.92	1.50	55.38
	Subtotal (2)				**741.62**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	14.00	407.22
b	Type (A) way side- EM works etc	Each	8.06	14.00	112.86
c	Type (B) Way side with signalling-civil works	Each	28.48	1.00	28.48
d	Type (B) Way side with signalling-EM works etc	Each	8.06	1.00	8.06
a	Type (C), Terminal station -civil works	Each	32.45	2.00	64.90
b	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	2.00	16.12
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	34.00	83.30
3.2	Metro bhawan, OCC bldg.				
a	civil works	LS			50.00
b	EM works etc	LS			25.00
	Subtotal (3)				**795.94**
4.0	**Maintenance Depot at Charkop**	LS			
4.1	Depot				
a	Civil works	LS			90.00
b	EM works etc	LS			60.00
	Subtotal (4)				**150.00**

5.0	**P-Way**				
5.1	Ballast less track	R. Km.	**8.58**	20.09	172.36
5.2	Ballasted track for Depot	R. Km.	**4.72**	5.00	23.60
	Subtotal (5)				**195.96**
6.0	**Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R.Km.	10.50	20.09	210.93
	Subtotal (6)				**210.93**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	20.09	321.30
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	5.50	17.00	93.50
	Subtotal (7)				**414.80**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.5 cr/km)** + EM works (3.5 cr/km)	R. Km.	8.00	20.09	160.71
	Subtotal (9)				**160.71**
10.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	48.00	470.40
	Subtotal (10)				**470.40**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.30	20.09	6.00
b	EM works etc	R.Km.	0.06	20.09	1.24
	Subtotal (11)				**7.24**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.32	20.09	26.60
b	EM works etc	R.Km.	0.28	20.09	5.70
	Sub Total (12)				**32.30**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	17.00	39.27
	Sub Total (13)				**39.27**
14.0	**Total of all items except Land**				**3284.64**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**229.92**
16.0	**Total of all items including G. Charges except land**				**3514.56**
17.0	**Contingencies @ 3 %**				**105.44**
18.0	**Gross Total**				**3620.00**
	Cost without land			=	**3620**
	Cost with land including contingencies on land			=	**4226**

Table 0.17A Details of Taxes and Duties

Dahisar(E) – D. N. Nagar Corridor

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT (Cr.)		
1	**Alignment & Formation**						
	Underground	0.00	0.00	0.00	0.00		**0.00**
	Elevated, at grade & entry to Depot	741.62		64.89	73.00	16.13	**137.90**
2	**Station Buildings**						
	Elevated station - civil works	583.89		51.09	57.48	12.70	**108.57**
	Elevated station-EM works	137.05	6.42	11.65	13.11	4.34	**31.17**
	OCC bldg-civil works	50.00		4.38	4.92	1.09	**9.30**
	OCC bldg-EM works	25.00	1.17	2.13	2.39	0.79	**5.69**
3	**Depot**						
	Civil works	90.00	6.32	5.51	6.20	2.04	**18.04**
	EM works	60.00	2.81	5.10	5.74	1.90	**13.65**
4	**P-Way**	195.96	36.71	4.16	4.68	6.63	**45.56**
5	**Traction & power supply**						
	Traction and power supply	210.93	19.76	13.45	15.13	6.84	**48.33**
6	**S and T Works**						
	S & T	321.30	60.19	8.03	9.04	10.91	**77.26**
	AFC	93.50	16.42	2.92	3.29	3.16	**22.63**
	PSD	0.00	0.00	0.00	0.00	0.00	**0.00**
7	**R & R hutments**	65.46			4.09	1.31	**4.09**
8	**Misc.**						
	Civil works	182.58		15.98	17.97	3.97	**33.95**
	EM works	56.93		6.05	6.81	1.76	**12.85**
9	**Rolling stock**	470.40	96.93	4.59	5.16	18.30	**106.68**
	Total	**3284.64**	**246.72**	**199.92**	**229.00**	**91.87**	**767.52**
	Total taxes & Duties						**768**

0.10B COST ESTIMATE:

(Option -2, considering the entire corridor from Dahisar to Mandale, will be operational)

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

The overall Capital Cost for the Dahisar (E) – D. N. Nagar Metro Corridor of Mumbai at July 2015 price level works out to Rs. 5263 Crores excluding applicable Taxes & Duties of Rs 1017 Crores. as tabulated hereunder in Tables 0.16B and 0.17B.

Table 0.16B

Dahisar (E)to DN Nagar Corridor

Capital Cost Estimate **July 2015 level**

Total length = 18.589 km Elevated (including elevated ramp) =18.589 km Total Station (All Elevated) =17					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	21.65	433.00
b	Private	ha	100.00	0.50	50.00
1.2	Temporary Land for Construction Depot	Ha.	5.00	8.00	40.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.52	18.59	65.46
	Subtotal (1)				**588.46**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	18.59	686.25
2.2	Depot entry connection	R. Km.	36.92	1.50	55.38
	Subtotal (2)				**741.62**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	14.00	407.22
b	Type (A) way side- EM works etc	Each	8.06	14.00	112.86
c	Type (B) Way side with signalling-civil works	Each	28.48	1.00	28.48
d	Type (B) Way side with signalling-EM works etc	Each	8.06	1.00	8.06

a	Type (C), Terminal station -civil works	Each	32.45	2.00	64.90
b	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	2.00	16.12
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	34.00	83.30
3.2	Metro bhawan, OCC bldg.				
a	civil works	LS			50.00
b	EM works etc	LS			25.00
	Subtotal (3)				**795.94**
4.0	**Maintenance Depot at Charkop**	LS			
4.1	Depot				
a	Civil works	LS			90.00
b	EM works etc	LS			60.00
	Subtotal (4)				**150.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	**8.58**	20.09	172.36
5.2	Ballasted track for Depot	R. Km.	**4.72**	5.00	23.60
	Subtotal (5)				**195.96**
6.0	**Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R.Km.	10.50	20.09	210.93
	Subtotal (6)				**210.93**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	20.09	321.30
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	5.50	17.00	93.50
	Subtotal (7)				**414.80**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.5 cr/km)** + EM works (3.5 cr/km)	R. Km.	8.00	20.09	160.71
	Subtotal (9)				**160.71**
10.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	144.00	1411.20
	Subtotal (10)				**1411.20**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.30	20.09	6.00
b	EM works etc	R.Km.	0.06	20.09	1.24
	Subtotal (11)				**7.24**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.32	20.09	26.60
b	EM works etc	R.Km.	0.28	20.09	5.70
	Sub Total (12)				**32.30**

13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	17.00	39.27
	Sub Total (13)				**39.27**
14.0	**Total of all items except Land**				**4225.44**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**295.78**
16.0	**Total of all items including G. Charges except land**				**4521.22**
17.0	**Contingencies @ 3 %**				**135.64**
18.0	**Gross Total**				**4656.85**
	Cost without land			**=**	**4657**
	Cost with land including contingencies on land			**=**	**5263**

Table 0.17B Details of Taxes and Duties

Dahisar (E) to D. N. Nagar Corridor

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

S. No.	**Description**	**Total cost without Taxes & duties (Cr.)**	**Taxes and duties**			**Octroi**	**Total taxes & duties (Cr.)**
			custom duty (Cr.)	**excise duty (Cr.)**	**VAT(Cr .)**		
1	**Alignment & Formation**						
	Underground	0.00	0.00	0.00	0.00		**0.00**
	Elevated, at grade & entry to Depot	741.62		64.89	73.00	16.13	**137.90**
2	**Station Buildings**						
	Elevated station - civil works	583.89		51.09	57.48	12.70	**108.57**
	Elevated station-EM works	137.05	6.42	11.65	13.11	4.34	**31.17**
	OCC bldg-civil works	50.00		4.38	4.92	1.09	**9.30**
	OCC bldg-EM works	25.00	1.17	2.13	2.39	0.79	**5.69**
3	**Depot**						
	Civil works	90.00	6.32	5.51	6.20	2.04	**18.04**
	EM works	60.00	2.81	5.10	5.74	1.90	**13.65**
4	**P-Way**	195.96	36.71	4.16	4.68	6.63	**45.56**
5	**Traction & power supply**						
	Traction and power supply	210.93	19.76	13.45	15.13	6.84	**48.33**
6	**S and T Works**						
	S & T	321.30	60.19	8.03	9.04	10.91	**77.26**
	AFC	93.50	16.42	2.92	3.29	3.16	**22.63**
	PSD	0.00	0.00	0.00	0.00	0.00	**0.00**
7	**R & R hutments**	65.46			4.09	1.31	**4.09**

8	**Misc.**						
	Civil works	182.58		15.98	17.97	3.97	**33.95**
	EM works	56.93		6.05	6.81	1.76	**12.85**
9	**Rolling stock**	1411.20	290.79	13.76	15.48	54.90	**320.03**
	Total	**4225.44**	**440.58**	**209.09**	**239.32**	**128.47**	**1017.47**
	Total taxes & Duties						**1017**

0.11 A FINANCIAL VIABILITY, FARE STRUCTURE AND FINANCING OPTIONS: (Option -1, Considering the proposed corridor as isolated Stretch)

It is assumed that the construction work will start on 01.10.2015 and is expected to be completed on 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2019 for the corridor. The cash flow of investments separately is placed in Table –0.18A as below.

Table 0.18A Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost
2015-16	243.00	247.00
2016-17	609.00	667.00
2017-18	1178.00	1386.00
2018-19	1017.00	1286.00
2019-20	813.00	1106.00
2020-21	407.00	595.00
2021-22	406.00	638.00
Total	**4673.00**	**5925.00**

Fare Structure

The fare structure for the FY 2019-20 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 0.19A below:

Table 0.19A Fare Structure in 2019-20

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

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

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

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

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

Corridor	FIRR
FIRR without PD	**6.41%**
FIRR with PD	**8.65%**

Alternative Models Of Financing

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

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

SPV Model: - The State Government has already constituted a fully owned company in the name of Mumbai Metro Rail Corporation (MMRC), a SPV company and is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The issue of extending JICA loan for the project was discussed informally with JICA India Office. It was told that an informal understanding between GOI & GOJ has taken place. According to which JICA will extend only modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan will be 40 years with 10 years moratorium period. JICA shall fund to the extent of 85% of the cost of project excluding cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. However, pending formal notification from the MOF, GOI, the existing terms applicable for JICA loan have been assumed except the quantum of project cost eligible for funding. The funding pattern under this model (SPV) is placed in table 0.20A as under: -

Table 0.20A

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

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	759.50	14.44%
Equity By GOM	759.50	14.44%
SD for CT by GOM	292.50	5.56%
SD for CT by GOI	292.50	5.56%
Loan with 1.4% interest from JICA / 12% Market Borrowings	3156.00	60.00%
Total	**5260.00**	**100.00%**
SD for Land by GOM	**665.00**	
Total	**5925.00**	
Interest During Construction	**20.00**	
Grand Total	**5945.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.465.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in table 0.21A and 0.22A tabulated as under: -

Table 0.21A Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost and without Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	
VGF by GOI	1052.00	20.00%
VGF by GOM	2217.00	42.15%
Equity by Concessionaire	664.00	12.62%
Concessionaire's debt @12% PA	1327.00	25.23%
Total	**5260.00**	**100.00%**
Land Free by GOM	665.00	
Total	**5925.00**	
IDC	18.00	
Total	**5943.00**	

Table 0.22A Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost and with Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1052.00	20.00%
VGF by GOM	1708.00	27.18%
Equity by Concessionaire	664.00	14.37%
Concessionaire's debt @12% PA	1837.00	38.45%
Total	**5261.00**	**100.00%**
Land Free by GOM	665.00	
Total	**5926.00**	
IDC	56.00	
Total	**5982.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.465.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

11.1A RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 8.65% with revenue from additional property development on 10 hectares of land. The pre-tax Equity FIRR to the BOT operator worked out to 18% with total VGF of Rs.3425.00 crore excluding the cost of 10 hectare Land. Since the Maharashtra State Government is providing land parcels for PD, it is advisable to take up the job on

DMRC/BMRCL/CMRL model. Accordingly, the corridors are recommended for implementation.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 0.23A excluding state taxes.

Table 0.23A

Rs. In crore

Particulars	SPV Model	BOT Model without PD	BOT Model with PD
GOI	1052.00	1052.00	1052.00
GOM	1717.00	2882.00	2373.00
Total	**2769.00**	**3934.00**	**3425.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.465.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Considering the more cash outgo on BOT model, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern

0.11 B FINANCIAL VIABILITY, FARE STRUCTURE AND FINANCING OPTIONS: (Option -2, considering the entire corridor from Dahisar to Mandale, will be operational

It is assumed that the construction work will start on 01.10.2015 and is expected to be completed on 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2019 for the corridor. The cash flow of investments separately is placed in Table –0.18B as below.

Table 0.18B Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost
2015-16	255.00	260.00
2016-17	733.00	802.00
2017-18	1476.00	1737.00
2018-19	1327.00	1679.00
2019-20	1061.00	1443.00
2020-21	531.00	776.00
2021-22	530.00	833.00
Total	**5913.00**	**7530.00**

Fare Structure

The fare structure for the FY 2019-20 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 0.19B below:

Table 0.19B Fare Structure in 2019-20

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

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

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

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

The **Financial Internal Rate of Return (FIRR)** obtained costs for 30 years business model including construction period is **10.91%.**

Alternative Models Of Financing

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

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

SPV Model: - The State Government has already constituted a fully owned company in the name of Mumbai Metro Rail Corporation (MMRC), a SPV company and is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The issue of extending JICA loan for the project was discussed informally with JICA India Office. It was told that an informal understanding between GOI & GOJ has taken place. According to which JICA will extend only modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan will be 40 years with 10 years moratorium period. JICA shall fund to the extent of 85% of the cost of project excluding cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. However, pending formal notification from the MOF, GOI, the existing terms applicable for JICA loan have been assumed except the quantum of project cost eligible for funding. The funding pattern under this model (SPV) is placed in table 0.20B as under: -

Table 0.20B

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

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	949.00	13.82%
Equity By GOM	949.00	13.82%
SD for CT by GOM	424.00	6.18%
SD for CT by GOI	424.00	6.18%
Loan with 1.4% interest from JICA / 12% Market Borrowings	4119.00	60.00%
Total	**6865.00**	**100.00%**
SD for Land by GOM	665.00	
Total	**7530.00**	
Interest During Construction	27.00	
Grand Total	**7557.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.538.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in table 0.21B as under: -

Table 0.21B Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	
VGF by GOI	1373.00	20.00%
VGF by GOM	587.00	8.55%
Equity by Concessionaire	1635.00	23.82%
Concessionaire's debt @12% PA	3270.00	47.63%
Total	**6865.00**	**100.00%**
Land Free by GOM	665.00	
Total	**7530.00**	
IDC	86.00	
Total	**7616.00**	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.538.00 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 0.22B excluding state taxes.

Table 0.22B

Particulars	SPV Model	BOT Model
GOI	1373.00	1052.00
GOM	2038.00	2052.00
Total	**3411.00**	**3104.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.538.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

11.1B RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 10.91%. The pre-tax Equity FIRR to the BOT operator worked out to 16% with total VGF of Rs.3104.00 crore.

In spite that Project FIRR is high and cash outgo in BOT model is lesser than completely Government model, BOT model is not recommended for the number of uncertainties during implementation. This project should be implemented as completely government funded on the pattern of Bangalore Chennai and Delhi on the funding pattern as given in table 20B

0.12 A ECONOMIC ANALYSES:

(Option -1, Considering the proposed corridor as isolated Stretch)

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

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

0.12.2A ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **table 16.11**. Project period is 2015-2045, On the basis of **completion** cost, EIRR is 17.19% B/C Ratio is 4.88 and NPV is 82193, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **21.53%** and B/C ratio as **13.53** and with 12 % discount, EIRR is **8.51%** and B/C ratio is **2.67**. NPV without discount is Rs **95714** Cr. and with 12% discount rate, NPV is Rs. **6286** Cr.

Table 0.24A: Economic Indicator Values (2044-45)

DAHISAR(E) - DN NAGAR	(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.)	103354	10051	103354	10051
Benefit Cost Ratio	4.88	1.64	13.53	2.67
NPV(Cr.)	82193	3909	95714	6286
EIRR	17.19%	4.63%	21.53%	8.51%

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 12.88%.

0.12 B ECONOMIC ANALYSES:

(Option -2, considering the entire corridor from Dahisar to Mandale, will be operational

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

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

0.12.2B ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **table 16.11**. Project period is 2015-2045, On the basis of **completion** cost, EIRR is **25.33%** B/C Ratio is **9.67** and NPV is **211188** (without discount), which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **30.58%** and B/C ratio as **25.59** and with 12 % discount, EIRR is **16.59%** and B/C ratio is **4.97**. NPV without discount is Rs **226340** Cr. and with 12% discount rate, NPV is Rs. **18634** Cr.

Table 0.24B: Economic Indicator Values (2044-45)

ANDHERI-DAHISAR	(Completion Cost Basis)		(Economic Cost Basis)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	24357	7537	9205	4690
Cumulative benefit(Cr.)	235545	23324	235545	23324
Benefit Cost Ratio	9.67	3.09	25.59	4.97
NPV(Cr.)	211188	15787	226340	18634
EIRR	25.33%	11.90%	30.58%	16.59%

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 19.86%.

0.13 IMPLEMENTATION PLAN:

- **Option -1, Considering the proposed corridor as isolated Stretch**

The Dahisar (E) – D.N. Nagar Corridor is carved out of corridors recommended in Phase-I and Phase-II with route length of 18.589 Kms and completion cost of Rs 5925 Crores. World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for the Dahisar (E) – D. N. Nagar Corridor is **8.65 %** (with PD from 10 Ha. area).

- **Option -2, Considering the entire corridor from Dahisar to Mandale**

The Dahisar (E) – D.N. Nagar Corridor is carved out of corridors recommended in Phase-I and Phase-II with route length of 18.589 Kms and completion cost of Rs 7530 Crores. World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for the Dahisar (E) – D. N. Nagar Corridor is **10.91 %.**

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

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

0.13.1 Implementation Schedule

A suggested project implementation schedule for Project Implementation on Turnkey Basis (Deposit Terms) is given in Table 0.25

Table 0.25 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

0.13.2 Institutional Arrangements:

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

0.13.3 Legal Cover for Mumbai Metro

Implementation of proposed Dahisar (E) – D.N. Nagar Corridor can now be done under “The Metro Railways (Amendment) Act 2009”..

0.14 CONCLUSIONS:

0.14.1 Mumbai is the Commercial Capital of India and it's fast growth especially in the suburbs is causing heavy stress on all infrastructure, especially the Transport. Being a linear city, the existing suburban rail services are very effective and the modal split in favour of public transport is about 88%, which is very high. Since the existing transport infrastructure has been heavily loaded, it has been observed that the population of private vehicles is increasing and it was also predicted that, the modal split in favour of public transport may also recede. Hence, it is proposed by MMRDA to introduce a rail based Mass Transportation System in Greater Mumbai and a master plan has been prepared for the same. It is proposed to take up the Dahisar (E) – D. N. Nagar Corridor with route length of 18.589 Kms immediately for implementation**.**

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

0.14.3 **Project Cost:**

- **Option -1, Considering the proposed corridor as isolated Stretch**

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 4673 crores exclusive of State taxes and Octroi of Rs 321 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 5925 crores excluding State taxes and Octroi of Rs 465 Crores.

- **Option -2, considering the entire corridor from Dahisar to Mandale**

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 5913 crores exclusive of State taxes and Octroi of Rs 368 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 7530 crores excluding State taxes and Octroi of Rs 538 Crores.

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

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

- **Option -1, Considering the proposed corridor as isolated Stretch**

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **6.41%** without Property Development and **8.65%** with revenue from additional property development on 10 hectares of land. The Economic Internal Rate of Return (EIRR) works out to **17.19%**

- **Option -2, considering the entire corridor from Dahisar to Mandale**

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **10.91%.** The Economic Internal Rate of Return (EIRR) works out to **25.33%**

0.14.6 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. The second option may be through General Consultants which may take about 8 to 9 months more as compared to turn key Consultancy.

FIG. 0.1


Index Plan
DAHISAR(W)
DAHISAR(E)
Depot
DAHISAR
RUSHI SANKUL
IC COLONY
LIC COLONY
DON BOSCO
KASTUR PARK
EKATA NAGAR
KANDIVALI NAGAR
CHARKOP
MALAD METRO
KASTURI PARK
BANGUR NAGAR
OSHIWARA METRO
SAMARTHA NAGAR
SHASTRI NAGAR
DN NAGAR

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND:

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

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

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

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

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

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

1.2 DEMOGRAPHIC PROFILE:

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

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

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

1.2.2 There is no population growth in the Island City during 1971 – 2015. The population growth during 1971 – 2015 in Western Suburbs is 235% and in Eastern Suburbs is 233%. It is evident that the share of Island City population is declining continuously. The proportion of population in Island City compared to total population of Greater Mumbai declined from 51% in 1971 to 24% in 2015. In the same period the proportion for Western Suburbs went up from 28% to 44% and that in Eastern Suburbs from 20 % to 31%.

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

Table 1.2: Spatial Growth Profile of Greater Mumbai

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

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

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

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

Table 1.4: Planning Parameters

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

1.3 EMPLOYMENT SCENARIO:

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

1. Agriculture, Forestry and Fishing
2. Mining and Quarrying
3. Manufacturing and Repair services
4. Electricity, Gas and Water
5. Construction

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

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

Table 1.5

Employment in Different Areas of Greater Mumbai (in Millions)

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

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

Table 1.6

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

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

1.4 LAND USE POLICY:

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

1.4.1 Major recommendations of the Regional Plan are as follows:

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

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

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

Table 1.7

Proposed Redevelopment of Textile Mill Land Area

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

1.5 VEHICLE REGISTRATION:

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

Table 1.8

Greater Mumbai Motor Vehicle Statistics

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

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

Table 1.9

Distribution and Growth of Vehicles in Island and Suburbs

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

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

1.6 SUBURBAN RAIL SYSTEM:

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

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

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

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

1.6.5 Within Mumbai many suburban stations are less than 1.5 km apart and in some cases less than 1 km. Such closely spaced stations are characteristic of a metropolitan urban railway rather than a suburban system. In addition to the three radiating lines from Mumbai CBD there is also a double line track connection beyond Greater Mumbai limits between Vasai Road on the Western Railway and Diva / 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 being converted to 25 kV A.C. In some areas tracks are prone to flooding during the monsoon season due to drainage system shortcomings on adjacent land or due to inadequate or partially blocked storm water outlets.

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

1.7 THE ROAD NETWORK:

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

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

1.7.3 To the North of Mumbai Island, the East – West movements are further restricted by the limited number of crossing points of the River Mithi. The lack of a good link between places such as Santa Cruz and Chembur or Vashi often results in considerable detours via Sion and the Western and Eastern Express Highways. A major North – South link from Santacruz to Chembur via Kurla has been completed and 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 footways. In some places, notably on the Western Express Highway, part of the right of way (though not the carriageway) has also been encroached upon by slums. These other functions, together with frequent disruption due to service provision and maintenance, severely reduce the traffic capacity of the highways.

1.8 BUS TRANSPORT SYSTEM:

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

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

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

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

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

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

1.9 AIR POLLUTION:

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

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

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

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

1.10 NEED FOR METRO:

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

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

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

The proposed Dahisar (E) – D. N. Nagar Metro Corridor will basically serve the western parts of Mumbai and the route where this corridor is suggested is heavily loaded. 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 top 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 6^{th} and 7^{th} Rail Corridors.

(ii) **Techno-Economic Feasibility of the 7^{th} 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 7^{th} Corridor in 1981.

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

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

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

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

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

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

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

The TEWET study also identified total network for Greater Mumbai after examining 3 alternatives. The recommended Network is of 57 km length with an estimated cost of Rs. 12,000 crore and in Island city it follows the 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 in July, 2008.

Following are the objectives of the study:

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

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

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

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

Figure 1.1

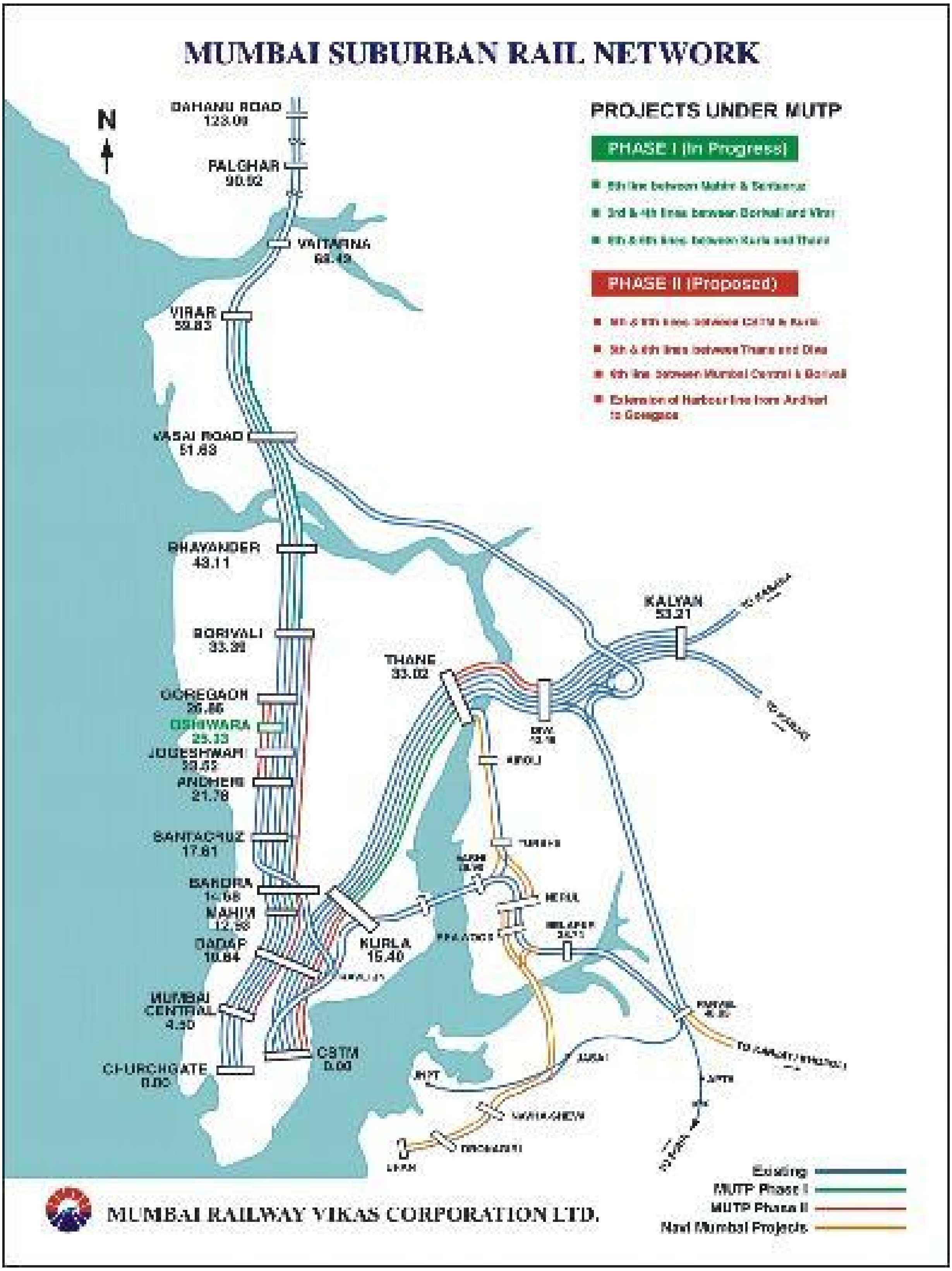
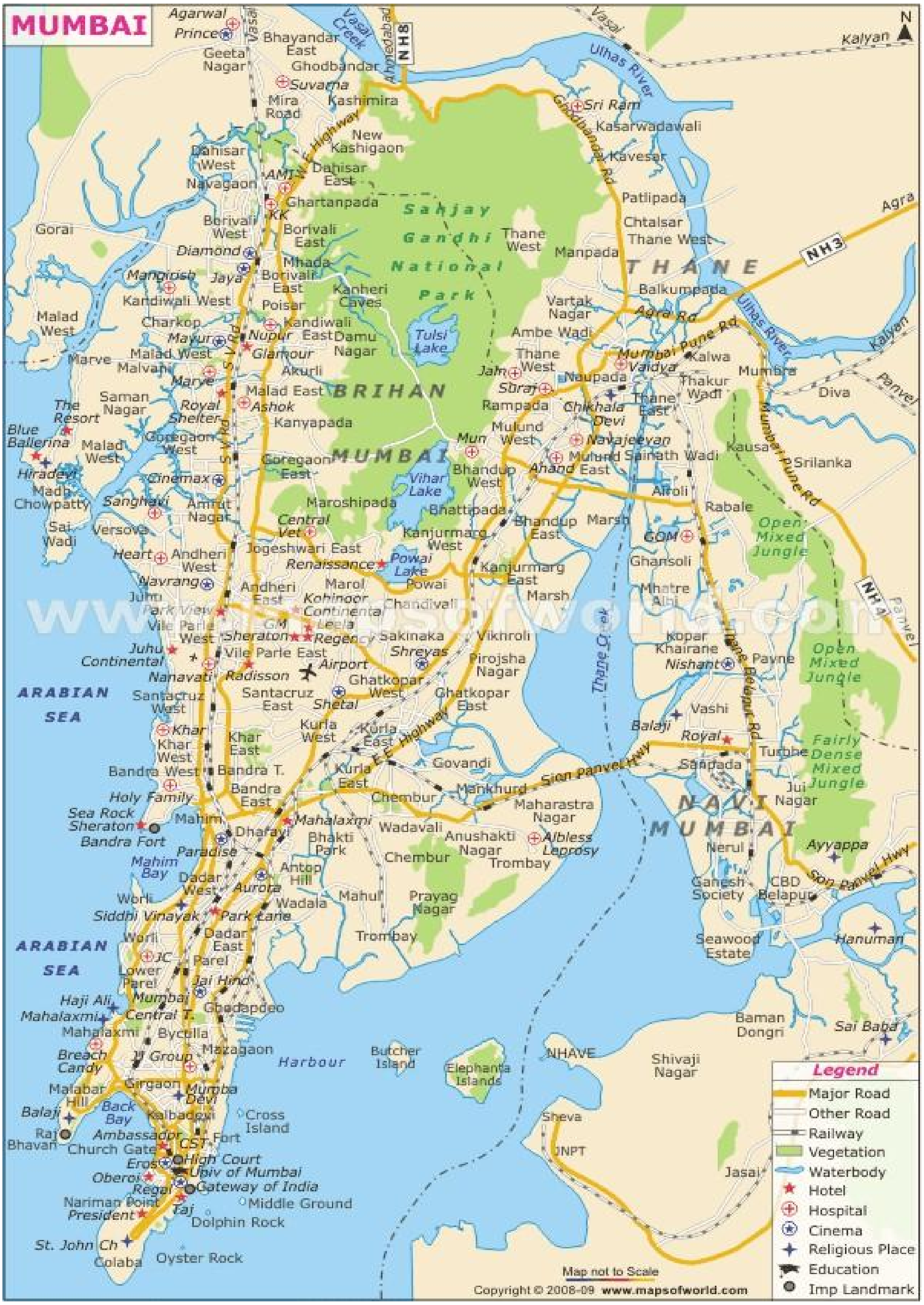

MUMBAI SUBURBAN RAIL NETWORK
N
PROJECTS UNDER MUTP
PHASE I (In Progress)
PHASE II (Proposed)
DAHANU ROAD 123.09
PALGHAR 90.92
VAITARNA
VIRAR
VASAI ROAD 51.63
BHAYANDER 43.11
BORIVALI 33.39
GOREGAON
OSHIWARA 25.33
JOGESHWARI
ANDHERI 21.78
SANTACRUZ 17.61
BANDRA
MAHIM
DADAR 10.84
MUMBAI CENTRAL 4.50
CHURCHGATE 0.00
CSTM 0.00
KURLA 15.40
THANE 33.02
KALYAN 53.21
NERUL
MUMBAI RAILWAY VIKAS CORPORATION LTD.
Existing
MUTP Phase I
MUTP Phase II
Navi Mumbai Projects

Figure 1.2


MUMBAI
ARABIAN SEA
Harbour
Sanjay Gandhi National Park
BRIHAN MUMBAI
THANE
NAVI MUMBAI
Dahisar East
Dahisar West
Borivali East
Borivali West
Kandiwali West
Malad West
Goregaon East
Andheri West
Andheri East
Bandra West
Dadar
Colaba
Legend
Major Road
Other Road
Railway
Vegetation
Waterbody
Hotel
Hospital
Cinema
Religious Place
Education
Imp Landmark
Map not to Scale
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CHAPTER 2

EVOLUTION OF MUMBAI METRO MASTER PLAN AND PRESENT STATUS

2.1 BACKGROUND:

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

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

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

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

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

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

2.2 PRELIMINARY NETWORK:

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

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

2.3 MASTER PLAN:

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

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

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

Table 2.1

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

2.4 PHASING OF MASTER PLAN:

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

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

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

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

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

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

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

Table 2.2

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

2.5 Implementation Period

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

Table 2.3

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

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

2.6 PRESENT STATUS:

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

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

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

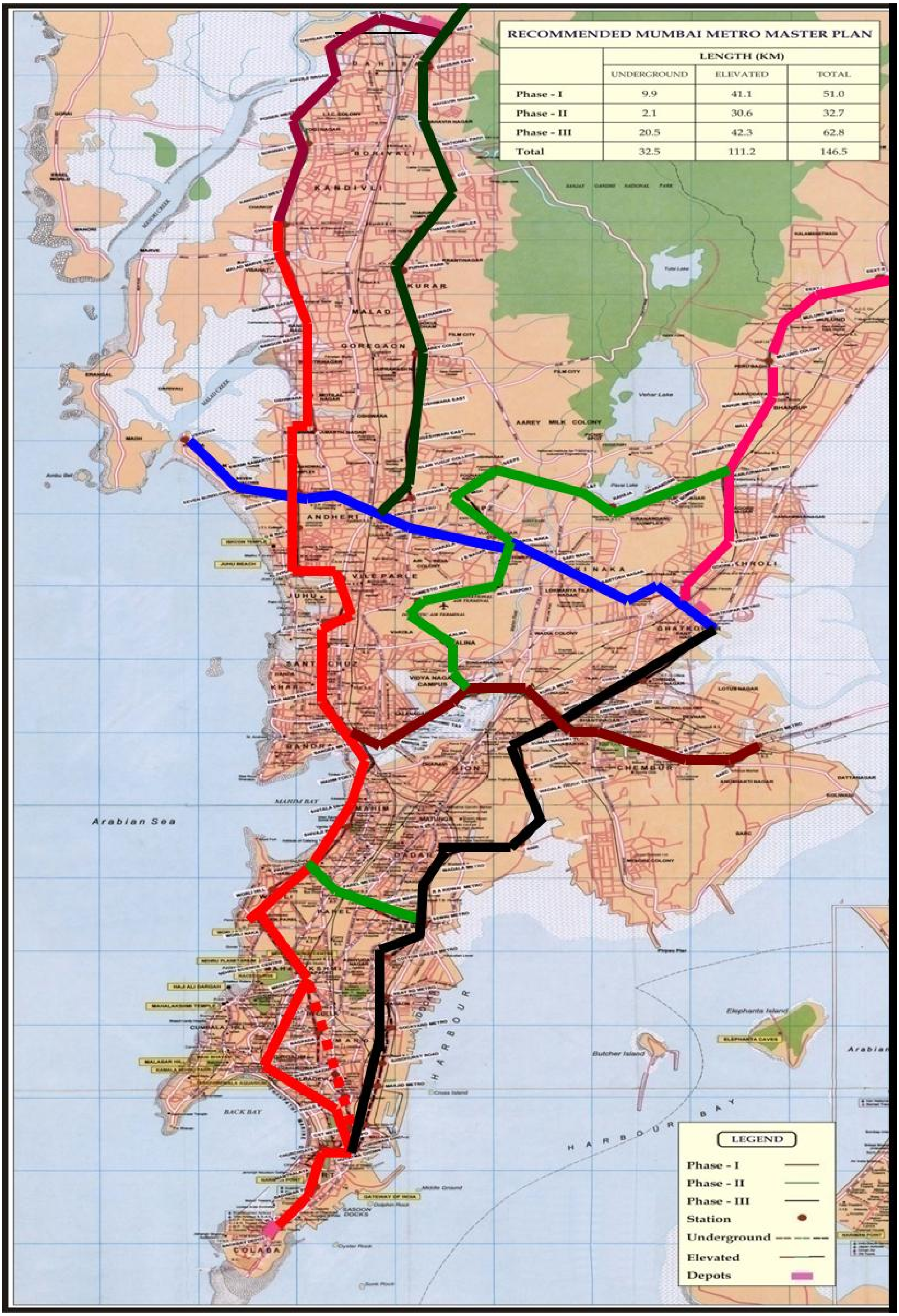
i) Charkop – Dahisar (7.50 Km.)	–	M/s SPAN Consultants Pvt. Ltd.
ii) Andheri(E) – Dahisar(E) (18.00 Km.)	–	M/s SPAN Consultants Pvt. Ltd.
iii) BKC Kanjur Marg (via Airport) (19.50 Km.) with Extension from BKC to Mahim (4.0 Km.)	–	M/s RITES.
iv) Ghatkopar – Mulund (12.50 Km.)	–	M/s Consulting Engineering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

2.6.4 All the above reports have been submitted to MMRDA.

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

2.6.6 MMRDA is intending to implement other corridors by itself.

Annexure 2.1


RECOMMENDED MUMBAI METRO MASTER PLAN

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

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

s 

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 (E)- D. N. Nagar Corridor

It is proposed to have seventeen stations on the Dahisar (E) to D. N. Nagar Metro corridor. Dahisar (E) station will be common to both corridors. i.e. Dahisar (E) to D. N. Nagar Corridor and Dahisar (E) to Andheri(E) Corridor. The platforms of Dahisar (E) - D. N. Nagar Corridor at Dahisar (E) will be located above the platforms of Dahisar (E) – Andheri (E) Corridor. The locations of proposed stations are as under

Table 3.1 Station Locations

Dahisar(E) to DN Nagar Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G/ ELEVATED**
0	DEAD END	(-) 413.941		
1	DAHISAR (E)	0.0	413.941	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
	DEAD END	18175.0	596.4	

3.2 Traffic Projections

MMRDA were requested to give the traffic data for the above corridor with the proposed stations given in the table above. The information received in respect of ridership flows, boarding alighting etc. is shown in Table No. 3.2, 3.3 and 3.4.

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

The station to station segment flows in both directions during peak hours for the years 2016, 2021 and 2031 as furnished by MMRDA considering entire corridor from Dahisar to Mandale are shown in Table No. 3.2, 3.3 and 3.4.

Table 3.2
Peak Hr. Ridership for Metro line -2 for 2016 (via SCLR)

Sr. No.	Station Name	Volume from D-M	Volume from M-D	Boarding	Alighting
1	Dahisar (E)	1155	0	1155	2147
2	Dahisar	3296	2147	2141	4835
3	Rishi Sankool	10581	6981	12375	1357
4	IC Colony	10532	3248	31	49
5	LIC Colony	10945	3217	774	766
6	Don Bosco	11141	3622	715	583
7	Kasturi Park	11774	3686	1314	823
8	Ekata Nagar	13048	3827	2027	1655
9	Kandivali	15866	4728	4863	3233
10	Charkop	17625	5916	2753	1642
11	Malad Metro	16698	6564	2089	4022
12	Kasturi Park	16205	7570	743	1665
13	Bangur Nagar	19391	7997	3702	2104
14	Oshiwara Metro	20719	9586	2239	1336
15	Samartha Nagar	20774	10011	1198	2467
16	Shastri Nagar	**21346**	11335	1246	1051
17	D.N. Nagar	17858	11711	5520	6391
18	ESIC Nagar	18201	9095	1817	2489
19	JVPD	18996	10110	1773	1373
20	Ville Parle	18612	10505	770	1385
21	Nanavati Hospital	18614	10737	1106	1330
22	Arya Samaj Road	18179	10963	1270	1906
23	Khar Metro	17751	11163	989	1241
24	National College	17653	10988	645	695
25	Bandra Metro	12414	10940	8470	11066
26	Kala Nagar	11648	8296	735	1038

Table 3.2 Peak Hr. Ridership for Metro line -2 for 2016 (via SCLR)					
Sr. No.	**Station Name**	**Volume from D-M**	**Volume from M-D**	**Boarding**	**Alighting**
27	ITO	12530	7834	2126	1961
28	Baharat Diamond	11173	8552	509	1848
29	MTNL Metro	11120	8534	95	119
30	Budh Nagar	6647	8504	4955	6283
31	Kurla Railway	6431	5360	298	445
32	Tilak Nagar	6214	5291	619	333
33	Kurla East Metro	6747	4788	2821	4898
34	S.G. Barve Marg	5552	7398	662	1420
35	R.C. Marg	3247	6961	1237	2737
36	Shivaji Chowk	2475	6156	5342	2300
37	BSNL Metro	1556	2343	1394	919
38	Mankhurd Metro	252	950	621	1305
39	Mandale Metro	0	329	329	252
	Maximum PHPDT	**21346**	**11711**	83464	83465
	Daily Ridership			**834636**	

Dist.	No. of Trips	%
0-2	6675	8.00
2-4	14566	17.45
4-6	8667	10.38
6-9	15637	18.73
9-12	11423	13.69
12-15	8653	10.37
15-18	6581	7.88
18-21	3547	4.25
21-24	2785	3.34
24-27	2336	2.80
27-31	1321	1.58
31-35	743	0.89
>35	532	0.64
	83466	**100**
Avg. Trip Length =9.97 km		

Table 3.3 Peak Hr. Ridership for Metro line -2 for 2021 (via SCLR)					
Sr. No.	Station Name	Volume from D-M	Volume from M-D	Boarding	Alighting
1	Dahisar (E)	4546	0	4546	3439
2	Dahisar	5709	3439	1163	1788
3	Rishi Sankool	14907	5228	15099	11719
4	IC Colony	14883	11046	224	24
5	LIC Colony	15999	10822	1728	1457
6	Don Bosco	16859	11666	1472	927
7	Kasturi Park	18986	11981	2961	1482
8	Ekata Nagar	21187	12629	3764	2361
9	Kandivali	24950	13426	6058	3582
10	Charkop	27808	14713	3970	1998
11	Malad Metro	29582	15598	5386	5686
12	Kasturi Park	29156	17672	1233	1750
13	Bangur Nagar	33072	17763	4638	2778
14	Oshiwara Metro	**35142**	19819	3268	1598
15	Samartha Nagar	28789	20219	7775	10529
16	Shastri Nagar	29615	16620	1609	1259
17	D.N. Nagar	28922	17096	4808	4514
18	ESIC Nagar	29795	16110	3296	3453
19	JVPD	30819	17140	2151	1402
20	Ville Parle	30758	17415	1380	1749
21	Nanavati Hospital	30875	17724	1538	1530
22	Arya Samaj Road	30914	17833	2270	2253
23	Khar Metro	31088	17855	1906	1529
24	National College	31326	17651	1101	776
25	Bandra Metro	23754	17565	12985	17753
26	Kala Nagar	21544	14760	1749	2763
27	ITO	22720	13564	2582	1768
28	Baharat Diamond	21167	13926	879	2379
29	MTNL Metro	21140	13873	187	176
30	Budh Nagar	15234	13835	5137	8424
31	Kurla Railway	14677	11217	589	1014
32	Tilak Nagar	14251	11084	915	548
33	Kurla East Metro	14166	10291	3597	5892
34	S.G. Barve Marg	13112	12501	781	1640
35	R.C. Marg	11436	12307	2866	4718
36	Shivaji Chowk	10816	12483	6222	2351
37	BSNL Metro	9169	7992	1651	1648
38	Mankhurd Metro	771	6341	5456	8398
39	Mandale Metro	0	885	885	771
	Maximum PHPDT	**35142**	**20219**	129826	129825
	Daily Ridership			**1298260**	

Trip length frequency Distribution -2021		
Dist.	%	Trips
0-2	12.73	16530
2-4	12.30	15971
4-6	10.52	13656
6-9	15.66	20328
9-12	9.31	12091
12-15	10.18	13213
15-18	9.09	11798
18-21	4.84	6287
21-24	3.18	4132
24-27	5.61	7278
27-31	2.91	3773
31-35	1.91	2477
>35	1.76	2291
	100.00	129826
Avg. Trip Length =11.26 km		

Table 3.4
Peak Hr. Ridership for Metro line -2 for 2031 (via SCLR)

Sr. No.	Station Name	Volume from D-M	Volume from M-D	Boarding	Alighting
1	Dahisar (E)	6300	0	6300	4749
2	Dahisar	8580	4749	2280	3209
3	Rishi Sankool	16764	7957	17751	15757
4	IC Colony	16721	14147	581	43
5	LIC Colony	18282	13567	2981	3361
6	Don Bosco	20252	15509	3680	2777
7	Kasturi Park	23759	16576	5478	3285
8	Ekata Nagar	25691	17889	4037	3306
9	Kandivali	29881	19090	7681	5198
10	Charkop	32359	20798	4052	2441
11	Malad Metro	33061	21664	5692	7762
12	Kasturi Park	32451	24436	1646	2178
13	Bangur Nagar	36684	24358	5204	3675
14	Oshiwara Metro	**38509**	27063	3445	1932
15	Samartha Nagar	29979	27376	11550	12941
16	Shastri Nagar	30675	20236	1813	1952
17	D.N. Nagar	29221	21072	6036	5977
18	ESIC Nagar	29738	19559	3529	4463
19	JVPD	30683	21010	2270	1598
20	Ville Parle	30209	21284	1423	1949

21	Nanavati Hospital	30277	21335	1710	1797
22	Arya Samaj Road	29630	21490	2144	2876
23	Khar Metro	29494	21575	1844	1734
24	National College	29627	21329	1105	913
25	Bandra Metro	19630	21270	13621	18663
26	Kala Nagar	17550	16316	1724	2492
27	ITO	19110	15004	3514	5337
28	Baharat Diamond	17426	18386	1000	2942
29	MTNL Metro	17413	18644	116	175
30	Budh Nagar	11794	18690	7898	8453
31	Kurla Railway	11481	13625	449	663
32	Tilak Nagar	10821	13528	3590	3028
33	Kurla East Metro	11016	12305	4608	8494
34	S.G. Barve Marg	9893	16386	875	1710
35	R.C. Marg	8845	16098	2598	3325
36	Shivaji Chowk	7988	15777	7392	3385
37	BSNL Metro	6294	10913	2040	1694
38	Mankhurd Metro	3443	8873	7421	6217
39	Mandale Metro	0	4819	4819	3443
	Maximum PHPDT	**38509**	**27376**	165894	165894
	Daily Ridership			**1658943**	

Trip length frequency Distribution -2031		
Dist.	**%**	**Trips**
0-2	15.3376	25444
2-4	14.6688	24335
4-6	10.0838	16728
6-9	16.919	28067
9-12	10.4044	17260
12-15	9.86024	16357
15-18	7.09103	11764
18-21	5.02527	8337
21-24	3.68349	6111
24-27	3.10743	5155
27-31	1.78163	2956
31-35	1.23363	2047
>35	0.80379	1333
	100	165893
Avg. Trip Length =9.8km		

3.4 Daily Trips and Average Lead

The projected Daily ridership and average lead in Km for the entire corridor from Dahisar (E) to Mandale for various horizon years are given in Table 3.5.

Table 3.5
Daily Trips and Average Lead

Year	Trips per day (lakhs)	
	Daily Trips	Average Lead in KM
2016	834636	9.97
2019	1112810	10.74
2021	1298260	11.26
2031	1658943	9.80

3.4.1 Daily Trips and Average Lead
(Option -1, Considering the proposed corridor as isolated Stretch)

In the present case, the DPR is being prepared for only part corridor. i.e. between Dahisar (E) to D. N. Nagar.. Hence adoption of the figures i.e. PHPDT and total ridership for this Corridor from the tables 3.2, 3.3 and 3.4 will not be appropriate. Therefore station to station O-D of passenger trips furnished by MMRDA for the year 2016, 2021 and 2031 have been made use of to arrive at PHPDT and Peak hour load of the section. Daily ridership has been taken considering that peak hour factor as 10%. Therefore likely Peak hour, segmental flows, Peak hour boarding, alighting with the commissioning of the part Corridor from Dahisar (E) to D. N. Nagar are given in Table 3.6 and 3.7 respectively. Daily ridership and average lead is given in table 3.8

Table no 3.6
Peak Hour Station to Station Segment Flows

From	To	2016		2019		2021		2031	
		Forward	Reverse	Forward	Reverse	Forward	Reverse	Forward	Reverse
DAHISAR (E)	DAHISAR (W)	1089	0	2980	0	4241	0	6096	0
DAHISAR (W)	RUSHI SANKUL	2986	2076	4231	2795	5061	3275	8161	4593
RUSHI SANKUL	I C COLONY	7258	6721	7582	5511	7797	4705	12198	7528
I C COLONY	LIC COLONY	7209	2680	7547	5231	7773	6931	12154	10515

From	To	2016		2019		2021		2031	
		Forward	Reverse	Forward	Reverse	Forward	Reverse	Forward	Reverse
LIC COLONY	DON BOSCO	7310	2650	7852	5083	8213	6706	12707	9935
DON BOSCO	KASTUR PARK	7251	2873	7975	5424	8457	7125	12958	11092
KASTUR PARK	EKATA NAGAR	7305	2807	8582	5407	9433	7140	13802	11405
EKATA NAGAR	KANDIVALI NAGAR	7750	2734	9031	5554	9885	7435	14034	11768
KANDIVALI NAGAR	CHARKOP	8132	3157	9725	5794	10788	7552	14958	12113
CHARKOP	MALAD METRO	**8279**	3395	**10213**	5949	11502	7651	**15565**	12177
MALAD METRO	KASTURI PARK	6217	3451	9041	6040	10923	7766	14334	12246
KASTURI PARK	BANGUR NAGAR	5540	3280	8330	6196	10190	8141	13377	12962
BANGUR NAGAR	OSHIWARA METRO	6374	3203	9330	5920	11301	7731	14660	12335
OSHIWARA METRO	SAMARTHA NAGAR	6370	3679	9484	6363	**11560**	8152	14822	13096
SAMARTHA NAGAR	SHASTRI NAGAR	5649	3642	4307	6214	3412	7928	4651	12756
SHASTRI NAGAR	D N NAGAR	5248	3982	3968	3147	3115	2591	4137	3584
Maximum PHPDT		**8279**	**6721**	**10213**	**6363**	**11560**	**8152**	**15565**	**13096**

Table no 3.7
Peak Hour Boarding and Alighting

Station	2016		2019		2021		2031	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
DAHISAR (E)	1089	2076	2980	2795	4241	3275	6096	4593
DAHISAR (W)	1897	4646	1251	2716	820	1429	2066	2935
RUSHI SANKUL	9347	1035	8921	5290	8637	8127	13603	12554
I C COLONY	31	49	147	34	225	24	580	43
LIC COLONY	463	585	816	852	1052	1031	1972	2576
DON BOSCO	468	462	701	561	856	628	1907	1969
KASTUR PARK	766	638	1393	933	1811	1129	2816	2334
EKATA NAGAR	1198	1177	1688	1479	2015	1680	2338	2451

Station	2016		2019		2021		2031	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
KANDIVALI NAGAR	2396	2252	2877	2337	3198	2394	4414	3554
CHARKOP	1141	1050	1553	1157	1827	1227	2182	1644
MALAD METRO	953	2844	2201	3529	3033	3986	3759	5706
KASTURI PARK	560	1161	779	1214	925	1249	1299	1629
BANGUR NAGAR	1349	991	1640	1083	1834	1144	2253	1731
OSHIWARA METRO	908	875	1237	934	1457	974	1782	1280
SAMARTHA NAGAR	422	1484	3756	5868	5979	8791	9964	10964
SHASTRI NAGAR	272	451	401	527	487	578	602	885
D N NAGAR	3760	5248	2935	3968	2386	3115	3353	4137
Total	**27021**	**27021**	**35278**	**35278**	**40783**	**40783**	**60985**	**60985**

3.4.2 Daily Trips and Average Lead (Option -1, Considering the proposed corridor as isolated Stretch)

The projected Daily ridership and average lead in Km for the proposed Corridor from Dahisar (E) to D. N. Nagar for various horizon years are given in Table 3.8..

Table no 3.8

Daily Ridership and Average lead in Km

Year	Trips per day (lakhs)	
	Daily Trips	Average Lead in KM
2016	270215	6.02
2019	352782	6.25
2021	407826	6.41
2031	609847	6.33

3.4.3 Daily Trips and Average Lead (Option -2, considering the entire corridor from Dahisar to Mandale, Length = 42.5 Kms will be operational)

In Option-2, considering that entire corridor will be operational, the ridership for this stretch for different horizon years is given as under:

Daily Trips and Average Lead

Year	Trips per day (lakhs)	
	Daily Trips	Average Lead in KM
2016	448800	9.97
2019	597744	10.74
2021	697040	11.26
2031	902050	9.80

In working out financial viability for option 2, the average length has been taken as calculated for entire corridor.

Considering Dahisar (E) – D. N. Nagar stretch in isolation, sectional load and average lead is very less. However, entire corridor from Dahisar (E) to Mandale is recommended for implementation so that large public is benefited and also project gives High return.

CHAPTER 4

SYSTEM SELECTION

4.0 INTRODUCTION:

4.0.1 Dahisar (E) - D. N. Nagar Corridor of Mumbai Metro starts at Dahisar (E). The alignment runs through Rushi Sankul, LIC Colony, Don Bosco, , Kandivali Nagar, Charkop, Malad, Bangur Nagar and Shastri Nagar to end at the junction of D. N. Nagar and M.V. Road.

4.0.2 Versova – Ghatkopar corridor also passes through the junction of D. N. Nagar and M.V. Road. One station (i. e. D. N Nagar) of Versova to Ghatkopar Metro Line is located on west side of proposed D. N. Nagar Metro station at Chainage 17578.6 m.

4.0.3 The entire corridor will be elevated.

4.0.4 Length of corridor is 18.589 Kms. (Dead end to dead end)

4.0.5 Seventeen 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 628.5 metres and farthest 1711.7 metres.

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

4.0.7 Maintenance Depot has been proposed near Charkop station on Land identified by MMRDA.

4.0.8 The corridor can be extended beyond D. N. Nagar, if required.

4.1 PERMANENT WAY:

4.1.1 Choice of Gauge:

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

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

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

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

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

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

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

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

- Rolling Stock characteristics,
- Signaling Systems,

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

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

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

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

4.1.2 Track Structure:

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

General

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

From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose even the turnouts will have to be incorporated in LWR/CWR.

The track will be laid with 1 in 20 canted rails and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

Rail Section

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

Ballastless Track on Viaducts

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

Ballastless Track in Depot

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

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

Turnouts

- From considerations of maintainability and riding comfort, it is proposed to lay the turnouts also with 1 in 20 cant. Further, it is proposed to adopt the following two types of turnouts:
  i) On main lines, 1 in 9 type turnout with a lead radius of 300 metres and permissible speed on divergent track as 40 km/h (shown in **Fig.4.2**).
  ii) On Depot lines, 1 in 7 type turnout with a lead radius of 190 metres and permissible speed on divergent track as 25 km/h (shown in **Fig.4.3**).

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

- The proposed specifications for turnouts are given below: -

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

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

- The switch rail should be with thick web sections, having forged end near heel of switch for easy connection with lead rails, behind the heel of switch. The switches should have anti creep device at heel of switch for minimising the additional LWR forces transmitted from tongue rail to stock rail.
- The crossings should be made of cast manganese steel and with welded leg extensions. These crossings should be explosive hardened type for main lines and without surface hardening for Depot lines.
- The check rails should be with UIC-33 rail section without being directly connected to the running rails.

Buffer Stops

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

4.1.3 Rail Structure Interaction:

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

Welding

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

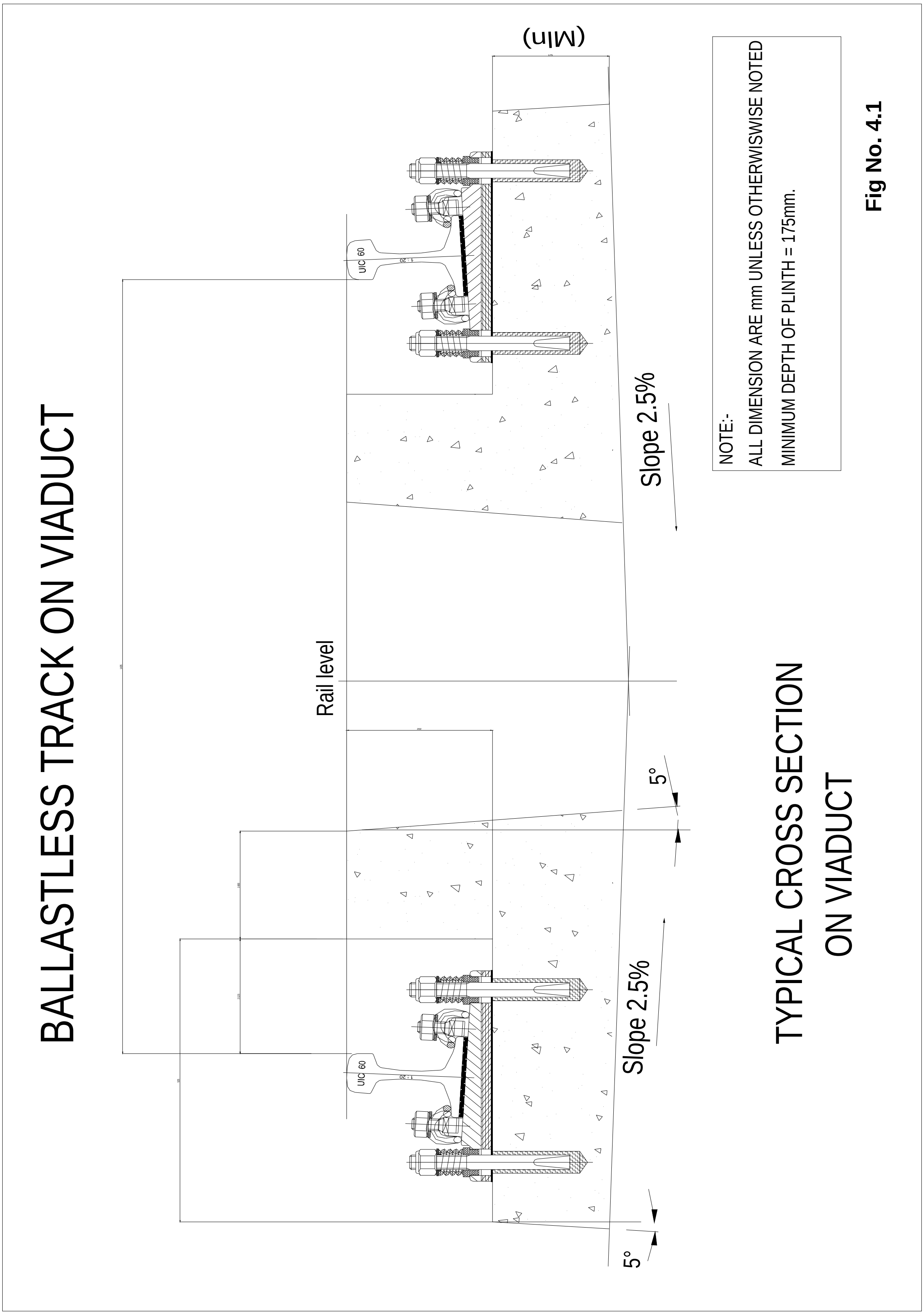
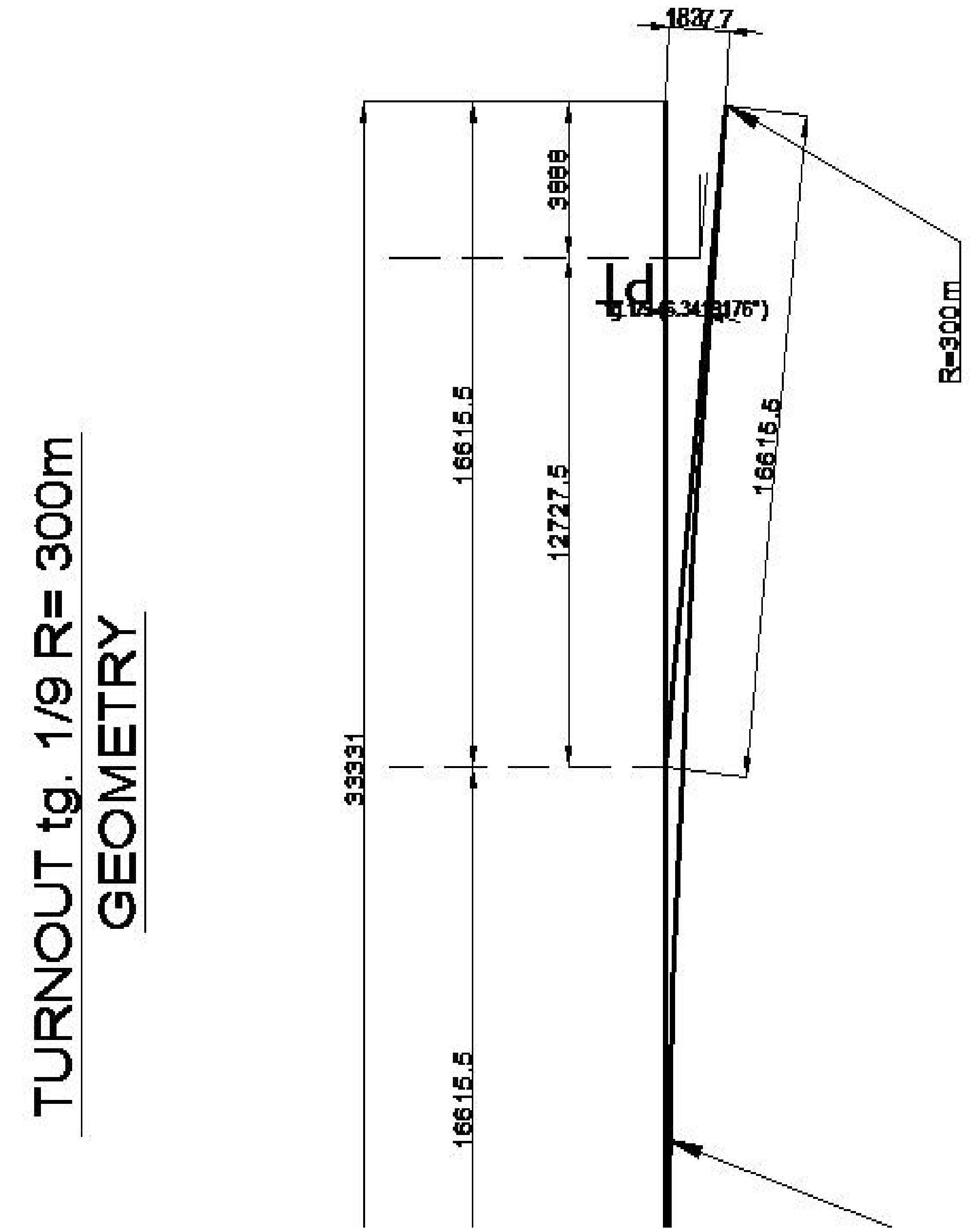

BALLASTLESS TRACK ON VIADUCT
Rail level
UIC 60
UIC 60
(Min)
Slope 2.5%
Slope 2.5%
5°
5°
TYPICAL CROSS SECTION
ON VIADUCT
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWISE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.

Fig No. 4.1

Fig No. 4.2


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

TURNOUT tg. 1/7 R=140 m

GEOMETRY

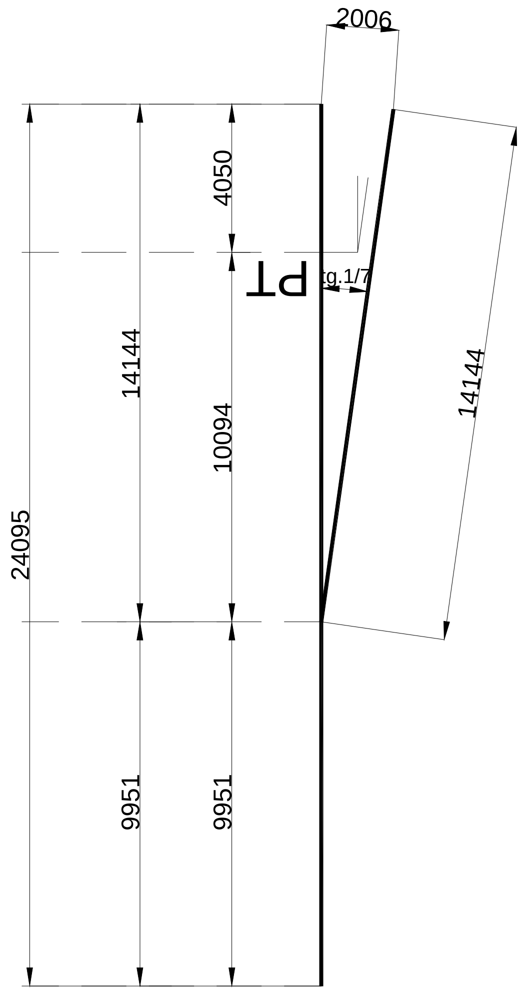


Fig No. 4.3

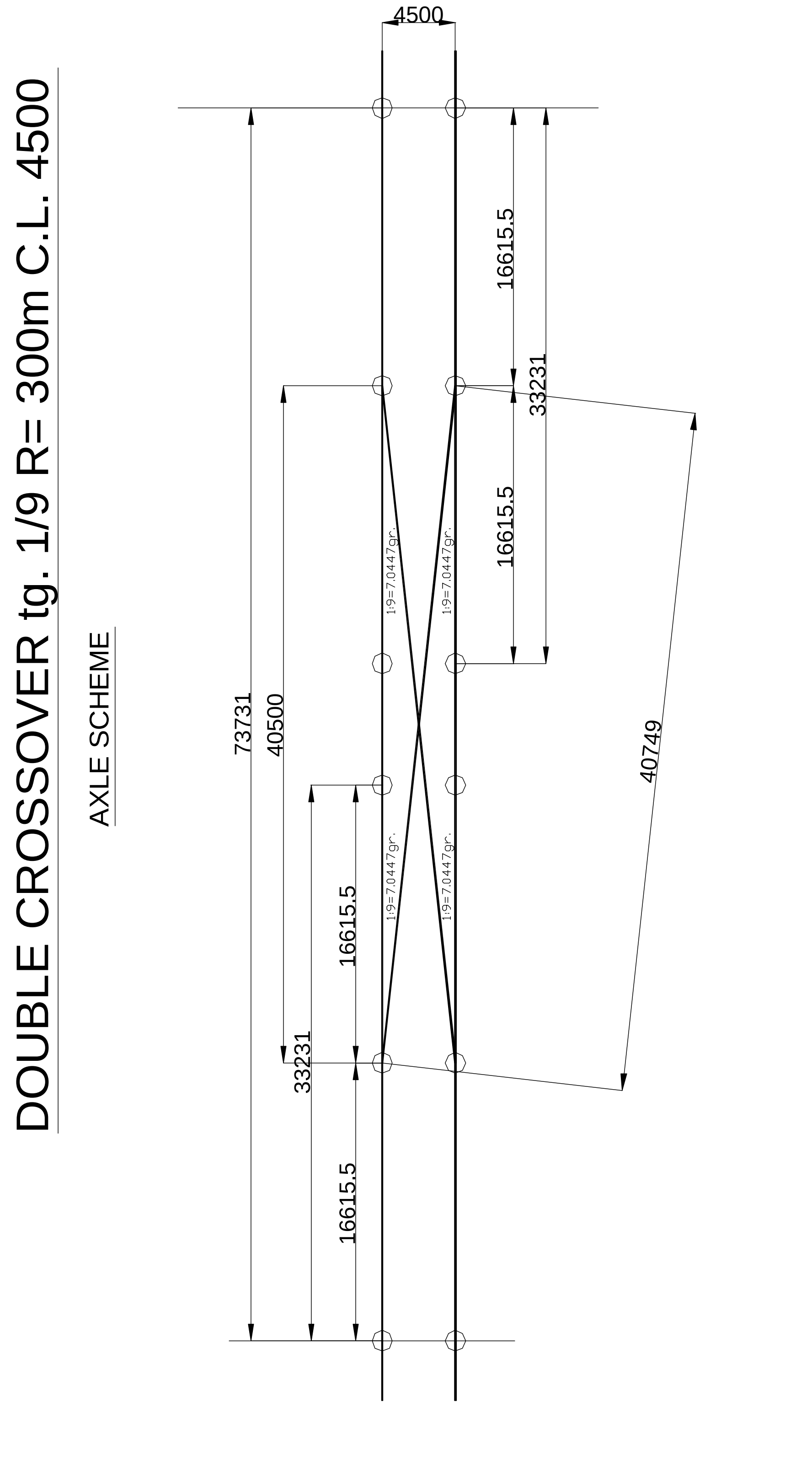

DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500
AXLE SCHEME
4500
73731
40500
16615.5
33231
16615.5
16615.5
33231
16615.5
40749
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.

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 and depot entry/ exit.

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

.

4.3.3.2.4 Point Machines

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

4.3.3.3 Train Depot: Signalling

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

4.3.3.4 Interface for PSD

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

4.3.4 Standards

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

Table 4.1

Description	Standards
▪ Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for workshop lines, inspection shed lines etc.
▪ Block Working	Moving Block working concept may be followed.
▪ Operation of Points	Non-Trailable Electrical Point Machine capable of operating with 3-phase, 50 Hz. 380V AC will be used on main line and the depot point machine will be trailable/ non -trailable type electrical point machine capable of operating with either 3 phase, 50 Hz. 380V AC or 110V DC.

▪ Track Vacancy Detection System	Primary mode for track vacancy detection system on main line and test track in depot may be through radio and for depot and secondary detection it can be through Track circuit / Axle Counter.
▪ Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
▪ UPS (uninterrupted power at stations as well as for OCC)	For Signalling, Telecommunications and AFC.
▪ Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide for redundancy. The system will conform to IEEE 1474 standards.
▪ Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC. The system architecture shall provide for redundancy.
▪ Cables	Outdoor cables will be steel armoured as far as possible.
▪ Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for Signal and Train Control System.
▪ Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables as per standard. CENELEC standards to be implemented for EMC.
▪ Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 kmph.
▪ Environmental Conditions	Air-conditioners for all equipment rooms.
▪ Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.

4.3.5 Space Requirement for Signaling Installations

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

4.3.6 Maintenance Philosophy for Signalling systems

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

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

4.4 TELECOMMUNICATION

4.4.1 Introduction

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

4.4.2 Overview

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

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

The proposed Telecom system will cater to the following requirements:

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

4.4.3 Telecommunication System and Transmission Media

4.4.3.1 Fibre Optic System (FOTS) - Main Telecommunication Bearer

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

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

4.4.3.2 Telephone Exchange

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

4.4.3.3 Mobile Radio Communication

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

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

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

4.4.3.8 Access Control System

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

4.4.3.9 Network Monitoring and Management

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

4.4.4 Technology

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

Table 4.2

System	Standards
Transmission Media	Optical Fibre system as the main bearer for bulk of the Telecommunication network
Telephone Exchange	IP EPABX of minimum 30 ports is to be provided at all Stations, an Exchange of 60 Ports to be provided at Terminal Station
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel and central control.
Train Destination Indicator System	LED based boards with adequate visibility to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and also special messages in emergencies.
Centralized clock System	Accurate display of time through a synchronization system of slave clocks driven from a GPS master clock at the OCC and sub – master clock in station. This shall also be used for synchronization other systems.
Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement.
Redundancy (Major System)	Redundancy on Radio's in the Base Stations, Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.
Environmental Conditions	All equipment rooms to be air-conditioned.
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

4.4.5 Space Requirement for Telecom Installations

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

4.4.6 Maintenance Philosophy for Telecom Systems

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

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

4.5 AUTOMATIC FARE COLLECTION SYSTEM:

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

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

Card / Token) in comparison to paper tickets and prevention of leakage of revenue. Relative advantages of automatic fare collection system over manual system are as follows.

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

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

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

B. Automatic fare collection systems have the following advantages:

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

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

C. Choice of Control Gates:

Retractable flap type or Turnstile type Control Gates are proposed.

D. Passenger Operated Machines:

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

4.5.2 Standards:

The standard proposed for AFC system are as under:

Table 4.3

Standards	Description
Fare media	a) **Contactless Smart Token –** For single journey. Token are captured at the exit gate. b) **Contactless Smart Card –** For multiple journeys. Contactless readers shall be as per ISO 14443 standards.
Gates	Computer controlled retractable flap / turnstile type automatic gates at entry and exit. There will be following types of gates : - **Entry** - **Exit** - **Reversible** - **Disabled –** Wide reversible gate for 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.
Ticket Readers	**Ticket Reader** shall be installed near EFO for passengers to check information stored in the token / cards.
UPS	**Common UPS of S&T system will be utilized.**

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.

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

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

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

4.6 ROLLING STOCK

4.6.1 INTRODUCTION

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

- **OPTIMIZATION OF COACH SIZE**

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

Table 4.4 - Size of the coach

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

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

- **Passenger Carrying Capacity**

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

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

Following train composition is recommended:

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

Table 4.5 shows the carrying capacity of Medium Rail Vehicles.

Table 4.5 Carrying Capacity of Medium Rail Vehicles

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

NORMAL-3 Person/sqm of standee area

CRUSH -6 Person/sqm of standee area

- **WEIGHT**

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

Table 4.6 Weight of Light Rail Vehicles (TONNES)

	DMC	**TC/MC**	**6 Car train**
TARE (maximum)	42.69	41.61/41.98	252.56
Passenger			

(Normal)	10.48	11.29/11.29	66.13
(Crush @6p/sqm)	18.33	19.37/19.37	114.14
(Crush @8p/sqm)	23.4	24.7/24.7	145.6
Gross			
(Normal)	53.17	52.90/53.27	318.69
(Crush @6p/sqm)	61.02	60.98/61.35	366.7
(Crush @8p/sqm)	66.09	66.31/66.68	398.16
Axle Load @6 person/sqm	15.25	15.24/15.33	
Axle Load @8 person/sqm	16.52	16.57/16.67	

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

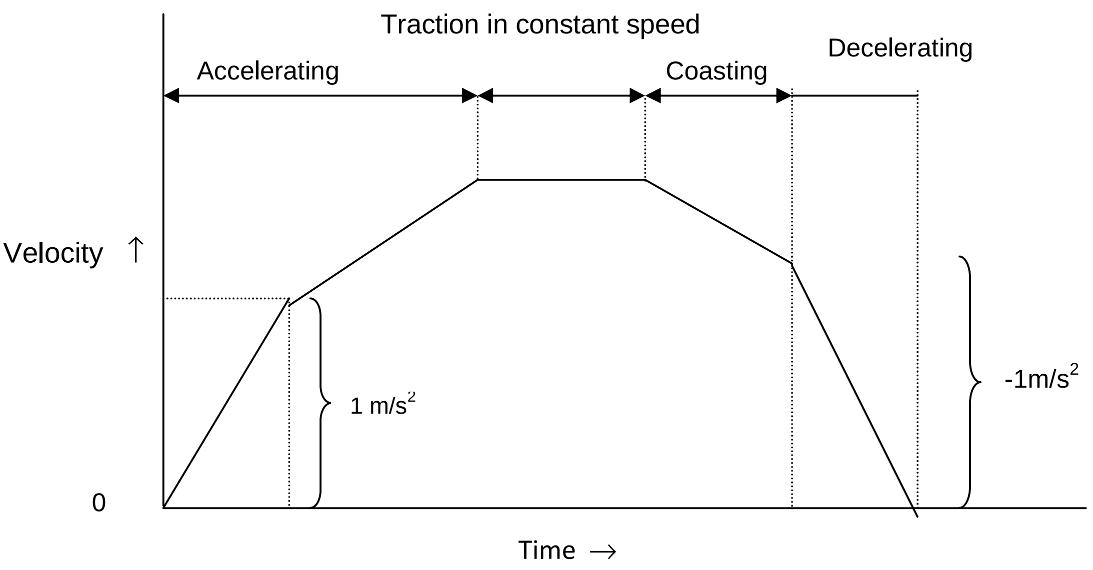
4.6.2 PERFORMANCE PARAMETERS

The recommended performance parameters are:

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

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

1.35m/s^2(Emergency Brake)



4.6.3 COACH DESIGN AND BASIC PARAMETERS

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

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

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

4.6.4 SELECTION OF TECHNOLOGY

- **Low life cycle cost**

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

- **Car body**

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

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

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

- **Bogies**

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

- **Braking System**

The brake system shall consist of –

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

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

4.6.5 PROPULSION SYSTEM TECHNOLOGY

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

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

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

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

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

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

4.6.6 INTERIOR AND GANGWAYS

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

Interior View

4.6.7 PASSENGER DOORS

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

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

Passenger Doors

4.6.8 AIR–CONDITIONING

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

4.6.9 CAB LAYOUT AND EMERGENCY DETRAINMENT DOOR

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

Driving cab

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

4.6.10 COMMUNICATION

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

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

4.6.11 NOISE AND VIBRATION

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

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

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

4.6.12 PASSENGER SAFETY FEATURES

(i) ATP/ATO

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

(ii) Fire

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

(iii) Emergency door

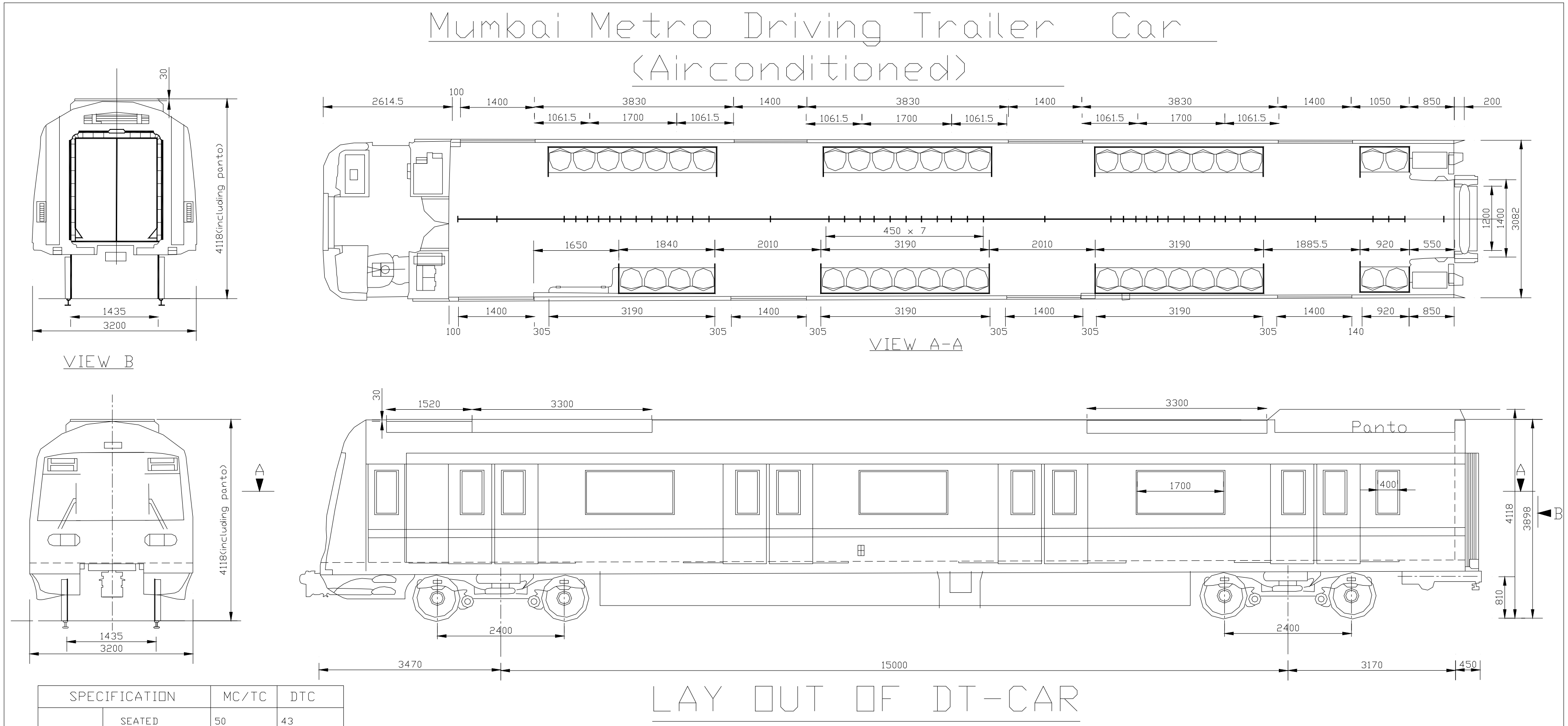
In Standard Gauge (3.2 m wide) Cars, the rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train.

(iv) Crash worthiness features

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

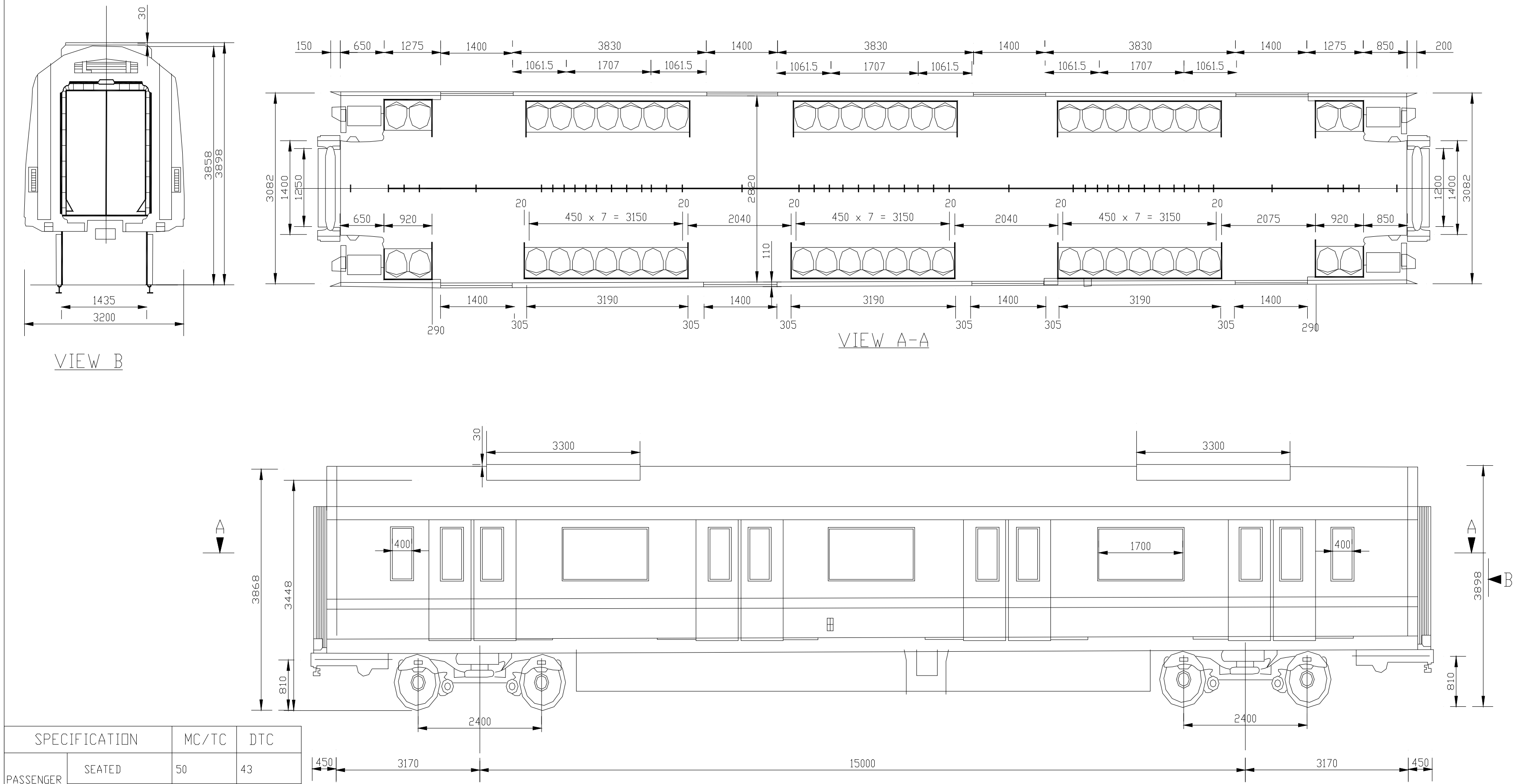
(v) Gangways

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



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

5.1 GEOMETRIC DESIGN NORMS:

5.1.1 General:

The alignment of this corridor has been designed based on the parameters already adopted and in use for Delhi Metro network. The parameters are time tested and metro services are being run successfully without any disruption. It has been decided that the alignment of this corridor has to be located on the centre verge of the road except at Dahisar near flyover where alignment has to be necessarily outside flyover on the right side between Apartments and flyover road edge. The pillar will be almost butting the edge of flyover and will be of the height so as to allow Metro viaduct clear headway of 5.5 m over Flyover road. Road between Dahisar and D.N. Nagar is having varying ROW. The station planning has been done so as to allow clear 2 lane each way for road traffic all through with 3 lane each way in some length of the corridor.

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

5.1.2 Horizontal Alignment:

Horizontal alignment of this corridor runs between Dahisar (E) and D.N.Nagar. The alignment starts with Dahisar (E) Station on left side (facing Dahisar) of WEH and take left turn to align along link road.

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

Horizontal Curves:

Elevated section

Minimum	:	200 m
Absolute minimum	:	120 m
Minimum curve radius at stations	:	1000 m
Maximum permissible cant	:	125 mm
Desirable maximum cant	:	110 mm

Maximum cant deficiency : 85 mm

Transition Curves:

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

- Length of transitions of horizontal curves (m)

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

  Desirable : 0.72 times actual cant or cant deficiency (in mm), whichever is higher.
- Overlap between transition curves and vertical curves not allowed.
- Minimum straight between two transition curves: Either 25 m or Nil.
- Minimum curve length between two transition curves: 25 m.

5.1.3 Vertical Alignment:

a) Elevated sections:

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

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

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

b) Gradients:

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

c) Vertical curves:

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

- Radius of vertical curves
  - On main line
    Desirable : 2500 m
    Minimum : 1500 m
  - Other locations : 1500 m
  - Minimum length of vertical curve : 20 m

5.1.4 Design Speed:

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

Table 5.1.1

Cant, Permitted Speed and Minimum Transition Length for Various Curves

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

5.1.5 Codes and Standards:

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

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

5.1.6 General technical requirements of the Rail System:

The rail system shall be designed to:

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

The design of the Rail System shall also conform to:

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

5.2 ALIGNMENT:

5.2.1 Introduction:

5.2.1.1 Dahisar (E) – D.N. Nagar corridor of Mumbai Metro Project is proposed to start at Western Express Highway with its station named as Dahisar (East) and platform located above the already proposed Dahisar (East) metro station for Andheri (E) – Dahisar corridor. The alignment stretches from Dahisar (E) to D.N. Nagar via Dahisar (W), Rushi Sankul, I.C. Colony, Don Bosco, Charkop, Kasturi Park, Oshiwara and runs on link road. D.N. Nagar Metro Station on this corridor is proposed on the median of the road and will be integrated with D.N. Nagar Station of Line No. 1.

5.2.1.2 The chainage of Dahisar (E) proposed station is taken as 0.0 and dead end chainage of this station as (-) 413.9 m.

5.2.1.3 Total length of the corridor from dead end to dead end is 18.589 km. The entire corridor proposed is elevated.

5.2.1.4 The corridor starts on W.E.H. and takes left turn to reach Dahisar (W) and thereafter aligns along Link Road.

5.2.1.5 Seventeen stations have been proposed on the corridor. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one Km. distance apart. The maximum and minimum inter station distances are 1711.7 m and 628.5 m respectively.

5.2.2 Station Locations:

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

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

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

Table 5.2.1 List of Stations

Dahisar(E) to DN Nagar Corridor (Mumbai)				
S.No	**Station Name**	**Chainage(m)**	**Inter Distance Between Two Stations.**	**U/G/ ELEVATED**
0	DEAD END	(-) 413.941		
1	DAHISAR (E)	0.0	413.941	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
	DEAD END	18175.0	596.4	

5.2.3 Terminals:

5.2.3.1 Dahisar (E) Terminal:

This terminal station proposed on WEH (S.V & L.R. Junction) near junction of S.V. Road and Link Road at Dahisar (East), the centre line being at Ch.0.0. Station is in the midst of residential and commercial area of Dahisar.

5.2.3.2 D.N. Nagar Terminal:

This Station is proposed on median of the road by the side of Sewage treatment plant. 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. This Station will be integrated with the D.N. Nagar station of line-1 by providing skywalk

5.2.4 Scissors Crossovers:

Scissors Crossovers will be provided at both the terminal stations viz. Dahisar (E) (S.V. & L.R Junction) and also D.N. Nagar. In between, crossovers are proposed at two intermediate stations for making one of the platform line as common loop for its use in emergencies.

5.2.5 Description of Alignment:

5.2.5.1 Horizontal Alignment:

The proposed alignment starts from CH: (-) 413.9 m and Station No. 1 named as Dahisar (E) is located at CH:00. Alignment starts on WEH (S.V. & L.R Junction) of Western Express Highway.

The platform of Dahisar (E) Station of the proposed Dahisar - D. N. Nagar corridor has been planned over the platform of already planned corridor between Andheri (E) – Dahisar (E) along WEH and takes turn towards left to come to Dahisar (W) area. Alignment before reaching Dahisar (W) area traverses on some of the shops and thereafter along the drain. Dahisar (W) station is located at chainage 711.0 on straight alignment. From there on alignment deviates to the outside Dahisar flyover and to be located between flyover and Group housing. Foundation of the pillars will be so located that pillars will be just butting the edge of the flyover and the height of the viaduct is kept to allow the headway of at least 5.5 m on the flyover. The flyover is located between the chainage 300m and 1300m. From there on alignment continues to run on the median of link road.

The next station on the corridor comes Rushi Sankul at chainage 2422.7 m. This station is located on the radius of 1000 m. There are two cross roads joining on this station; one is going to Ezan Garden and other to Khanderpada. This station is likely to have a good ridership. Thereafter alignment continues to run on the curve and next station is IC Colony at the chainage of 3383.1. Thereafter, also alignment follows road just on the curve with the sharper curvature of 595 m. In this stretch, there is a road joining from Borivali station. From there is the next station falls at chainage 4468.4 m names as LIC Colony. Just after LIC Colony station, there is a curve of 700 m radius with a straight of 68.38 m thereof. After a straight there is a curve of 330 m and next station is located at chainage 5537.5 m named as Don Bosco. This station is also located at the curve of 1010 m radius. Station is closely followed by a curve of 500 m radius and subsequently by 3000 m radius with the straight length of 138.6 m in between. The next station is at chainage 6465.9 m with it name as Kastur Park. The station is followed by a curve of 700 m radius and thereafter straight length of 114 m. Again, there is a curve of 375 m followed by the curve of 230 m radius. The next station located at chainage 7571 m names as Ekata Nagar. This station is also located on the curve of 1010 m. The station is closely followed by radius of 650 m then by straight length of 126 m and radius of 500 m. The next station is located at chainage 8200 m named as Kandivali Nagar. From thereon there is straight track of 96.1 m which is followed by the curve of radius 2000 m and thereafter with a curve of 800 m and 850 m. The next station is located at chainage 9535 m named as Charkop which is closely followed by a curve of 510 m radius. The next station is Malad Metro at chainage 10846 m which is also located on the curve of radius 1800 m. Subsequently followed by a curve of 1510 m, 690 m, 600 m, 3500 m, 3000 m.

The next station is located at chainage 12243 m named as Kasturi Park. The station is on straight. Thereafter alignment crosses a Nallah with the radius 1010m. This curve is followed by a curve of radius 360 m. The next station is at chainage 13183 m named as Bangur Nagar. This station is followed by a curve of 2000 m and thereafter by a curve of 810 m, 325 m, 1010 m, 610 m, 1750 m before reaching the station Oshiwara at chainage 1445 m.

Subsequently, after Oshiwara metro station, alignment crosses the Oshiwara Nallah and passes through Jogeswari area with the curve of 1500 m, 1857 m. Thereafter, alignment continues on right turn with a sharp curvature of 122 m leading acquisition at the corner affecting some of the properties. The alignment thereafter comes to Samartha Nagar at chainage 14468 m. The alignment again takes a sharp curve affecting the number of properties and comes to New Link Road. Alignment runs at the median of the road upto station Shastri Nagar located at chainage 16443 m. This station is followed by radius of 600 m, 2650 m, 260 m and 350 m before reaching to D.N. Nagar metro station located at chainage 17578.6 m. It is proposed to provide extended length in the rear of D.N. Nagar station for reversal of the train from rear.

The details of curves are shown in Table No.5.2.4.

5.2.5.2 **Vertical Alignment:**

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

Gradient details are given in Table 5.2.2

5.2.7 Maintenance Depot:

It is proposed to provide the Car maintenance depot at Charkop in the Government land identified by MMRDA. The land parcel available is of 20. Ha but of irregular shape. Detailed planning of depot in this area has been done.

5.2.8 The proposed rail levels in Table 5.2.2 and abstracts of gradients are given in Table 5.2.3.

Table 5.2.2 Proposed Gradients of Rail Track

Dahisar(E) to DN Nagar Corridor (Vertical Curve Details)							
S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-413.9	-140.0	273.9	34.6	27.7	-2.520%	Fall
2	-140.0	240.0	380.0	27.7	27.7	0.000%	Level
3	240.0	560.0	320.0	27.7	18.7	-2.813%	Fall
4	560.0	916.3	356.3	18.7	18.7	0.000%	Level
5	916.3	1444.5	528.2	18.7	27.8	1.723%	Rise
6	1444.5	1560.3	115.8	27.8	27.8	0.000%	Level
7	1560.3	1940.0	379.7	27.8	18.8	-2.370%	Fall
8	1940.0	2170.0	230.0	18.8	22.0	1.391%	Rise
9	2170.0	2560.0	390.0	22.0	22.0	0.000%	Level
10	2560.0	2930.0	370.0	22.0	14.7	-1.973%	Fall
11	2930.0	3184.8	254.8	14.7	19.6	1.923%	Rise
12	3184.8	3510.0	325.2	19.6	19.6	0.000%	Level
13	3510.0	3860.0	350.0	19.6	17.0	-0.743%	Fall
14	3860.0	4300.0	440.0	17.0	19.7	0.614%	Rise
15	4300.0	4680.0	380.0	19.7	19.7	0.000%	Level
16	4680.0	4850.0	170.0	19.7	18.2	-0.882%	Fall
17	4850.0	5120.0	270.0	18.2	18.5	0.111%	Rise
18	5120.0	5380.0	260.0	18.5	22.2	1.423%	Rise
19	5380.0	5700.0	320.0	22.2	22.2	0.000%	Level
20	5700.0	6000.0	300.0	22.2	18.3	-1.300%	Fall
21	6000.0	6270.0	270.0	18.3	21.8	1.296%	Rise
22	6270.0	6580.0	310.0	21.8	21.8	0.000%	Level
23	6580.0	6850.0	270.0	21.8	16.8	-1.852%	Fall
24	6850.0	7140.0	290.0	16.8	15.8	-0.345%	Fall
25	7140.0	7400.0	260.0	15.8	21.6	2.231%	Rise
26	7400.0	7740.0	340.0	21.6	21.6	0.000%	Level
27	7740.0	8040.0	300.0	21.6	21.8	0.067%	Rise
28	8040.0	8360.0	320.0	21.8	21.8	0.000%	Level
29	8360.0	8620.0	260.0	21.8	16.8	-1.923%	Fall
30	8620.0	8900.0	280.0	16.8	18.6	0.643%	Rise
31	8900.0	9160.0	260.0	18.6	14.7	-1.500%	Fall
32	9160.0	9380.0	220.0	14.7	18.6	1.773%	Rise
33	9380.0	9680.0	300.0	18.6	18.6	0.000%	Level
34	9680.0	9920.0	240.0	18.6	14.4	-1.750%	Fall

35	9920.0	10320.0	400.0	14.4	13.9	-0.125%	Fall
36	10320.0	10670.0	350.0	13.9	17.7	1.086%	Rise
37	10670.0	11025.0	355.0	17.7	17.7	0.000%	Level
38	11025.0	11280.0	255.0	17.7	18.0	0.118%	Rise
39	11280.0	11570.0	290.0	18.0	18.0	0.000%	Level
40	11570.0	11846.8	276.8	18.0	13.8	-1.517%	Fall
41	11846.8	12210.0	363.2	13.8	14.5	0.193%	Rise
42	12210.0	12800.0	590.0	14.5	14.3	-0.034%	Fall
43	12800.0	13040.0	240.0	14.3	17.2	1.208%	Rise
44	13040.0	13300.0	260.0	17.2	17.2	0.000%	Level
45	13300.0	13580.0	280.0	17.2	13.9	-1.179%	Fall
46	13580.0	14095.0	515.0	13.9	13.6	-0.058%	Fall
47	14095.0	14290.0	195.0	13.6	18.1	2.308%	Rise
48	14290.0	14620.0	330.0	18.1	18.1	0.000%	Level
49	14620.0	14970.0	350.0	18.1	13.9	-1.200%	Fall
50	14970.0	15350.0	380.0	13.9	20.6	1.763%	Rise
51	15350.0	15680.0	330.0	20.6	20.6	0.000%	Level
52	15680.0	15960.0	280.0	20.6	13.7	-2.464%	Fall
53	15960.0	16220.0	260.0	13.7	17.2	1.346%	Rise
54	16220.0	16620.0	400.0	17.2	17.2	0.000%	Level
55	16620.0	16874.6	254.6	17.2	16.4	-0.314%	Fall
56	16874.6	17422.4	547.8	16.4	26.0	1.752%	Rise
57	17422.4	18175.0	752.6	26.0	26.0	0.000%	Level

Table 5.2.3

Abstract of Gradients

S. N.	Description	Nos. Occurrences	Length (m)	% w. r. t. total Alignment length
1	Level	18	6254.9	33.65%
2	> 0% to = 1%	13	4477.82	24.09%
3	> 1% to = 2%	20	6147.57	33.07%
4	> 2% to = 3%	6	1708.63	9.19%
5	> 3% to = 4%	0	0	0.00%
	Total	**57**	**18588.9**	100.00%

5.2.9 Curvature:

There are many sharp turns and curves along the road. This necessitates provision of curves for metro alignment also. The radius of curves is kept as low as 122 m to reduce the property acquisition. Total 87 Nos. of curves have been provided in the entire length of Dahisar (E) – D. N. Nagar Corridor. The details of curves and abstracts of horizontal curves are indicated in Table 5.2.4 and 5.2.5 respectively.

Table 5.2.4 Details of Curves

Dahisar(E) to DN Nagar Corridor (Horizontal Curve Details)								
Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle	Tangent (m)	Straight Length (m)
				L1	L2	D M S		446.147
1	Left	2010	24.624	20	20	00 42 06.886	12.312	28.808
2	Left	190	255.162	55	55	76 56 44.622	150.986	0.057
3	Left	1027	203.428	35	35	11 20 56.834	102.048	63.576
4	Right	1070	25.108	25	25	01 20 40.119	12.555	26.675
5	Left	550	28.046	40	40	02 55 17.931	14.026	27.386
6	Left	610	33.148	40	40	03 06 48.677	16.578	241.994
7	Right	3510	28.572	10	10	00 27 59.033	14.286	43.63
8	Right	800	35.782	30	30	02 33 45.825	17.894	45.267
9	Left	600	43.67	35	35	04 10 12.772	21.845	0
10	Left	600	184.727	55	55	17 38 24.616	93.1	35.644
11	Left	500	113.504	40	40	13 00 23.764	56.997	129.123
12	Left	1200	51.386	25	25	02 27 12.582	25.697	66.206
13	Left	750	125.61	35	35	09 35 45.190	62.952	77.333
14	Left	700	73.009	35	35	05 58 32.999	36.537	117.94
15	Left	430	26.27	50	50	03 30 01.317	13.139	27.854
16	Left	1260	241.153	25	25	10 57 57.319	120.946	47.24
17	Left	525	36.452	40	40	03 58 41.431	18.233	35.603
18	Right	1500	25.955	20	20	00 59 29.036	12.978	61.164
19	Right	595	428.62	40	40	41 16 26.903	224.085	66.26
20	Left	2000	105.535	15	15	03 01 24.053	52.78	68.389
21	Left	700	127.632	40	40	10 26 48.635	63.994	0
22	Left	330	26.111	55	37.465	04 32 00.788	13.063	0
23	Left	710	177.501	37.465	45	14 19 26.467	89.216	293.542
24	Left	1010	40.067	25	25	02 16 22.567	20.036	32.259
25	Right	500	49.022	40	40	05 37 03.057	24.531	133.63
26	Left	3000	38.17	15	15	00 43 44.377	19.085	176.072
27	Left	2000	49.1	20	20	01 24 23.759	24.551	74.137
28	Left	2500	37.354	20	20	00 51 21.938	18.677	233.551
29	Right	700	112.559	35	35	09 12 47.102	56.401	114.082
30	Right	375	49.56	55	55	07 34 20.130	24.816	123.356
31	Right	230	32.802	50	50	08 10 16.862	16.429	0
32	Left	1010	84.869	25	25	04 48 52.215	42.46	24.535
33	Left	1010	101.685	25	25	05 46 06.419	50.886	28.312
34	Left	650	102.035	30	30	08 59 38.916	51.123	126.113
35	Left	500	72.162	40	40	08 16 09.104	36.144	137.199
36	Left	1200	33.122	25	25	01 34 53.207	16.562	96.184
37	Right	2000	120.267	15	15	03 26 43.409	60.152	112.58
38	Left	1800	31.553	20	20	01 00 15.700	15.777	84.34
39	Left	850	55.376	30	30	03 43 57.707	27.698	62.801
40	Left	1500	45.173	20	20	01 43 31.762	22.588	96.255
41	Right	2000	44.15	15	15	01 15 53.252	22.076	143.435
42	Right	2000	61.456	15	15	01 45 38.143	30.731	67.526
43	Left	510	164.442	55	55	18 28 27.240	82.941	103.655
44	Right	2750	36.827	15	15	00 46 02.229	18.414	29.54

45	Right	800	58.135	30	30	04 09 49.006	29.08	27.123
46	Left	1500	32.162	20	20	01 13 42.623	16.082	98.146
47	Right	650	61.388	35	35	05 24 40.301	30.717	27.162
48	Right	1500	74.54	20	20	02 50 50.022	37.278	47.737
49	Right	2000	29.44	15	15	00 50 36.251	14.72	50.382
50	Left	6000	35.504	10	10	00 20 20.533	17.752	48.436
51	Right	1800	40.47	15	15	01 17 17.523	20.236	0
52	Left	1510	150.703	20	20	05 43 05.895	75.414	25.177
53	Left	690	102.32	35	35	08 29 47.087	51.254	35.985
54	Right	600	56.374	35	35	05 22 59.790	28.208	139.453
55	Left	3500	47.919	10	10	00 47 04.027	23.96	40.377
56	Left	3000	35.206	10	10	00 40 20.559	17.603	33.989
57	Right	170	26.85	55	55	09 02 57.120	13.453	25.765
58	Right	1360	51.544	20	20	02 10 17.362	25.775	0
59	Left	4365	27.102	10	10	00 21 20.673	13.551	79.189
60	Right	1860	39.813	15	15	01 13 35.049	19.907	25.008
61	Left	1010	44.235	25	25	02 30 33.762	22.121	63.569
62	Left	360	27.295	55	55	04 20 38.768	13.654	584.292
63	Left	6000	29.606	10	10	00 16 57.782	14.803	58.159
64	Left	2000	34.28	15	15	00 58 55.381	17.14	36.795
65	Left	810	211.801	40	40	14 58 54.808	106.508	0
66	Right	325	44.895	55	55	07 54 53.153	22.483	113.499
67	Left	1010	37.108	25	25	02 06 18.341	18.556	41.82
68	Left	610	40.73	40	40	03 49 32.490	20.373	0
69	Right	1750	61.729	20	20	02 01 15.751	30.868	0
70	Left	2010	47.299	20	20	01 20 53.774	23.651	57.869
71	Left	3000	29.902	10	10	00 34 15.921	14.951	314.043
72	Right	1500	35.908	20	20	01 22 17.696	17.955	0
73	Left	1857	59.784	20	20	01 50 40.415	29.894	45.734
74	Right	122.1	142.854	55	55	67 02 04.798	80.869	75.31
75	Right	2000	66.949	15	15	01 55 04.615	33.478	102.889
76	Left	122.1	138.733	55	55	65 06 02.964	77.937	166.488
77	Right	21000	27.921	10	10	00 04 34.242	13.96	27.522
78	Right	6500	33.357	10	10	00 17 38.522	16.679	118.615
79	Left	4500	32.854	10	10	00 25 05.922	16.427	220.522
80	Left	6000	28.106	10	10	00 16 06.227	14.053	79.355
81	Right	2650	36.583	15	15	00 47 27.462	18.292	76.573
82	Right	350	31.139	55	55	05 05 50.896	15.58	288.246
83	Left	260	37.99	45	45	08 22 18.703	19.029	0
84	Right	220	31.991	45	45	08 19 53.768	16.024	188.696
85	Left	290	28.019	40	40	05 32 08.790	14.02	104.796
86	Right	200	43.556	40	40	12 28 40.209	21.864	0
87	Left	410	27.742	35	35	03 52 36.745	13.876	82.783

Table 5.2.5 Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length without TL(m)	% w. r. t. total curved length
1	>200m - 510m	20	1370.099	23%
2	>510m - 1010m	25	2402.879	40%

3	>1010m - 2010m	27	1786.631	29%
5	>2010m - 5010m	10	350.489	6%
6	>5010m	5	154.494	3%
	Total	**87**	**6064.592**	**100.00%**

5.3 STATION PLANNING:

5.3.1 General:

5.3.1.1 Stations on the line:

The proposed Dahisar (E) – D. N. Nagar Metro Corridor runs southwards from Dahisar (West) and aligns along the Link Road covering a distance of 17.578 Km from Centre of Dahisar (E) station to D. N. Nagar station. A total of 17 stations have been planned along the proposed corridor. All stations are planned as elevated stations. Stations are generally located around 900 -1100 m apart, though the inter station distance varies from 628.5 m to 1711.5.4 m due to traffic and topographic reasons as well as design constraints.

The details of stations with rail level, inter station distances are given in the table 5.3.1.

Table 5.3.1 Dahisar(E) to DN Nagar Corridor (Mumbai) *Date: 22.08.2015*

S.No	Station Name	Chainage(m)	Inter Distance Between Two Stations.	Rail Level	Ground Level	Depth/ Height	U/G / ELEVATED
0	DEAD END	(-) 413.941					
1	DAHISAR (E)	0.0	413.941	27.700	7.986	19.714	ELEVATED
2	DAHISAR (W)	711.0	711.0	18.700	4.609	14.091	ELEVATED
3	RUSHI SANKUL	2422.7	1711.7	22.000	8.182	13.818	ELEVATED
4	I C COLONY	3383.1	960.4	19.600	5.956	13.644	ELEVATED
5	LIC COLONY	4468.4	1085.3	19.700	6.067	13.633	ELEVATED
6	DON BOSCO	5537.5	1069.1	22.200	8.634	13.566	ELEVATED
7	KASTUR PARK	6465.9	928.4	21.800	8.273	13.527	ELEVATED
8	EKATA NAGAR	7571.8	1105.9	21.600	7.023	14.577	ELEVATED
9	KANDIVALI NAGAR	8200.3	628.5	21.800	8.233	13.567	ELEVATED
10	CHARKOP	9535.5	1335.2	18.600	5.075	13.525	ELEVATED
11	MALAD METRO	10846.0	1310.5	17.700	4.367	13.333	ELEVATED
12	KASTURI PARK	12243.4	1397.4	18.000	4.569	13.431	ELEVATED
13	BANGUR NAGAR	13183.1	939.7	17.200	3.408	13.792	ELEVATED
14	OSHIWARA METRO	14455.5	1272.4	18.100	3.963	14.137	ELEVATED
15	SAMARTHA NAGAR	15468.7	1013.2	20.600	7.003	13.597	ELEVATED
16	SHASTRI NAGAR	16433.0	964.3	17.200	3.549	13.651	ELEVATED
17	D N NAGAR	17578.6	1145.6	26.000	3.780	22.220	ELEVATED
	DEAD END	18175.0	596.4				

5.3.1.2 **Rail Levels and Alignment:**

Alignment is planned as elevated and is governed by a ground clearance of 5.50 m from road level. This in turn determines the level of the entire station structure on the elevated section. The alignment is planned to start on Western Express Highway from Dahisar (E) but changes over to western side and thereby runs along the link road. Entry/exit structures for the proposed stations have been planned on both sides of stations but acquisition of private land has been kept to minimum.

5.3.1.3 ***Platforms:***

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

Table 5.3.2

Station Location Characteristics

Dahisar to D. N. Nagar Corridor (Mumbai)					
S.No	**Station Name**	**Location**	**Chainage (m)**	**Inter Distance Between Two Stations.**	**Areas served**
0	DEAD END		(-) 413.941		
1	DAHISAR (E)	First Station Near Vardhaman Industry	0.0	413.941	Avaduth Nagar CS Complex, Shakti Nagar, Penkarpada,, Dharkhadi, Ketkipada, Maratha Colony, N. I. Complex.
2	DAHISAR (W)	Located on central verge/along the median of Link Road.	711.0	711.0	Shakti Nagar, Shrinath Nagar, Daulat Nagar, Ambawadi, Krishna Colony, Anand Nagar, C.S. Complex, Dahisar Railway Station
3	RUSHI SANKUL	Located on central verge/along the median of Link Road,	2422.7	1711.7	Dahisar West, Avdhut Nagar, Krishna Colony, Shakti Nagar, Ambawadi, Dahisar Railway Station
4	I C COLONY	Located on central verge/along the median of Link Road.	3383.1	960.4	Kandar Pada, Dahisar West, Mandapeshwar
5	LIC COLONY	Located on central verge/along the median of Link Road.	4468.4	1085.3	I.C Colony, LIC Colony, Borivli West, Jivan Bima Nagar, Yogi Nagar
6	DON BOSCO	Located on central verge/along the	5537.5	1069.1	Yogi Jayraj Nagar, Babhai, Vazira Naka area,

		median of Link Road..			Haridas Nagar, Kastur Park, MHADA Colony, Roshan Nagar, Borivli Railway Station, Govind Nagar
7	KASTUR PARK	Located on central verge/along the median of Link Road.	6465.9	928.4	Padma Nagar, Satya Nagar, Mahavir Nagar, Shimpoli, Haridas Nagar, Kastur Park, Mhatre Wadi, Dalvi Nagar
8	EKATA NAGAR	Located on central verge/along the median of Link Road,	7571.8	1105.9	Sector 4 of Charkop, Shravan Nagar, Sector 6-7 of Charkop, Padma Nagar, Satya Nagar, Mohan Nagar, Mahavir Nagar, Shimpoli, Haridas Nagar, Siddhi Vinayak Nagar.
9	KANDIVAL I NAGAR	Located on central verge/along the median of Link Road	8200.3	628.5	Dahanukar Wadi, Kandivli West, Sidhi Vinayak Nagar, Mohan Nagar, Shravan Nagar, Bander Pakhadi, Kandivli Railway Station
10	CHARKOP	Located on central verge/along the median of Link Road	9535.5	1335.2	Sai Baba Nagar, Ushma nagar, Mith Chowky area, Lourdes Colony, Jai Janta Nagar, Ganesh Nagar and may extend to Dominic Colony, other areas in Kandivali West like Gandhi Nagar, Bhut Nagar, Hemu Colony and Bhagal Colony
11	MALAD METRO	Located on central verge/along the median of Link Road	10846.0	1310.5	Usha Nagar, Bhandarwada, NSC Colony, Liberty Garden Area, Malad Industrial Units Cooperative Society and Evershine Nagar. Commuters from Malad West areas, Kumbhar Wada and Mamletdar Wada may also use the station.
12	KASTURI PARK	Located on central verge/along the median of Link Road	12243.4	1397.4	Entire commercial and Mall area, Prem Nagar, Hanuman Nagar, Bangur Nagar,and other Goregaon West areas. Commuters from Motilal Nagar Part III, Shiva ji Nagar, police Colony and part of Malad West may also use the station

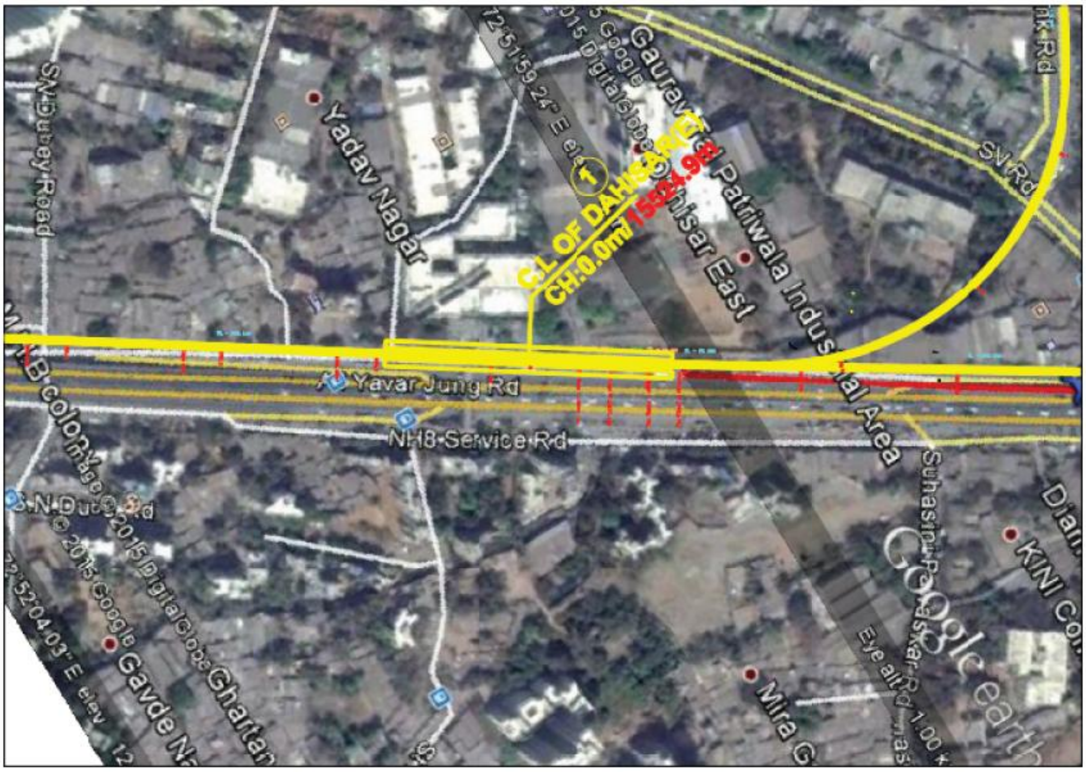
13	BANGUR NAGAR	0	13183.1	939.7	Bhagat Singh Nagar, Motilal Nagar Part I, Mitha Nagar and Laxmi Nagar and may extend to part of Bangru Nagar, Motilal Nagar Part II and areas upto Ayyappa Temple.
14	OSHIWARA METRO	Located on central verge of Goregaon Link Road	14455.5	1272.4	Entire Goregaon West area including Bhagat Singh Nagar Colonies No. 1, 2, 3, Oshiwara Industrial Estate, Kulandi Industrial Estate, Motilal Nagar Part I, Prakash Nagarand BEST nagar and may extend to Haryana Basti, MHADA colony, Oshiwara, Gulshan Nagar, Subhash Nagar and several areas in Goregaon East
15	SAMARTHA NAGAR	Located on central verge of Goregaon Link Road	15468.7	1013.2	Kadam Nagar, Vikas Nagar, Anand Nagar, Yamuna Nagar and Milat Nagar and may extend to Amboli Hill area, Behram Baug, Oshiwara area, and MHADA Colony
16	SHASTRI NAGAR	Along the median of New Link Road, station.	16433.0	964.3	Largely Shastri Nagar and Shastri Nagar D Phase, Veera Desai Industrial Estate, Amboli Hill, Saibaba Nagar and part of Jogeshwari west area. Commuters from Lokhandwala Complex, S Samrath Nagar, part of Andheri West and part of SV Patel Nagar may also use the station.
17.	D N NAGAR	Along the median of New Link Road, Terminal Station adjacent to D. N. Nagar Station on Line No. 1	17578.6	1145.6	Interchange station between the two proposed East West and North South MRTS corridors and would cater to DN Nagar, Indian Oil Nagar, New LIC Colony, Madhuban Colony and MHADA Colony Phase I and may extend to Shanti Nagar and Bahadurgarh Colony.
	DEAD END		18175.0	596.4	

5.3.2 Station Locations:

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

5.3.2.1 Station no.1 Dahisar (E):

Chainage	0.0
Inter station Distance	Nil (First Station)
Rail Level	27.700 M
Height of Rail Level from ground	19.714 M
Location	Located on W.E.H 5th lane on west side, station centerline passes through Karan marble. Station Block is proposed on the land of Tanvy Contractors Pvt. Limited.
Entry / Exit	Entry and exits provided on West side through station tower as above
Catchment Area	Avadhut Nagar,CS Complex,Shakti Nagar,Penkarpada, Dharkhadi, Ketkipada, Maratha Colony, N.I Complex.



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5.3.2.2 **Station no. 2 Dahisar (W)**

Chainage	711.0
Inter station Distance	711.0
Rail Level	18.700 M
Height of Rail Level from ground	14.091 M
Location	Located on central verge/along the median of Link Road.
Entry / Exit	Western entry/exit within the footpath, in front of open plot beside Shivalaya building whereas eastern entry/exit located within the footpath in front of an existing residential building and open green space.
Catchment Area	Shakti Nagar, Shrinath Nagar, Daulat Nagar, Ambawadi, Krishna Colony, Anand Nagar, C.S. Complex, Dahisar Railway Station

5.3.2.3 **Station no. 3 (RUSHI SANKUL):**

Chainage	2422.7 M
Inter station Distance	1711.7 M
Rail Level	22.000 M
Height of Rail Level from ground	13.818 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through Prithvi Villa building on west of the alignment.
Entry / Exit	Western and eastern entry/exit within the footpath, in front of existing residential buildings.
Catchment Area	Dahisar West, Avdhut Nagar, Krishna Colony, Shakti Nagar, Ambawadi, Dahisar Railway Station.

5.3.2.4 **Station no. 4 (I C COLONY):**

Chainage	3383.1 M
Inter station Distance	960.4 M
Rail Level	19.600 M
Height of Rail Level from ground	13.644 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through open BMC land beside MHADA toilet on east of the alignment.
Entry / Exit	Western entry/exit within the footpath, in front of existing local shops whereas eastern entry/exit located within the footpath in front of an open plot near Auto garage
Catchment Area	Kandar Pada, Dahisar West, Mandapeshwar

5.3.2.5 **Station no. 5 (LIC COLONY):**

Chainage	4468.4 M
Inter station Distance	1085.3 M
Rail Level	19.700 M
Height of Rail Level from ground	13.633 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through Amazing Park building on east of the alignment.
Entry / Exit	Western entry/exit within the footpath, in front of an open plot beside the Eskay Resort whereas eastern entry/exit located within the footpath in front of existing high rise residential buildings.
Catchment Area	I.C Colony, LIC Colony, Borivli West, Jivan Bima Nagar, Yogi Nagar

5.3.2.5 Station no. 6 (DON BOSCO):

Chainage	5537.5 M
Inter station Distance	1069.1 M
Rail Level	22.200 M
Height of Rail Level from ground	13.566 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through Vishram Yog C-2 building on west side of the alignment.
Entry / Exit	Western entry/exit within the footpath, in front of Borivli Head post office whereas eastern entry/exit located within the footpath in front of existing residential buildings.
Catchment Area	Yogi Jayraj Nagar, Babhai, Vazira Naka area, Haridas Nagar, Kastur Park, MHADA Colony, Roshan Nagar, Borivli Railway Station, Govind Nagar

5.3.2.7 **Station no. 7 (KASTUR PARK):**

Chainage	6465.9 M
Inter station Distance	928.4 M
Rail Level	21.800 M
Height of Rail Level from ground	13.527 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through the Green Wood building on east side of the alignment.
Entry / Exit	Western entry/exit within the footpath, in front of high rise residential areas whereas eastern entry/exit located within the footpath in front of under construction AHCL building.
Catchment Area	Padma Nagar, Satya Nagar, Mahavir Nagar, Shimpoli, Haridas Nagar, Kastur Park, Mhatre Wadi, Dalvi Nagar

5.3.2.8 Station no. 8 (EKATA NAGAR)

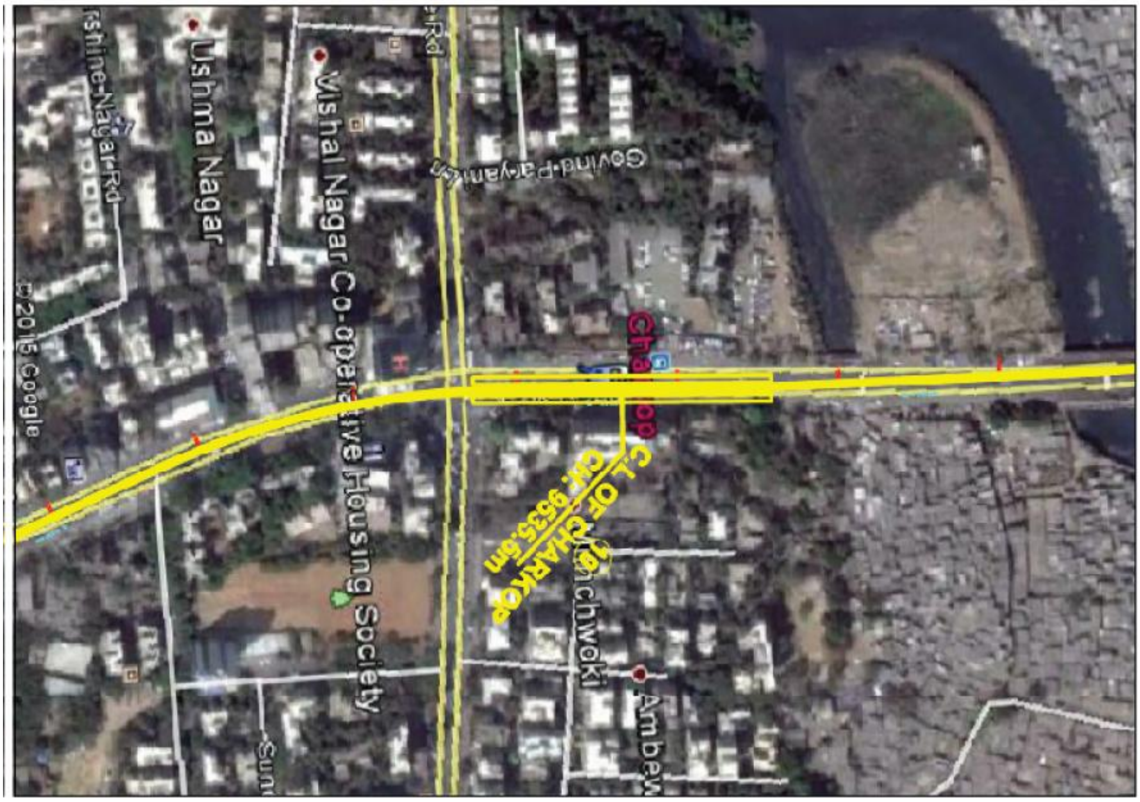
Chainage	7571.8 M
Inter station Distance	1105.9 M
Rail Level	21.600 M
Height of Rail Level from ground	14.577 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through road beside Bharat petrol pump on east side of alignment.
Entry / Exit	Western entry/exit within the footpath, in front of Charkop pumping station whereas eastern entry/exit located within the footpath in front of existing local shop area.
Catchment Area	Sector 4 of Charkop, Shravan Nagar, Sector 6-7 of Charkop, Padma Nagar, Satya Nagar, Mohan Nagar, Mahavir Nagar, Shimpoli, Haridas Nagar, Siddhi Vinayak Nagar.

5.3.2.9 **Station No.9 (KANDIVALI NAGAR):**

Chainage	8200.3 M
Inter station Distance	628.5 M
Rail Level	21.800 M
Height of Rail Level from ground	13.567 M
Location	Located on central verge/along the median of Linking Road, station centerline passes through the under construction J.P Corporation building premises on west of the alignment.
Entry / Exit	Western entry/exit within the footpath, in front of under construction J.P. Corporation building whereas eastern entry/exit located within the footpath in front of existing chawl buildings.
Catchment Area	Dahanukar Wadi, Kandivli West, Sidhi Vinayak Nagar, Mohan Nagar, Shravan Nagar, Bander Pakhadi, Kandivli Railway Station

5.3.2.10 Station no. 10 (CHARKOP):

Chainage	9535.5 M
Inter station Distance	1335.2 M
Rail Level	18.600 M
Height of Rail Level from ground	13.525 M
Location	Located on central verge of Link Road, station centerline passes through the boundary line of Sonal Link Residency on the east of the alignment
Entry / Exit	Western entry/exits within open spaces along the Road whereas eastern stairs within the footpath in front of existing shop area
Catchment Area	Sai Baba Nagar, Ushma nagar, Mith Chowky area, Lourdes Colony, Jai Janta Nagar, Ganesh Nagar and may extend to Dominic Colony, other areas in Kandivali West like Gandhi Nagar, Bhut Nagar, Hemu Colony and Bhagal Colony



5.3.2.11 Station no. 11 (MALAD METRO):

Chainage	10846.0 M
Inter station Distance	1310.5 M
Rail Level	17.700 M
Height of Rail Level from ground	13.333 M
Location	Along the median of Link Road, station centerline passes through the open plot beside the Palm Court Building on west of the alignment
Entry / Exit	Entry/exits in front of open plot beside the Palm Court Building on western side of station structure whereas eastern stairs opposite the vacant area
Catchment Area	Usha Nagar, Bhandarwada, NSC Colony, Liberty Garden Area, Malad Industrial Units Cooperative Society and Evershine Nagar. Commuters from Malad West areas, Kumbhar Wada and Mamletdar Wada may also use the station

5.3.2.12 **Station no. 12 (KASTURI PARK):**

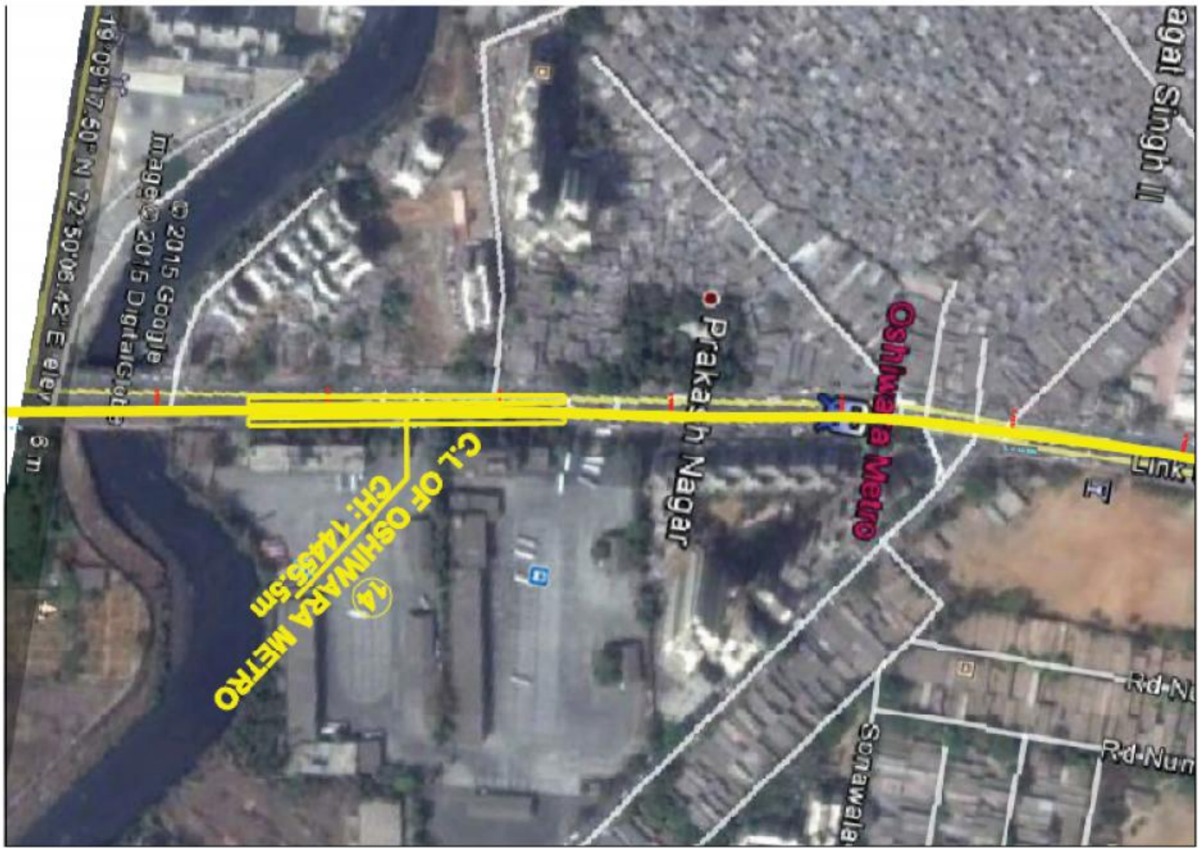
Chainage	11427.7 M
Inter station Distance	581.7 M
Rail Level	18.000 M
Height of Rail Level from ground	13.431 M
Location	Along the median of Link Road, station centerline passes beside the Shopper's Stop Building on west of the alignment
Entry / Exit	Entry/exits in front of Shopper's Stop Building on west of the alignment within open spaces whereas eastern stairs opposite the vacant area
Catchment Area	Entire commercial and Mall area, Prem Nagar, Hanuman Nagar, Bangur Nagar,and other Goregaon West areas. Commuters from Motilal Nagar Part III, Shiva ji Nagar, police Colony and part of Malad West may also use the station

5.3.2.13 **Station no. 13 (BANGUR NAGAR):**

Chainage	13183.1 M
Inter station Distance	1755.4 M
Rail Level	17.200 M
Height of Rail Level from ground	13.792 M
Location	Located on central verge of Link Road, station centerline passes through the Manav Kalyan Building premises on the west of the alignment
Entry / Exit	Western entry/exits in front of Manav Kalyan Building within open spaces whereas eastern stairs opposite the shops area within the footpath
Catchment Area	Bhagat Singh Nagar, Motilal Nagar Part I, Mitha Nagar and Laxmi Nagar and may extend to part of Bangru Nagar, Motilal Nagar Part II and areas upto Ayyappa Temple.

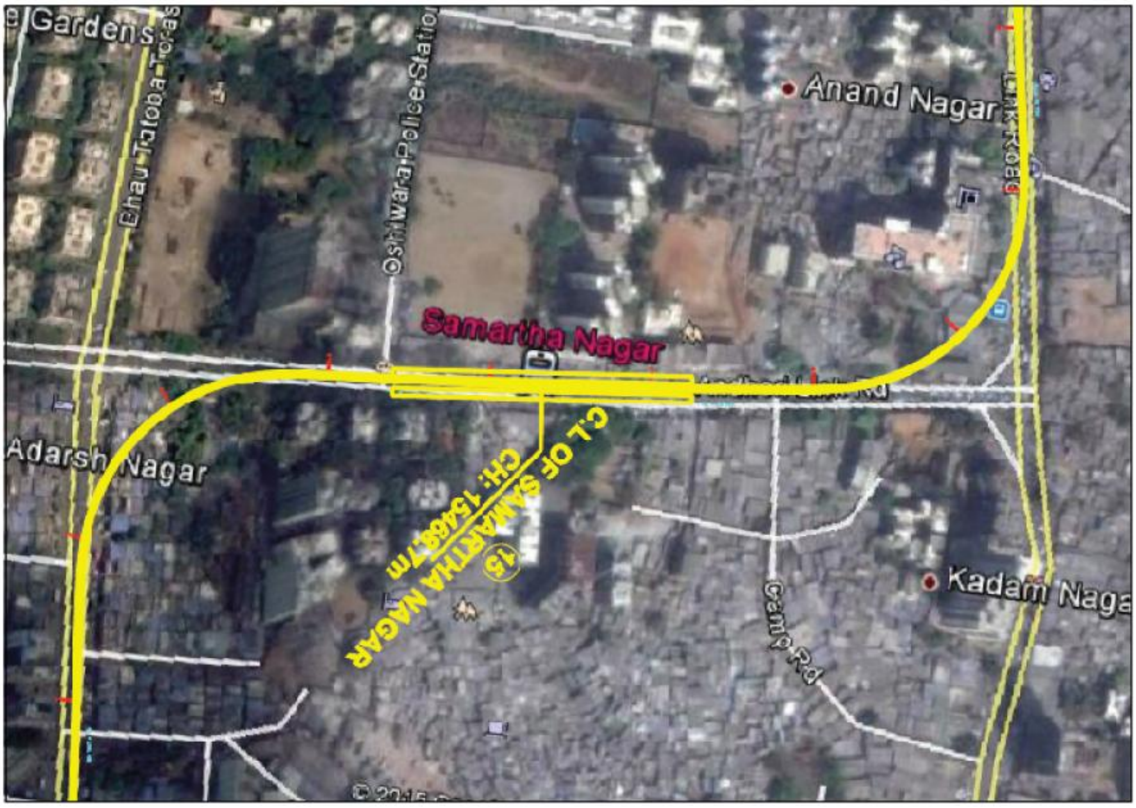
5.3.2.14 Station no. 14 (OSHIWARA METRO):

Chainage	14455.5 M
Inter station Distance	1272.4 M
Rail Level	18.100 M
Height of Rail Level from ground	14.137 M
Location	Located on central verge of Goregaon Link Road, station centre line passes through the Oshiwara bus depot premises
Entry / Exit	Both the entry/exits along Goregaon Link Road, Western structures located on the open plot beside Trupti Auto whereas western stairs within the Oshiwara Bus Depot Premises
Catchment Area	Entire Goregaon West area including Bhagat Singh Nagar Colonies No. 1, 2, 3, Oshiwara Industrial Estate, Kulandi Industrial Estate, Motilal Nagar Part I, Prakash Nagarand BEST nagar and may extend to Haryana Basti, MHADA colony, Oshiwara, Gulshan Nagar, Subhash Nagar and several areas in Goregaon East



5.3.2.15 Station no. 15 (SAMARTHA NAGAR):

Chainage	15468.7 M
Inter station Distance	1013.2 M
Rail Level	20.600 M
Height of Rail Level from ground	13.597 M
Location	Located on central verge of Goregaon Link Road, station centerline passes beside the Classic Supermarket on west of the alignment.
Entry / Exit	Located both side of station, Western structures beside the Classic Supermarket within the open space whereas eastern stairs in front of shops area
Catchment Area	Kadam Nagar, Vikas Nagar, Anand Nagar, Yamuna Nagar and Milat Nagar and may extend to Amboli Hill area, Behram Baug, Oshiwara area, and MHADA Colony.

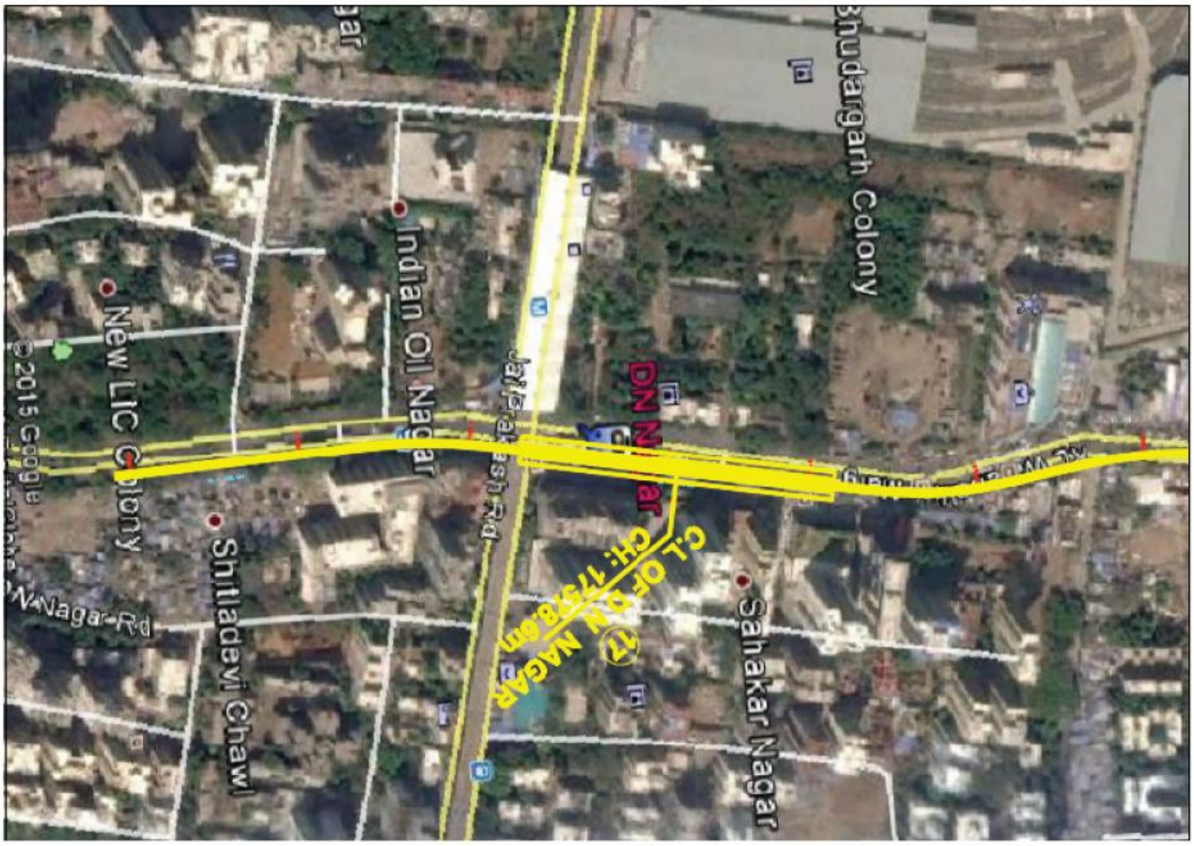


5.3.2.16 **Station no. 16 (SHASTRI NAGAR):**

Chainage	16433.0 M
Inter station Distance	964.3 M
Rail Level	17.200 M
Height of Rail Level from ground	13.651 M
Location	Along the median of New Link Road,
Entry / Exit	both the entry/exits along New Link Road, Western structures located on the space in front of City Mall whereas eastern stairs on the open space opposite the State Bank of Mysore
Catchment Area	Largely Shastri Nagar and Shastri Nagar D Phase, Veera Desai Industrial Estate, Amboli Hill, Saibaba Nagar and part of Jogeshwari west area. Commuters from Lokhandwala Complex, S Samrath Nagar, part of Andheri West and part of SV Patel Nagar may also use the station.

5.3.2.16 **Station no. 17 (D N NAGAR):**

Chainage	17578.6 M
Inter station Distance	1145.6 M
Rail Level	26.000 M
Height of Rail Level from ground	22.220 M
Location	Along the median of New Link Road, DN Nagar would serve as interchange between the Dahisar -Bandra-Mandale corridor and the Versova -Andheri-Ghatkopar corridor
Entry / Exit	Entry/exits of this station is linked with stairs of East west corridor station and combined structure is located on the intersection of JP Road and New Link Road
Catchment Area	Interchange station between the two proposed East West and North South MRTS corridors and would cater to DN Nagar, Indian Oil Nagar, New LIC Colony, Madhuban Colony and MHADA Colony Phase I and may extend to Shanti Nagar and Bahadurgarh Colony.



5.3.3 Proposed Station Configuration:

5.3.3.1 All stations are located on the Road and are two level stations. Length of each station is 185 m. All the operating and passenger facilities are proposed in the concourse on the lower level while platforms are on the upper level of the stations. The concourse is of about 185m in length. Approaches to all stations are proposed from both sides. Station no1 (Dahisar(E) station) has been located on the Western Express Highway.

At station no. 2,3,4,5,6,7,8 and 9 stations have 10.5m wide carriage way on both side of median.

At station no. 10,11,12,13,14,15,16 and 17 Stations have 7m. wide carriage way on both side of median.

Station no 01 has two nos. of platform and the operational rooms and public facilities of station no. 01 has been planned on the off side of road.

5.3.3.2 For station number 2,3,4,5,6,7,8,9,10,11,12,13,14.15.16 and 17. layout proposed is with two unpaid and one paid area. Requirement of AFC gates at these stations is less than eight except station no 3,9,11 & 15.At these stations the number of passenger is quite large. At theses stations the number of gates required is 16,8,8, & 12 which can be accommodated in the station.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5m has been provided under the concourse. Concourse floor level is about 6.5m above the road. Platforms are at a height of about 14.5 from the road level. Commercial areas are provided in the concourse area.

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

5.3.3.3 First station of Dahisar (E) – DN Nagar corridor near junction of Western Express Highway and M.V. Road is proposed to be connected to Dahisar (E) – Andheri corridor on the Dahisar station. On Dahisar station there are two platforms one is for Dahisar (E) – Andheri corridor and one is for Dahisar (E) to DN Nagar Corridor.

5.3.4.4 Drawings:

Following drawings are enclosed:

1. Typical Elevated Proposed Metro Station no.1
   – Floor plans (Road, Concourse and Platform level)
2. Site plans of all stations with required land plan

5.3.5 Salient features:

Salient features of a Metro Rail stations are as follows:

i. Most of the stations have two unpaid area.

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

iii. The platform level at elevated stations is determined by a critical clearance of 5.50m above the road level, and 3.30m for the concourse height, about 1m for concourse floor and 2 m for structure of tracks above the concourse. Further, the platforms are 1.100m above the rail level. This would make the platforms in an elevated situation at least 13.0m above ground.

iv. At station no. 1, has two platform levels the rail level is 16.00 m above road

iv. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

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

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

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

viii. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The requirements of such areas are given in Table 3.1.1 below:

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

Table 5.3.3
Station Accommodation Requirements

Room No.	Description	Minimum Area(m^2)	Remarks
1	Station Control Room	50	
2	Station Manager	15	
3	Ticket Counter (2 nos.)		**2.5m deep x 1.7m per counter**
5	Security Room	9	
6	First Aid Room	10	

Room No.	Description	Minimum Area(m^2)	Remarks
7	Female Toilet in paid area	25	**As per National Building Code**
8	Male Toilet in paid area	25	**As per National Building Code**
9	Handicap Toilet	9	**As per National Building Code**
10	Signaling Equipment Room	60	
11	Communication Room	40	
12	UPS Room (SIG/TEL)	60	
13	Mess room	25	
14	Staff Lockers (Gents)	9	
15	Staff Lockers (Ladies)	9	
16	Tank / Pump Room		**At Street level as/requirement**
17	Excess Fare Collection (2 nos.)	6.25	**2.5mx2.5m**
18	Diesel Generator Room	29	**At Street level as/requirement**
19	ASS (Auxiliary Substation)	160	
20	Electrical Switch Room	40	
21	Electrical UPS room	25	
22	F.H.C		**As/requirement**
23	Cleaner Room	10	
24	Refuse Collection Room	5	**Street level**
25	Commercial Area		**As per space available at concourse**

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

- Minimum distance of travel to and from the platforms.
- Adequate capacity for passenger movements.
- Convenience, including good signages relating to circulation and orientation.
- Safety and security.

- To help visually impaired citizens, tactile tiles are laid in platform, concourse and road level to access metro rail.

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

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

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

5.3.6 Station Standards:

5.3.6.1 Queuing Requirements are shown in Table 5.3.4

Table 5.3.4 Queuing Requirements

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

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

Table 5.3.5 Station Planning Requirements

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

5.3.6.1.2 Platform:

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

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

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

5.3.6.2 Passenger Amenities:

5.3.6.2.1 Passenger amenities provided at the stations for the year 2019 are shown in Table 5.3.8. Passenger amenities which will be required in the year 2031 are shown in table 5.3.9. Adequate space has been provided for expansion as may be required in 2021 and 2031.

5.3.6.2.2 **Ticketing Gates:**

Ticketing gates' requirement has been calculated taking the gate capacity as 28 persons per minute per gate. Passenger forecast for the horizon year 2031 has been used to compute the maximum design capacity. At least two ticketing gates shall be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided in all stations where gates can be installed as and when required.

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

It is proposed to deploy manual ticket issuing in the beginning of the operation of the line. At a later stage, automatic POMS would be used for which space provision has been made in the concourse. At present, ticket counters would be provided, which could be replaced with POMS in future. Capacity of manual ticket vending counters is taken to be 10 passengers per minute and it is assumed that only 40% of the commuters would purchase tickets at the stations while performing the journey. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

5.3.6.2.4 Fare Collection Gates:

- Fare collection gates, when deactivated, shall provide a minimum 508 mm clear unobstructed aisle.
- Minimum requirement at each access is 2 entry gates and 2 exit gates.

- At each access, entry gates will be on left side of EFO (Excess Fare Collection) and exit gates on right side of EFO.
- Capacity of Automatic Fare Collection (AFC) will be 28 ppm per gate.
  One Excess Fare Collection Office at each exit gate has been provided

Table 5.3.8

PASSENGER TRAFFIC AND AMENITIES IN STATIONS (Projections for Year 2019)

Station	Peak Hour Boarding	Peak Hour Alighting	Ticketing Gates required (No.)	Ticket Counters Required (No.)	Stairs Width on Each platform (m)		Lifts Provided At Each Station (No.)		Escalators Provided At Each Station (No.)	
					G to C	C to P	G to C	C to P	G to C	C to P
STATION 1 (Dahisar East)	3190	2922	4	4	10	4.76	4	2	4	8
STATION 2 (Dahisar West)	1554	3007	4	4	10	4.60	4	2	4	8
STATION 3 (Rushi Sankul)	14009	7574	13	16	10	13.75	4	2	4	8
STATION 4 (I C Colony)	147	34	1	1	10	2.23	4	2	4	8
STATION 5 (LIC Colony)	1346	1181	2	2	10	3.22	4	2	4	8
STATION 6 (Don Bosco.)	1169	789	2	2	10	3.08	4	2	4	8
STATION 7 (Kastur Park)	2302	1218	3	3	10	4.02	4	2	4	8
STATION 8 (Ekata Nagar)	3069	2079	4	4	10	4.67	4	2	4	8
STATION 9 (Kandivali Nagar)	5580	3442	6	7	10	6.74	4	2	4	8
STATION 10 (Charkop)	3483	1856	4	4	10	5.00	4	2	4	8
STATION 11 (Malad Metro)	4067	5020	5	6	10	6.28	4	2	4	8
STATION 12 (Kasturi Park)	1037	1716	2	2	10	3.53	4	2	4	8
STATION 13 (Bangur Nagar)	4264	2508	5	5	10	5.65	4	2	4	8
STATION 14 (Oshiwara Metro)	2856	1493	3	4	10	4.48	4	2	4	8
STATION 15 (Samarth Nagar)	5144	7304	7	9	10	8.17	4	2	4	8
STATION 16 (Shastri Nagar)	1464	1176	2	2	10	3.32	4	2	4	8
STATION 17 (D N Nagar)	5093	5265	6	6	10	6.48	4	2	4	8

Table 5.3.9

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

Station	Peak Hour Boarding	Peak Hour Alighting	Ticketing Gates required (No.)	Ticket Counters Required (No.)	Stairs Width on Each platform (m)		Lifts Provided At Each Station (No.)		Escalators Provided At Each Station (No.)	
					G to C	C to P	G to C	C to P	G to C	C to P
STATION 1 (Dahisar East)	4546	3439	5	6	10	5.88	4	2	4	8
STATION 2 (Dahisar West)	1163	1788	3	2	10	3.59	4	2	4	8
STATION 3 (Rushi Sankul)	15099	11719	14	17	10	14.65	4	2	4	8
STATION 4 (I C Colony)	224	24	1	1	10	2.29	4	2	4	8
STATION 5 (LIC Colony)	1728	1457	2	2	10	3.54	4	2	4	8
STATION 6 (Don Bosco.)	1472	927	2	2	10	3.33	4	2	4	8
STATION 7 (Kastur Park)	2961	1482	4	4	10	4.56	4	2	4	8
STATION 8 (Ekata Nagar)	3764	2361	4	5	10	5.23	4	2	4	8
STATION 9 (Kandivali Nagar)	6058	3582	6	7	10	7.14	4	2	4	8
STATION 10 (Charkop)	3970	1998	4	5	10	5.40	4	2	4	8
STATION 11 (Malad Metro)	5386	5686	6	7	10	6.83	4	2	4	8
STATION 12 (Kasturi Park)	1233	1750	3	2	10	3.56	4	2	4	8
STATION 13 (Bangur Nagar)	4638	2778	5	6	10	5.96	4	2	4	8
STATION 14 (Oshiwara Metro)	3268	1598	4	4	10	4.82	4	2	4	8
STATION 15 (Samarth Nagar)	7775	10529	10	12	10	10.85	4	2	4	8
STATION 16 (Shastri Nagar)	1609	1259	2	2	10	3.44	4	2	4	8
STATION 17 (D N Nagar)	4808	4514	5	6	10	6.10	4	2	4	8

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

Station	Peak Hour Boarding	Peak Hour Alighting	Ticketing Gates required (No.)	Ticket Counters Required (No.)	Stairs Width on Each platform (m)		Lifts Provided At Each Station (No.)		Escalators Provided At Each Station (No.)	
					G to C	C to P	G to C	C to P	G to C	C to P
STATION 1 (Dahisar East)	6300	4749	6	7	10	6.03	4	2	4	8
STATION 2 (Dahisar West)	2280	3209	4	4	10	4.10	4	2	4	8
STATION 3 (Rushi Sankul)	17751	15757	16	20	10	13.17	4	2	4	8
STATION 4 (I C Colony)	581	43	1	1	10	2.47	4	2	4	8
STATION 5 (LIC Colony)	2981	3361	4	4	10	3.96	4	2	4	8
STATION 6 (Don Bosco.)	3680	2777	4	5	10	4.40	4	2	4	8
STATION 7 (Kastur Park)	5478	3285	6	7	10	5.52	4	2	4	8
STATION 8 (Ekata Nagar)	4037	3306	4	5	10	4.62	4	2	4	8
STATION 9 (Kandivali Nagar)	7681	5198	8	9	10	6.89	4	2	4	8
STATION 10 (Charkop)	4052	2441	4	5	10	4.63	4	2	4	8
STATION 11 (Malad Metro)	5692	7762	8	9	10	6.94	4	2	4	8
STATION 12 (Kasturi Park)	1646	2178	3	3	10	3.46	4	2	4	8
STATION 13 (Bangur Nagar)	5204	3675	5	6	10	5.35	4	2	4	8
STATION 14 (Oshiwara Metro)	3445	1932	4	4	10	4.25	4	2	4	8
STATION 15 (Samarth Nagar)	11550	12941	12	15	10	10.17	4	2	4	8
STATION 16 (Shastri Nagar)	1813	1952	3	3	10	3.32	4	2	4	8
STATION 17 (D N Nagar)	6036	5977	6	7	10	5.87	4	2	4	8

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

Peak hour boarding and alighting is taken from, Peak Hour Ridership Source: CTS-2019 & 2031 morning peak hour ridership flows for Andheri (E)- Dahisar (E) Metro.

1. Minimum requirement at each access: 2 entry Gates, 2 Exit Gates, 1 EFO and 2 Ticket Counters.
2. At each access, EFO will be in centre, entry Gates on left side of EFO and exit Gates on right side of EFO.
3. Maximum Gate throughput: 28 passengers per minute.
4. Maximum TOM throughput: 10 passengers per minute,
5. Maximum TVM throughput: 5 passengers per minute.
6. 40% of PMT buy tickets/Tokens from BOM/TVM.
7. 60% of PMT use smart cards
8. 10% of smart card users use BOM/TVM for card recharge.

5.3.6.4 Information Displays:

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

User information will comprise of:

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

5.3.6.5 Advertisement:

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

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

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

5.3.7 Station Constraints:

5.3.7.1 At most of the stations the station columns will intrude into current service R.O.W. The space for station portal columns required throughout 185 m station length will be 2.8m wide median, reducing the service road width. Existing carriageway width and balance width after construction of columns are shown in Table 5.4.1.1

Table 5.4.1.1

Sr. No.	STATION NAME	ROW Width (m)	Location	ROW Balance Width (m)	Purpose	Remarks
1.	STATION 1 (Dahisar East)		Left side of Western Express Highway, on 3.5 m wide divider	13.05	Station Columns	
2.	STATION 2 (Dahisar West)	30.81 m wide Road	On the road 2.8m in width excluding median	28.01	Station Columns	10.5m wide carriage way proposed on both side of median
3.	STATION 3 (Rushi Sankul)	30.27 m wide Road	On the road 2.8m in width excluding median	27.47	Station Columns	10.5m wide carriage way proposed on both side of median.
4.	STATION 4 (I C Colony)	30.51 m wide Road	On the road 2.8m in width excluding median	27.71	Station Columns	10.5m wide carriage way proposed on both side of median.
5.	STATION 5 (LIC Colony)	29.82 m wide Road	On the road 2.8m in width excluding median	27.02	Station Columns	10.5m wide carriage way proposed on both side of median.
6.	STATION 6 (Don Bosco.)	29.53 m wide Road	On the road 2.8m in width excluding median	26.73	Station Columns	10.5m wide carriage way proposed on both side of median.
7.	STATION 7 (Kastur Park)	30.25 m wide Road	On the road 2.8m in width excluding	27.45	Station Columns	10.5m wide carriage way proposed

Sr. No.	STATION NAME	ROW Width (m)	Location	ROW Balance Width (m)	Purpose	Remarks
			median			on both side of median.
8.	STATION 8 (Ekata Nagar)	30.42 m wide Road	On the road 2.8m in width excluding median	27.62	Station Columns	10.5m wide carriage way proposed on both side of median.
9.	STATION 9 (Kandivali Nagar)	30.75 m wide Road	On the road 2.8m in width excluding median	27.95	Station Columns	10.5m wide carriage way proposed on both side of median.
10.	STATION 10 (Charkop)	29.66 m wide Road	On the road 2.8m in width excluding median	26.86	Station Columns	10.5m wide carriage way proposed on both side of median.
11.	STATION 11 (Malad Metro)	30.64 m wide Road	On the road 2.8m in width excluding median	27.84	Station Columns	10.5m wide carriage way proposed on both side of median..
12	STATION 12 (Kasturi Park)	28.14 m wide Road	On the road 2.8m in width excluding median	25.34	Station Columns	10.5m wide carriage way proposed on both side of median.
13	STATION 13 (Bangur Nagar)	30.57 m wide Road	On the road 2.8m in width excluding median	27.77	Station Columns	10.5m wide carriage way proposed on both side of median.

Sr. No.	STATION NAME	ROW Width (m)	Location	ROW Balance Width (m)	Purpose	Remarks
14	STATION 14 (Oshiwara Metro)	33.58 m wide Road	On the road 2.8m in width excluding median	30.78	Station Columns	10.5m wide carriage way proposed on both side of median.
15	STATION 15 (Samarth Nagar)	25.93 m wide Road	On the road 2.8m in width excluding median	23.13	Station Columns	10.5m wide carriage way proposed on both side of median.
16	STATION 16 (Shastri Nagar)	27.20 m wide Road	On the road 2.8m in width excluding median	24.40	Station Columns	10.5m wide carriage way proposed on both side of median.
17	STATION 17 (D N Nagar)	33.84 m wide Road	On the road 2.8m in width excluding median	31.04	Station Columns	10.5m wide carriage way proposed on both side of median.

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.

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

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

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

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

5.4.6 STRUCTURAL SYSTEM OF VIADUCT

5.4.6.1. 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.

For this Corridor twin u girders are recommended. These girders will be pre stressed and cast in casting yard. The standard spans for these U – girders will be 19m, 22m, 25m, and 30m. These will be transported to site by trailers and launched by using two cranes of adequate capacity. Girders will be placed on elastomeric bearings. In case of Girders being placed on gradient, the level will be made up by using steel plates in the wedge form. Pier caps will also be precast, placed on the pier by using cranes and stitched and prestressed.

5.4.6.2 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 9.0 m.

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

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

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

5.4.7 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.

5.4.8 Grade of Concrete

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

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

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

5.4.9 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).

5.4.10 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

5.5.1 General Geology & Related Characteristics:

a) Location- The Geological site investigation data for the portion of the proposed Corridor from Charkop to D. N. Nagar has been extracted from DPR of Charkop Bandra- Mankhurd Corridor prepared by DMRC in 2006. Similarly the Geotechnical data for portion of proposed Corridor from Charkop to Dahisar (E) has been taken from DPR of Charkop –Dahisar Corridor prepared by M/s Span Consultants in 2010.

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

5.5.3 Field Investigations

This proposed corridor of the Mumbai MRTS is from Dahisar (E) to D. N. Nagar via Charkop. The details of boreholes along the corridor are shown in Table 5.5.1(A) and 5.5.1(B).

The Bore hole details for Charkop to Dahisar stretch have been extracted from the DPR of Charkop- Bandra- Mankhurd prepar5ed by Delhi Metro in 2006. The details of geotechnical bore holes for stretch between Charkop and Dahisar have been extracted from the DPR prepared by M/s SPAN Consultants in 2010. Total number of boreholes in this stretch from Dahisar (E) to D. N. Nagar comes to 29.

Table 5.5.1 (A)
DETAILS OF BOREHOLES (Charkop to D. N. nagar)

Sl. No.	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
1	BH 66	903.900	4.95	7.8	6.4	6.55	13
2	BH 65	1383.300	3.81	5.5	3.1	8.15	11.3
3	BH 64	1910.100	3.94	6.1	7.5	12.5	20
4	BH 63	2420.300	3.85	6.1	1.5	8.8	10.3

Sl. No.	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
5	BH 62	2860.100	3.82	-	2.25	9.75	12
6	BH 61	3343.700	3.32	-	0	14	14
7	BH 60	3803.100	3.95	-	6	11.3	17.3
8	BH 59	4359.900	3.9	3.7	6.3	9.5	15.8
9	BH 58	4842.100	4.29	2.8	5.5	6.3	11.8
10	BH 57	5439.900	3.87	3.4	9	10	19
11	BH 56	5845.300	3.93	3.5	7.5	7	14.5
12	BH 55	6353.300	3.8	3.5	6	9.65	15.7
13	BH 54	6799.000	6.59	4.3	9	12	21
14	BH 53	7243.600	4.17	4.8	2.25	17.8	20
15	BH 52	7772.800	3.41	3.8	7.5	10	17.5
16	BH 51	8210.800	3.33	5.8	5	16.6	21.6
17	BH 50	8707.600	3.65	6	5.65	14.9	20.5
	BH 49	9223.900	3.44	7	7.3	16.2	23.5

Note: Borehole No. 66 to 49 belongs to portion of Coloba-Bandra-Charkop Corridor from Charkop to D. N. Nagar.

Table 5.5.1 (B)
DETAILS OF BOREHOLES (Charkop to Dahisar)

Borehole Number	Chainage (in m)	Ground R.L. (m)	Depth of Investigation (in m)		
			In Soil	In Rock (soft/hard)	Total
BH 1	10.00	4.10	8.5	6.5	15.0
BH 2	1060.00	3.90	9.0	6.0	15.0
BH 3	2100.00	4.30	6.5	8.5	15.0
BH 4	2750.00	6.00	7.5	6.5	14.0
BH 5	3250.00	4.40	6.7	8.3	15.0
BH 6	4150.00	2.80	5.5	9.8	15.3
BH 7	5150.00	2.90	4.0	11.0	15.0
BH 8	6150.00	2.00	2.0	7.0	9.0
BH 9	6650.00	3.00	6.0	9.0	15.0
BH 10	6920.00	4.00	6.0	9.0	15.0
BH 11	7950.00	2.80	7.5	8.0	15.5

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

Table 5.5.2 (B)
DETAILS OF BOREHOLES (Charkop to Dahisar)

Bore hole no.	Chainage	Over burden depth	Weathered rock	Brecie or Basalt	Proposed foundation level (1.8 m in rock)	Depth of 1.2 m of pile
1	10	8.5 m	5.0 m	13.5 - 15.0	15.3 m	13.2 m
2	1060	9.0 m	4.0 m	13 - 15	15 m	12.9 m
3	2100	6.50 m	5.5 m	12 - 15	14 m	11.9 m
4	2750	7.50 m	4.0 m	12.5 - 15.0	14.3 m	12.2 m
5	3250	6.70 m	2.8 m	9.5 - 15.0	11.5 m	9.4 m
6	4150	5.50 m	-	5.5 - 7.5	7.5 m	5.4 m
7	5150	4.0 m	7.0 m	11.0 - 15.0	13.0 m	10.9 m
8	6150	2.0 m	-	2.0 - 5.0	4.0 m	Open
9	6650	6.0 m	-	6.0 - 15.0	8.0 m	5.9 m
10	6920	6.0 m	-	6.0 - 15.0	8.0 m	5.9 m
11	7950	7.5 m	Nil	7.5 – 15.0	9.5 m	7.4 m

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

5.5.5 Design Parameters - The sub-soil strata at the proposed site comprise of nine types of layers (based on field tests & laboratory test result data). Description of each layer along with various engineering parameters is as shown in **Table 5.5.2**

Table 5.5.2 (A)
LAYER TYPE AND DESCRIPTION Charkop to D. N. Nagar

Layer	Description	Classification as per IS : 1498-1970	Relative Density/ Consistency	Observed in Bore Hole Nos.
Charkop – D. N. Nagar				
IX	Slightly weathered to fresh BRECCIA/ SHALE/ LIMESTONE	-	-	BH 51, BH 53 to BH 59 & BH 61 to BH 66.
VIII	Highly to moderately weathered SANDSTONE/ BRECCIA/ BASALT	-	-	BH 49 to BH 57, BH 59 to BH 65
VII	Completely weathered rock	CI, CH, GM	-	BH 49, BH 51, BH 52 to BH 54 , BH 59, BH 60, BH 63, BH 64.
VI	Silty Sandy Clay with gravel	CH, CI	Very stiff to hard	BH 50 BH 56, BH 59.

V	Silty Clay	CH	Medium stiff to stiff	BH 49 to BH 51, BH 56 to BH 61
IV	Sandy Clay/ Silty Clay	-	Soft	BH 51,
III	Silty Sand	SP-SC, SM	Very dense	BH 54, BH 55, BH 57, BH 59, BH 64 to BH 66.
II	Silty Sand	SM-SC, SP-SC, SM, SC	Medium dense to dense	BH 49, BH 54, BH 58, BH 60.
I	Road material & Backfill	-	-	BH 49 to BH 66 Except in BH 51, BH 61

5.5.5 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 Dahisar (E) and terminates at D. N. Nagar. The details of existing utilities for Charkop to Dahisar stretch have been extracted from the DPR of Charkop- Bandra- Mankhurd prepar5ed by Delhi Metro in 2006. The details of existing utilities for stretch between Charkop and Dahisar have been extracted from the DPR prepared by M/s SPAN Consultants in 2010.

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 5.6.1**.

Table 5.6.1
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.

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

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

- 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 from main carriageway. However, in certain stretches, these have come near the central verge or under main carriageway, as a result of subsequent road widening.

The major sewer/drainage lines and water mains running across the alignment and likely to be affected due to location of column foundations are proposed to be taken care of by relocating on column supports of viaduct by change in span or by suitably adjusting the layout of pile foundations. Where, this is not feasible, lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility service lines. Details of sewer lines & storm water drains and water pipe lines affected along with their diversion proposals are indicated in **Table 5.6.2** and **Table 5.6.3**

Table 5.6.2 (A)
DETAILS OF SEWER LINES (Charkop to D. N. Nagar)

S. No.	Chainage	Affected length(m)	Dia. (mm)	Position wrt alignment	Diversion proposal
1	1255.000	30	300	Across	B
2	1260.000	50	500	Across	B
3	1425.000	30	300	Across	B
4	2254.000	30	500	Across	B
5	2520.000	30	350	Across	B
6	2800.000	30	350	Across	B
7	3050.000	80	350	Across	B
8	3350.000	30	350	Across	B
9	4060.000	30	500	Across	B
10	4400.000	30	230	Across	B
11	4550.000	40	300	Across	B
12	4650.000	30	230	Across	B
13	5100.000	30	350	Across	B
14	5250.000	30	350	Across	B
15	5850.000-5700.000	150	1200	Along	A
16	5850.000	30	1250	Across	B
17	6500.000	30	1400	Across	B
18	6500.000-2800.000	9300	1500	Along	A
19	6500.000-2800.000	9300	1500	Along	A
20	6700.000-6500.000	200	1100	Along	A
21	7200.000-6830.000	370	1000	Along	A
22	7700.000-7300.000	400	350	Along	A
23	7750.000	30	500	Across	B
24	7750.000	30	500	Across	B
25	8600.000-7800.000	800	500	Along	A
26	8600.000	30	700	Across	B
27	8800.000-8600.000	200	800	Along	A
28	8900.000-8800.000	100	1200	Along	A
29	9200.000-9100.000	100	75	Along	A
30	9200.000-9100.000	100	1200	Along	A
31	9200.000-9100.000	100	1400	Along	A
32	9200.000-9100.000	100	1600	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 5.6.2(B)
Details of Affected Sewer Lines (Charkop – Dahisar)

Sr. No.	Chainage From	Chainage To	Side	Affected Length (m)	DIA (MM)	Position w.r.t. Alignment	Diversion Proposals
1	0	1150	Center	1150	1100	Along	A
2	361		Right	20	350	Across	B
3	361		Left	20	300	Across	B
4	1000		Right	20	1000	Across	B
5	1570		Right	20	900	Across	B
6	1570	3290	Center	1720	1800	Along	A
7	1700		Right	20	300	Across	B
8	1780		Left	20	330	Across	B
9	2060		Left	20	600	Across	B
10	2060		Right	20	230	Across	B
11	2285		Left	20	300	Across	B
12	2400		Right	20	230	Across	B
13	2730		Left	20	350	Across	B
14	2730		Right	20	600	Across	B
15	3185		Right	20	350	Across	B
16	3285		Left	20	300	Across	B
17	3285		Right	20	350	Across	B
18	3290	4550	Center	1260	1600	Along	A
19	3850		Right	20	300	Across	B
20	4120		Right	20	230	Across	B
21	4550	5720	Center	1170	1280	Along	A
22	4550		Right	20	400	Across	B
23	5720		Right	20	350	Across	B
24	5720	6030	Center	310	1100	Along	A
25	6030	6350	Left	320	300	Along	A
26	6350		Left	20	1100	Across	B
27	7000	7500	Center	500	230	Along	A

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

Table 5.6.3(A)
DETAILS OF AFFECTED WATER PIPELINE (Charkop to D. N. Nagar)

S. No.	Chainage	Affected Length (in m.)	Dia (mm)	Position W.R.T Alignment	Proposal for Diversion
1	3000	30	300	Across	B
2	2700-3200	2X1000	250	Along	A
3	3200	30	300	Across	B
4	3300-3900	2X600	300	Along	A
5	3900	30	250	Across	B
6	4370	30	300	Across	B
7	4100-4800	700	900	Along	A
8	4840	30	450	Across	B
9	4850	50	600	Across Diagonally	B
10	4850-5200	350	600	Along	A
11	5200	75	600	Across Diagonally	B
12	5400-5700	300	450	Along	A
13	5650	30	300	Across	B
14	5700	30	300	Across	B
15	6100	30	300	Across	B

Table 5.6.3(B)
Details of Affected Water Lines (Charkop – Dahisar)

Sr. No	Chainage		Side	Affected Length (m)	DIA(MM)	Position w.r.t. Alignment	Diversion Proposal
	From	To					
1	0	1000	Center	1000	1200	Along	A
2	40			35	600 mmØ	Across	B
3	70			17.5	300mmØ	Across	B
4	112	317	Both	205	300mmØ	Along	A
5	361			17.5	150 mmØ	Across	B
6	685.00			17.5	450 mmØ	Across	B
7	742	945	Both	203	300mmØ	Along	A
8	1000			60	600 mmØ	Across	B
9	1073			50	900 mmØ	Across	B
10	1555		Right	30	300 mmØ	Across	B
11	1570		Right	20	1800	Across	B
12	1570		Right	17.5	600 mmØ	Across	B
13	1590		Left	17.5	300mmØ	Across	B
14	1690		Right	20	150 mmØ	Across	B
15	1846	2051	Right	205	1800	Along	A

16	1846	2051	Center	205	900 mmØ	Along	A
17	1846	2051	Left	205	300 mmØ	Along	A
18	2050		Left	20	450 mmØ	Across	B
19	2060		Right	20	300 mmØ	Across	B
20	2065		Left	20	150 mmØ	Across	B
21	2070		Left	20	600 mmØ	Across	B
22	2717		Left	30	600 mmØ	Across	B
23	2734		Right	50	600 mmØ	Across	B
24	2745		Right	20	900 mmØ	Across	B
25	2776	2979	Right	203	1500	Across	B
26	2776	2979	Right	203	300 mmØ	Across	B
27	2776	2979	Center	203	900 mmØ	Across	B
28	3280		Left	20	300 mmØ	Across	B
29	3150	3300	Center	150	900 mmØ	Along	A
30	3320	3500	Center	180	1500	Along	A
31	3844	4049	Center	205	1500	Along	A
32	3844	4049	Right	205	300 mmØ	Along	A
33	3844	4049	Right	205	900 mmØ	Along	A
34	3850		Right		150 mmØ	Across	B
35	3935		Right		150 mmØ	Across	B
36	4126		Right		900 mmØ	Across	B
37	4931	5135	Right	204	1200	Along	A
38	4931	5135	Right	204	300 mmØ	Along	A
39	4931	5135	Right	204	900 mmØ	Along	A
40	5245			30	900 mmØ	Across	B
41	5310		Right	20	150 mmØ	Across	B
42	5445			50	900 mmØ	Across	B
43	5889	6100	Left	211	900 mmØ	Along	A
44	5889	6100	Left	211	300 mmØ	Along	A
45	5889	6100	Right	211	300 mmØ	Along	A
46	6045		Right	30	300 mmØ	Across	B
47	6190		Left	30	300 mmØ	Across	B
48	6240			30	900 mmØ	Across	B
49	6350		Left	30	250 mmØ	Across	B

50	6360		Left	30	900 mmØ	Across	B
51	6400	6500	Left	100	300 mmØ	Along	A
52	6630			10	150 mmØ	Across	B
53	6630	6850	Left	220	600 mmØ	Along	A
54	6855			40	600 mmØ	Across	B
55	6990		Both	40	150 mmØ	Across	B
56	6965	7460	Left	245	300 mmØ	Along	A
57	6980	7215	Left	235	300 mmØ	Along	A
58	7215	7460		245	600 mmØ	Along	A
59	7215		Right	40	300 mmØ	Across	B
60	7220		Left	10	600 mmØ	Across	B
61	7230		Left	10	450 mmØ	Across	B
62	7600	7804	Left	204	600 mmØ	Along	A
63	7600	7804	Left	204	600 mmØ	Along	A
64	7600	7804	Right	204	300 mmØ	Along	A
65	7600	7804	Right	204	600 mmØ	Along	A
66	8021				600 mmØ	Across	B
67	8023				250mmØ	Across	B

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

5.6.5.1 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 running across & along the alignment are likely to be affected by the alignment are detailed in **Table 5.6.4** placed at the end of this sub-chapter. All these pipelines are placed at a depth of about 1 Met 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 5.6.4 (A)
(CHARKOP – D. N. NAGAR)
DETAILS OF AFFECTED GAS (MAHANAGAR) PIPELINE

S. No.	Chainage (m)	Affected length (m)	Approx. depth (m)	Position w.r.t. alignment	Diversion Proposals
1	1185	30	1.50	Across	B
2	2733	30	1.50	Across	B
3	4860	30	1.50	Across	B
4	4920-5225	300	1.00	Along	A
5	5660-5830	170	1.00	Along	A
6	6670-6720	50	1.00	Along	A
7	6720	30	1.50	Across	B
8	6748-6765	30	1.00	Along	A
9	6780-6810	30	1.00	Along	A
10	6780	30	1.50	Across	B
11	7272-7400	127	1.00	Along	A
12	7400	30	1.50	Across	B
13	8740	30	1.50	Across	B
14	8859-8900	41	1.00	Along	A
15	8940	30	1.50	Across	B
16	9170	40	1.00	Along	A

Table 5.6.4 (B)
(CHARKOP – DAHISAR)
Details of Affected Gas (Mahanagar) Pipeline

Sr. No	Chainage		Side	Affected Length (m)	DIA (MM)	Position w.r.t. Alignment	Diversion Proposals
	From	To					
1	700				4	Across	B
2	970				8	Across	B
3	1030				4	Across	B
4	1700				3	Across	B
5	1752				4	Across	B
6	1850				4	Across	B
7	1846	2051	Left	205	3	Along	A
8	2808	2925	Left	117	4	Along	A
9	2925				4	Across	B
10	2925	2979	Right	54	4	Along	A
11	3235				4	Across	B
12	3870				8	Across	B
13	3940				8	Across	B

14	3950	4049	Right	99	4	Along	A
15	3940	4049	Left	109	8	Along	A
	4931	5135	Right	204	8	Along	A
17	5889	6000	Right	111	8	Along	A
18	5889	6042	Right	153	4	Along	A
19	6030	6093	Left	63	4	Along	A
20	6000				8	Across	B
21	6042				3	Across	B
22	6042				4	Across	B
23	6560				4	Across	B
24	6585				8	Across	B

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

5.6.6 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.

Table 5.6.5
Details of Affected Above Ground Services(Charkop –Dahisar)

Sr. No.	Name of Utility	Numbers	Remarks
1.	Light Post	212	-
2.	Electric Post	Nil	-
3.	Traffic Signal Post	14	-
4.	Telephone Post	2	-
5.	Transformer / DP	Nil	-
6.	Electrical Junction Box	43	-
7.	Telephone Junction Box	Nil	-
8.	Trees	103	-
9.	H.T. Pylon	Nil	-

5.6.7 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 5.6.4 & Table 5.6.5 and placed below. These lines need to be modified/shifted or cabled well in advance of construction along this route.

Table 5.6.4 (A)
DETAILS OF AFFECTED RELIANCE POWER CABLES
(Charkop – D. N. Nagar)

S. No.	Chainage (m)	Affected Length (in m)	Type	Position W.R.T Alignment	Diversion Proposals
1	83	30	11 kv	Across	B
2	0 - 302	360	11 kv	Along	A
3	353	30	33 kv	Across	B
4	600	30	11 kv	Across	B
5	1246	30	33 kv	Across	B
6	1254	30	11 kv	Across	B
7	1558	30	11 kv	Across	B
8	1560	30	11 kv	Across	B
9	1612	30	11 kv	Across	B
10	1775	30	11 kv	Across	B
11	1898	30	33 kv	Across	B
12	2012	30	11 kv	Across	B
13	2010	30	11 kv	Across	B
14	2156	30	33 kv	Across	B
15	2170	30	11 kv	Across	B
16	2952	30	33 kv	Across	B
17	3039	30	11 kv	Across	B
18	3038	30	33 kv	Across	B
19	3040	30	11 kv	Across	B
20	3085	30	11 kv	Across	B
21	3319	30	11 kv	Across	B
22	3320	30	11 kv	Across	B
23	3495	30	11 kv	Across	B
24	3595	30	33 kv	Across	B
25	3756	30	11 kv	Across	B
26	3922	30	33 kv	Across	B
27	3919	30	33 kv	Across	B
28	3852	30	33 kv	Across	B
29	4414	30	33 kv	Across	B
30	4505	30	11 kv	Across	B
31	4553	30	33 kv	Across	B
32	4875	30	11 kv	Across	B
33	4888	30	11 kv	Across	B
34	4894	30	33 kv	Across	B
35	4900	30	11 kv	Across	B
36	5352	30	11 kv	Across	B
37	5366	30	33 kv	Across	B

S. No.	Chainage (m)	Affected Length (in m)	Type	Position W.R.T Alignment	Diversion Proposals
38	5389	30	33 kv	Across	B
39	5390	30	33 kv	Across	B
40	5442	30	11 kv	Across	B
41	5678	30	11 kv	Across	B
42	3883 - 5666	1783	33 kv	Along	A
43	5885	30	33 kv	Across	B
44	1248 - 6350	5102	11 kv	Along	A
45	6350	30	11 kv	Across	B
46	6453	30	11 kv	Across	B
47	6532	30	11 kv	Across	B
48	6710	15	11 kv	Across	B
49	6828	15	11 kv	Across	B
50	7235	30	11 kv	Across	B
51	7236	30	11 kv	Across	B
52	7320	15	33 kv	Across	B
53	7383 - 7524	141	11 kv	Along	A
54	7583 - 7705	122	11 kv	Along	A
55	7707 - 7820	113	11 kv	Along	A
56	7820	30	11 kv	Across	B
57	8174	30	11 kv	Across	B
58	8210	30	11 kv	Across	B
59	8209	30	11 kv	Across	B
60	8321	30	11 kv	Across	B
61	8319	30	11 kv	Across	B
62	8535	30	11 kv	Across	B
63	8536	30	11 kv	Across	B
64	8525	30	11 kv	Across	B
65	8452	30	11 kv	Across	B
66	8452	30	11 kv	Across	B
67	8452 - 8900	448	11 kv	Along	A
68	8900	30	11 kv	Across	B
69	8942	30	11 kv	Across	B
70	8942	30	33 kv	Across	B
71	9000	30	33 kv	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 5.6.6 (B)
Details of Affected Reliance Energy Cables
(Charkop – Dahisar)

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion
	From	To					
1	113			35	Cable Duct	Across	B
2	112	317	Left	205	Cable Duct	Along	A

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

Table 5.6.7 (A)
DETAILS OF AFFECTED TATA POWER CABLES
(Charkop – D. N. Nagar)

S. No.	Chainage (in m.)	Affected Length (in m.)	Type	Position w.r.t Alignment	Diversion Proposals
1.	3443 - 3405	37	33kv	Along	A
2.	7261 - 7235	26	33kv	Along	A
3.	7355 - 7336	19	33kv	Along	A
4.	7435	30	33kv	Across	B
5.	8953 - 8940	13	33kv	Along	A
6.	8995	30	33kv	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 5.6.7 (B)
Details of Affected TATA Power Cables
(Charkop – Dahisar)

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion
	From	To					
1	1386			35	33 KV Cable Duct	Across	B
2	1722			35	33 KV Cable Duct	Across	B
3	1816			35	33 KV Cable Duct	Across	B
4	1846	2051	Left	205	33 KV Cable Duct	Along	A
5	2050			35	33 KV Cable Duct	Across	B
6	2060			40	33 KV Cable Duct	Across	B
7	2065			44	33 KV Cable Duct	Across	B
8	2515			31	33 KV Cable Duct	Across	B

9	2721			55	33 KV Cable Duct	Across	B
10	2742			53	33 KV Cable Duct	Across	B
11	2768			33	33 KV Cable Duct	Across	B
12	2776	2979	Left	203	33 KV Cable Duct	Along	A
13	3055			35	33 KV Cable Duct	Across	B
14	3272			38	33 KV Cable Duct	Across	B
15	3290			35	33 KV Cable Duct	Across	B
16	3291			37	33 KV Cable Duct	Across	B
17	3844	4049	Right	205	33 KV Cable Duct	Along	A
18	3892			35	33 KV Cable Duct	Across	B
19	3893			35	33 KV Cable Duct	Across	B
20	4477			35	33 KV Cable Duct 3 Nos.	Across	B
21	4931	5135	Right	204	33 KV Cable Duct	Along	A
22	5126			35	33 KV Cable Duct 2 Nos.	Across	B
23	5889	6093	Right	204	33 KV Cable Duct	Along	A
24	6031			56	33 KV Cable Duct 2 Nos.	Across	B
25	6114			40	33 KV Cable Duct	Across	B
26	6563			28	33 KV Cable Duct	Across	B
27	6962			40	33 KV Cable Duct 2 Nos.	Across	B
28	6993			40	33 KV Cable Duct	Across	B
29	7601	7804	Right	203	33 KV Cable Duct	Along	A
30	7601	7804	Left	203	34 KV Cable Duct	Along	A
31	7625			30	33 KV Cable Duct	Across	B

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

5.6.8 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 is indicated in **Table 5.6.6** and placed below. Detailed proposals for tackling these lines needs to be prepared in consultation with the concerned agencies. However, Tentative provision has been made in cost estimates.

Table 5.6.6 (A)
DETAILS OF AFFECTED MTNL TELECOM CABLES
(Charkop – D. N. Nagar)

S.No.	Chainage	Affected Length(m)	Approx. Depth Below Ground	Type	Position w.r.t Alignment	Diversion Proposals
1	1610 - 1757	147	1	Cableduct	Along	A
2	1177	30	1	Cableduct	Across	B
3	1295	30	1	Cableduct	Across	B
4	1377	30	1	Cableduct	Across	B
5	1625 - 1545	80	1	Cableduct	Along	A
6	3890 - 3390	500	1	Cableduct	Along	A
7	5700 - 5500 (L)	200	1	Cableduct	Along	A
8	5790 - 5680 (R)	105	1	Cableduct	Along	A
9	6715 - 6644	70	1	Cableduct	Along	A
10	6805 - 6735	70	1	Cableduct	Along	A
11	8095	30	1	Cableduct	Across	B
12	8244	30	1	Cableduct	Across	B
13	8420 - 8395	30	1	Cableduct	Along	A
14	8415	30	1	Cableduct	Across	B
15	8420	30	1	Cableduct	Across	B
16	8430	30	1	Cableduct	Across	B
17	8825 - 8430	388	1	Cableduct	Along	A
18	8825	30	1	Cableduct	Across	A
19	8860 - 8825	35	1	Cableduct	Along	A

Table 5.6.9 (B)
Details of Affected MTNL Telecommunication Cables (Charkop – Dahisar)

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignme	Diversion
	From	To					
1	28			70	Cable duct	Across	B
2	43			52	Cable duct	Across	B
3	112	317	Left	205	Cable duct	Along	A
4	112	317	Right	205	Cable duct	Along	A
5	742	945	Left	203	Cable duct	Along	A
6	742	945	Right	203	Cable duct	Along	A
7	988			61	Cable duct	Across	B
8	1685			39	Cable duct	Across	B
9	1700			58	Cable duct	Across	B
10	1846	2051	Left	205	Cable duct	Along	A
11	1846	2051	Right	205	Cable duct	Along	A
12	2058			31	Cable duct	Across	B
13	2776	2979	Left	203	Cable duct	Along	A
14	2776	2979	Right	203	Cable duct	Along	A
15	3844	4049	Right	205	Cable duct	Along	A

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion
	From	To					
16	3962			32	Cable duct	Across	B
17	4931	5100	Right	169	Cable duct	Along	A
18	5090	5130		30	Cable duct	Along	A
19	5091			31	Cable duct	Across	B
20	5889	6093	Left	204	Cable duct	Along	A
21	5889	6093	Right	204	Cable duct	Along	A
22	6134			30	Cable duct	Across	B
23	6584			48	Cable duct	Across	B
24	6955	7675	Left	720	Cable duct	Along	A
25	7601	7804	Right	203	Cable duct	Along	A

Table 5.6.10 (A) (Charkop – D. N. Nagar)

DETAILS OF AFFECTED TATA TELE SERVICES (OFC) TELECOME CABLES

S.No.	Chainage	Affected Length(m)	Type	Position w.r.t Alignment	Diversion Proposals
1	1242	30	Tata Ofc	Across	B
2	2790	30	Tata Ofc	Across	B
3	4917	30	Tata Ofc	Across	B
4	6751-6768	17	Tata Ofc	Along	A
5	6836	30	Tata Ofc	Across	B
6	7341-7368	27	Tata Ofc	Along	A
7	8035	30	Tata Ofc	Across	B
8	8795	30	Tata Ofc	Across	B
9	8940-8955	15	Tata Ofc	Along	A
10	8997	30	Tata Ofc	Across	B

Table 5.6.10 (B)

Details of Affected TATA Communication Cables

(Charkop – Dahisar)

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion
	From	To					
1	112	317	Right	205	Tata OFC	Along	A
2	742	945	Right	203	Tata OFC	Along	A
3	1846	2051	Right	205	Tata OFC	Along	A
4	2776	2979	Right	203	Tata OFC	Along	A
5	3844	4049	Right	205	Tata OFC	Along	A
6	4931	5135	Right	204	Tata OFC	Along	A
7	5889	6093	Right	204	Tata OFC	Along	A
8	7600	7804	Right	204	Tata OFC	Along	A

Table 5.6.11 (B)
Details of Affected Reliance Telecommunication Cables (Charkop – Dahisar)

Sr. No.	Chainage From	Chainage To	Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
1	112	317	Right	205	48F	Along	A
2	742	945	Right	203	48F	Along	A
3	1846	2051	Right	205	48F	Along	A
4	2745			52	48F	Across	B
5	2776	2979	Right	203	12F	Along	A
6	2776	2979	Left	203	12F	Along	A
7	3843	4048	Right	204	48F	Along	A
8	4931	5134	Right	204	48F	Along	A
9	5889	6093	Right	204	48F	Along	A
10	5920	6093	Left	173	12F	Along	A
11	6050	6170	Right	120	12F	Along	A
12	6176			30	12F	Across	B
13	7600	7804	Right	204	48F	Along	A

Table 5.6.12
Details of Affected REVMAX Telecom Cables (Charkop – Dahisar)

Sr. No.	Chainage From	Chainage To	Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
1	112	317	Right	205	Cable duct	Along	A
2	742	945	Right	203	Cable duct	Along	A
3	1846	2051	Right	205	Cable duct	Along	A
4	2776	2979	Right	203	Cable duct	Along	A
5	3844	4049	Right	205	Cable duct	Along	A
6	4931	5135	Right	204	Cable duct	Along	A
7	5889	6093	Right	204	Cable duct	Along	A
8	7600	7804	Right	204	Cable duct	Along	A

Table 5.6.13
Details of Affected Bharati Airtel Cables (Charkop – Dahisar)

Sr. No.	Chainage From	Chainage To	Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
1	13			35	Cable Duct	Across	B
2	112	317	LEFT	205	Cable Duct	Along	A
3	742	945	LEFT	203	Cable Duct	Along	A
4	1324			35	Cable Duct	Across	B
5	1846	2051	LEFT	205	Cable Duct	Along	A
6	2690			30	Cable Duct	Across	B

Table 5.6.14
Details of Affected Vodafone Cables
(Charkop – Dahisar)

Sr. No.	Chainage		Side	Affected Length(m)	Type	Position w.r.t. Alignment	Diversion Proposals
	From	To					
1	112	317	Right	205	OFC	Along	A
2	742	945	Right	203	OFC	Along	A
3	1846	2051	Right	205	OFC	Along	A
4	2776	2979	Right	203	OFC	Along	A
5	3843	4048	Right	205	OFC	Along	A
6	4931	5134	Right	203	OFC	Along	A
7	5889	6093	Right	204	OFC	Along	A
8	7600	7804	Right	204	OFC	Along	A

Table 5.6.14
Details of Affected TATA Television Cables
(Charkop – Dahisar)

Sr. No.	Chainage		Side	Affected Length (m)	Type	Position w.r.t. Alignment	Diversion Proposals
	From	To					
1	112	317	LHS	205	Cable Duct	Along	A
			RHS	205			
2	742	945	LHS	203	Cable Duct	Along	A
			RHS	203			
3	1846	2051	LHS	205	Cable Duct	Along	A
			RHS	205			
4	2776	2979	LHS	203	Cable Duct	Along	A
			RHS	203			
5	3844	4049	LHS	205	Cable Duct	Along	A
			RHS	205			
6	4931	5135	LHS	204	Cable Duct	Along	A
			RHS	204			
7	5889	6093	LHS	204	Cable Duct	Along	A
			RHS	204			
8	6400	6640	LHS	240	Cable Duct	Along	A

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

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

5.7 LAND ACQUISITION:

5.7.1 Land:

5.7.1.1 Alignment and Profile:

As discussed in the previous chapters, the proposed corridor runs from Dahisar (E) to D. N. Nagar via Rushi Sankul, Don Bosco, Charkop, Malad, Oshiwara and Shastri Nagar

5.7.2 Land Requirement:

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

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

5.7.2 Alignment:

Dahisar (E) – D.N. Nagar corridor of Mumbai Metro Project is proposed to start at Western Express Highway with its station named as Dahisar (East) and platform located above the already proposed Dahisar (East) metro station for Andheri (E) – Dahisar corridor. The alignment stretches from Dahisar (E) to D.N. Nagar via Dahisar (W), Rushi Sankul, I.C. Colony, Don Bosco, Charkop, Kasturi Park, Oshiwara and runs on link road. D.N. Nagar Metro Station on this corridor is proposed on the median of the road and will be integrated with D.N. Nagar Station line.

For elevated section, single pier as well as portal structure supporting the viaduct will be located on road. Necessary permission for using such right of way will have to be obtained from the concerned authorities. All stations are proposed with elevated concourse so that minimum land is required. Traffic integration facilities are provided wherever the same are required.

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

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

5.7.4 Land for Traffic Integration:

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

5.7.5 Land for Depot:

Car Maintenance Depot for Dahisar (E) - D. N. Nagar Corridor has been proposed in land identified by MMRDA at Charkop.

5.7.6 Land Requirement for Stations and Running Section:

Details of land acquisition required e are shown in Table 5.7.1.

Table 5.7.1

Land Requirement (Sqm)		
A. Running section		
RS-1	192.66	Pvt.
RS-2	125.503	Pvt.
RS-3	553.331	Pvt.
RS-4	385.195	Govt.
RS-5	679.28	Govt.
RS-6	1113.895	Govt.
RS-7	288.469	Govt.
RS-8	974.225	Govt.
RS-9	271.144	Govt.

RS-10	1294.913	Pvt.
RS-11	2000	Pvt.
RS-12	67.471	Govt.
RS-13	38.778	Pvt.
Total	**7984.864**	
Pvt.	**4205.185**	
Govt.	**3779.679**	

Land Requirement for Stations in Sqm			
S.No	**Station Name**	**Private**	**Govt.**
1	DAHISAR (E)	-	800
2	DAHISAR (W)	-	800
3	RUSHI SANKUL	-	800
4	I C COLONY	-	800
5	LIC COLONY	-	800
6	DON BOSCO	-	800
7	KASTUR PARK	-	800
8	EKATA NAGAR	-	800
9	KANDIVALI NAGAR	-	800
10	CHARKOP	-	800
11	MALAD METRO	-	800
12	KASTURI PARK	300	500
13	BANGUR NAGAR	-	800
14	OSHIWARA METRO	500	300
15	SAMARTHA NAGAR	-	800
16	SHASTRI NAGAR	-	800
17	D N NAGAR	-	800
	Total	**800**	**12800**

Maintenance Depot		
	Govt Land	
1	Charkop Depot Land identified by MMRDA Near Charkop) including land for One Receiving Sub Station in Depot area	**200000**

Table 0.10 Summary of Permanent Land Requirement				
		Govt	**Private**	**Total**
1	Stations including running sections	**16579.679**	**5005.185**	**21584.864**
2	Depot including one RSS	**200000**	**0**	**200000**
3	Receiving Sub stations (RSS) at Charkop	**Included in Depot Land**	**0**	**0**
	Total	**216579.67**	**5005.185**	**221584.864**

5.7.8 Temporary Construction Depot:

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

5.8 SAFETY & SECURITY SYSTEMS:

5.8.1 General:

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

5.8.1.2 **Requirements:**

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

5.8.2 Fire Alarm System:

5.8.2.1 **General:**

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

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

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

5.8.2.2 **Scope:**

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

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

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

5.8.2.3 **System Components:**

Fire Alarm Control Panel:

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

The CPU communicates with control panel installed, for the system to function effectively. The system comprises of:
i. Addressable pull stations – Manual Call Point.
ii. Intelligent photo electric smoke, thermal detector.
iii. Addressable control model.
iv. Isolated modules.

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

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

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

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

5.8.2.6 **Addressable Control Module:**

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

5.8.2.7 **Isolator Module:**

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

5.8.3 Fire Hydrant System:

5.8.3.1 **General:**

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

5.8.3.2 **Scope:**

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

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

Fire Hydrant System comprises of the following:

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

Hydrant System is proposed to be installed at following Places

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

5.8.3.3 System Component:

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

5.8.3.4 Landing Valve:

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

5.8.3.5 Hoses:

Hose is a flexible tube used to carry water

5.8.3.6 Hose Reel:

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

5.8.3.7 **Coupling:**

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

5.8.3.8 **Fire Brigade Connector:**

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

5.8.4 Sprinkler System:

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

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

5.8.6.3 Integrated Port Cameras:

For operation of IP Cameras, no external supply connection is needed. However, Power Over Ethernet (PoE) shall be attached to an Uninterruptible Power Supply (UPS) and sized to maintain camera operations. PoE technology, enables a system to pass electrical power, along with data, on Ethernet cabling. Standard version of PoE specify Category 5 cable or higher to be used for the system.

Two types of IP Cameras Shall be used:

*Fix Camera– Use of this camera is restricted to 20 m range.
*PTZ Camera– Pan/Tilt/Zoom Camera is used for range from 20 m to 100 m.

5.8.6.4 **Computer:**

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

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

5.8.6.5 **Software:**

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

5.8.6.6 **Server Software:**

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

Server maintains a catalog of settings for all clients. It also encodes & decodes of stored information through I P cameras.
Software enables the client to dynamically create connections between Cameras and workstations and view live or recorded video on the digital monitors (Audio, video, serial ports and digital I/Os)

5.8.6.7 **Client Software:**

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

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

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

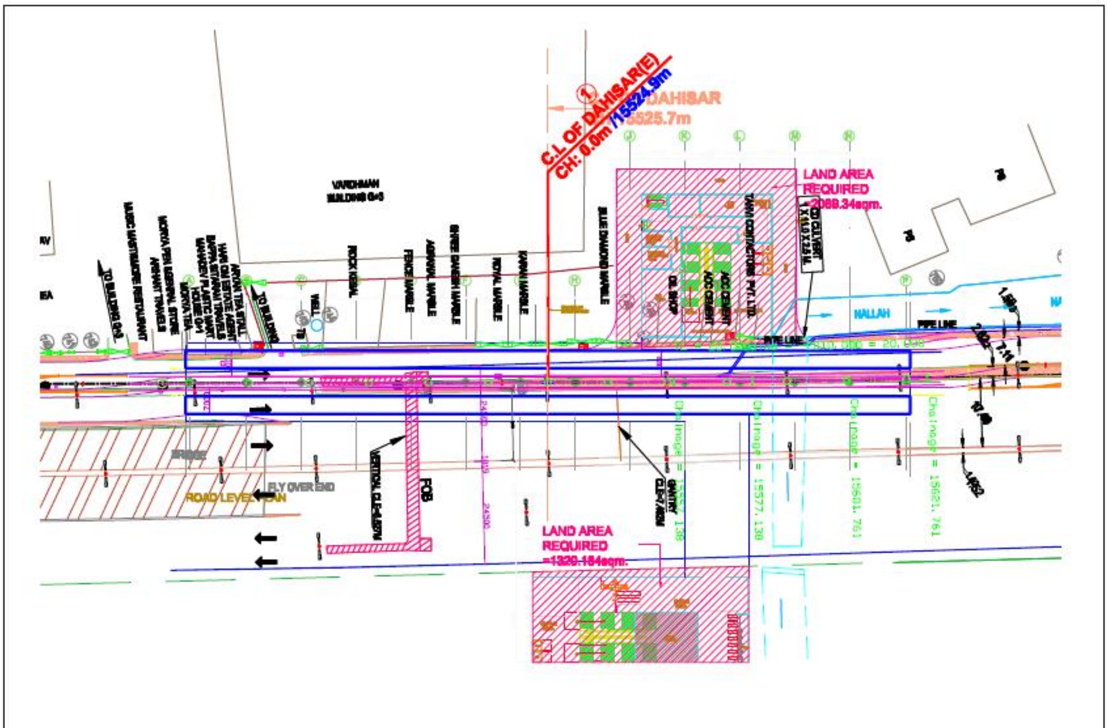
Client application provides, management and control over the system, using a standard PC mouse, keyboard or CCTV keyboard. Standard scroll mouse moves the camera by merely clicking on the extremes of the picture, in all directions and zoom function by scroll button, to avoid the use of joystick keyboard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

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

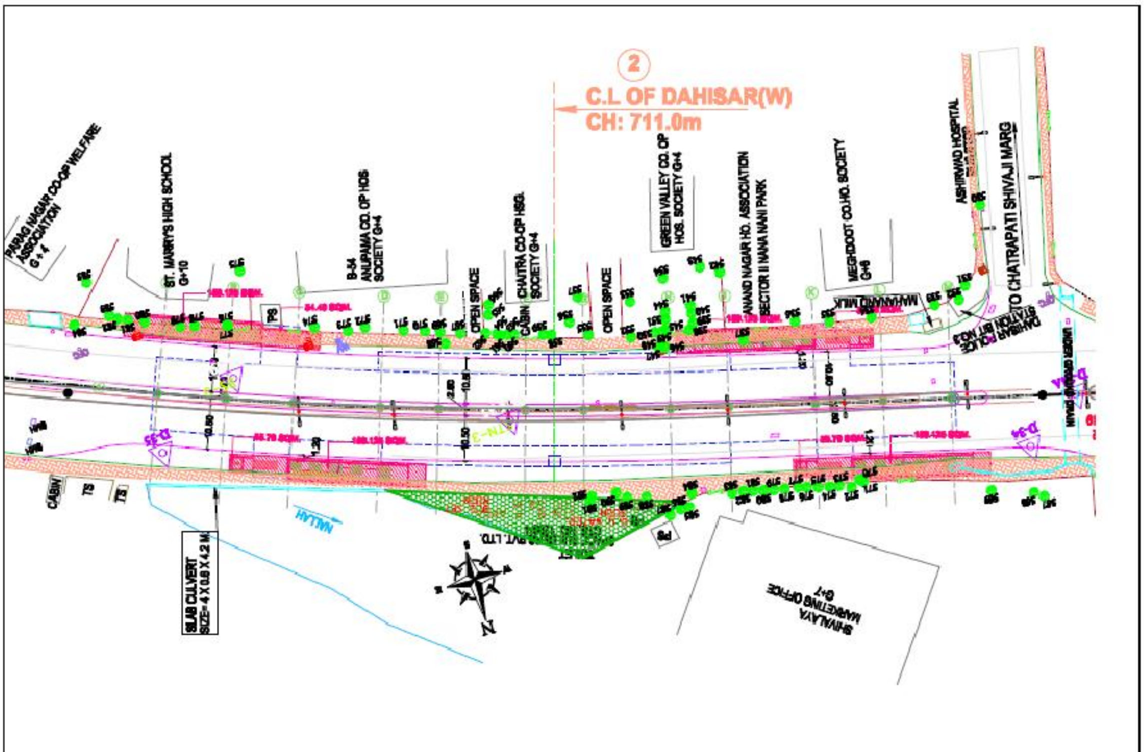
Software provides utility to play multiple exported clips simultaneously. It also provides the ability to play multiple clips in time sync with each other to understand the sequence of events occurred during an emergency.

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

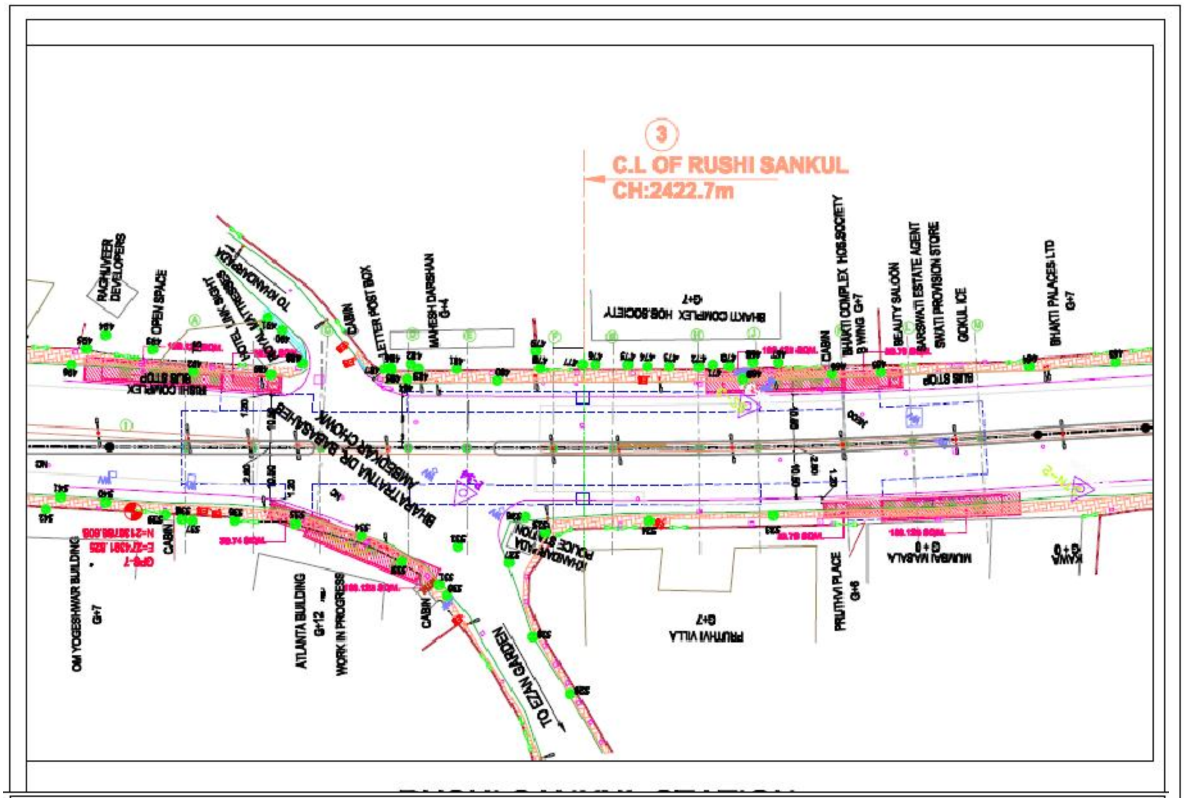
The estimate for security may, however, need revision after level and quantum of security to be provided are known in greater detail.

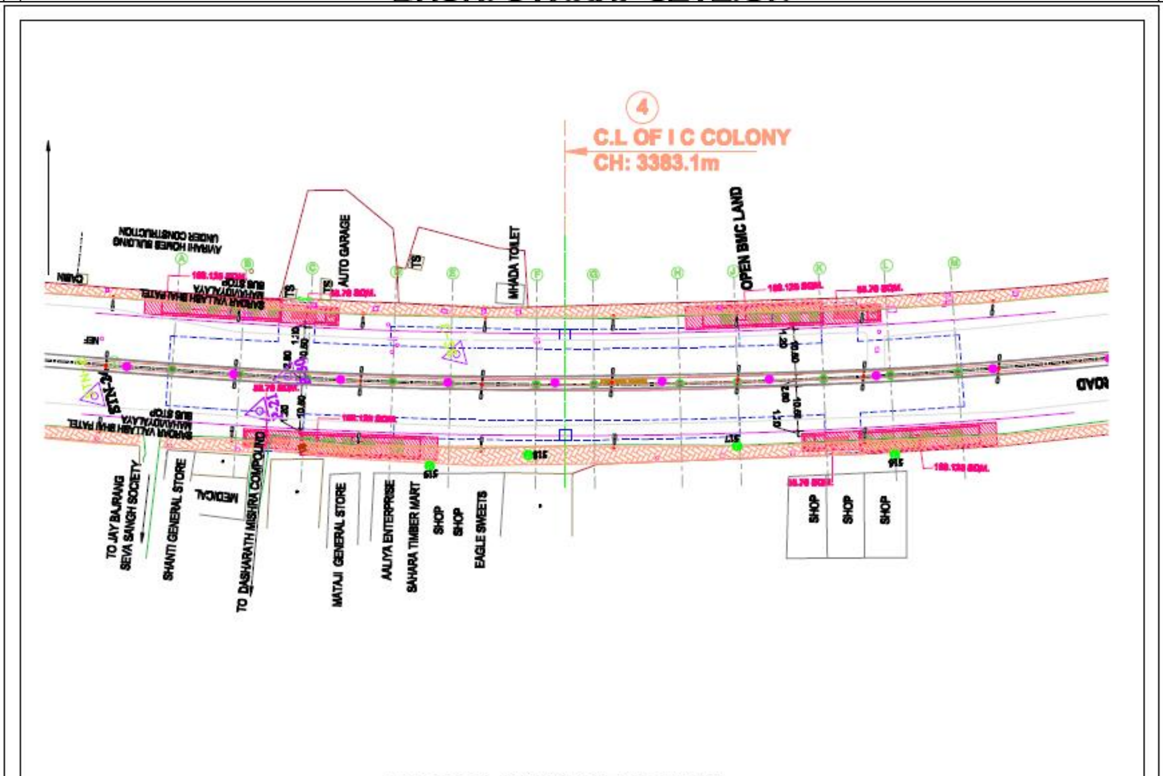


Dahisar(E) STATION

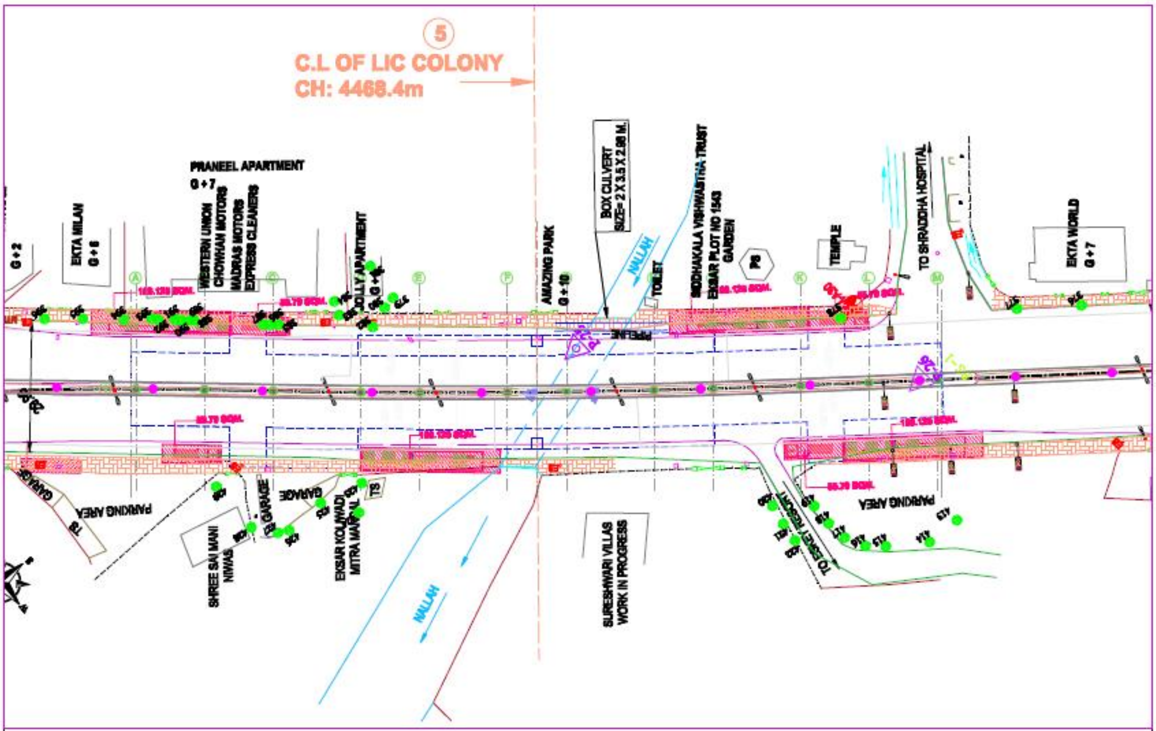


DAHISAR(W) STATION



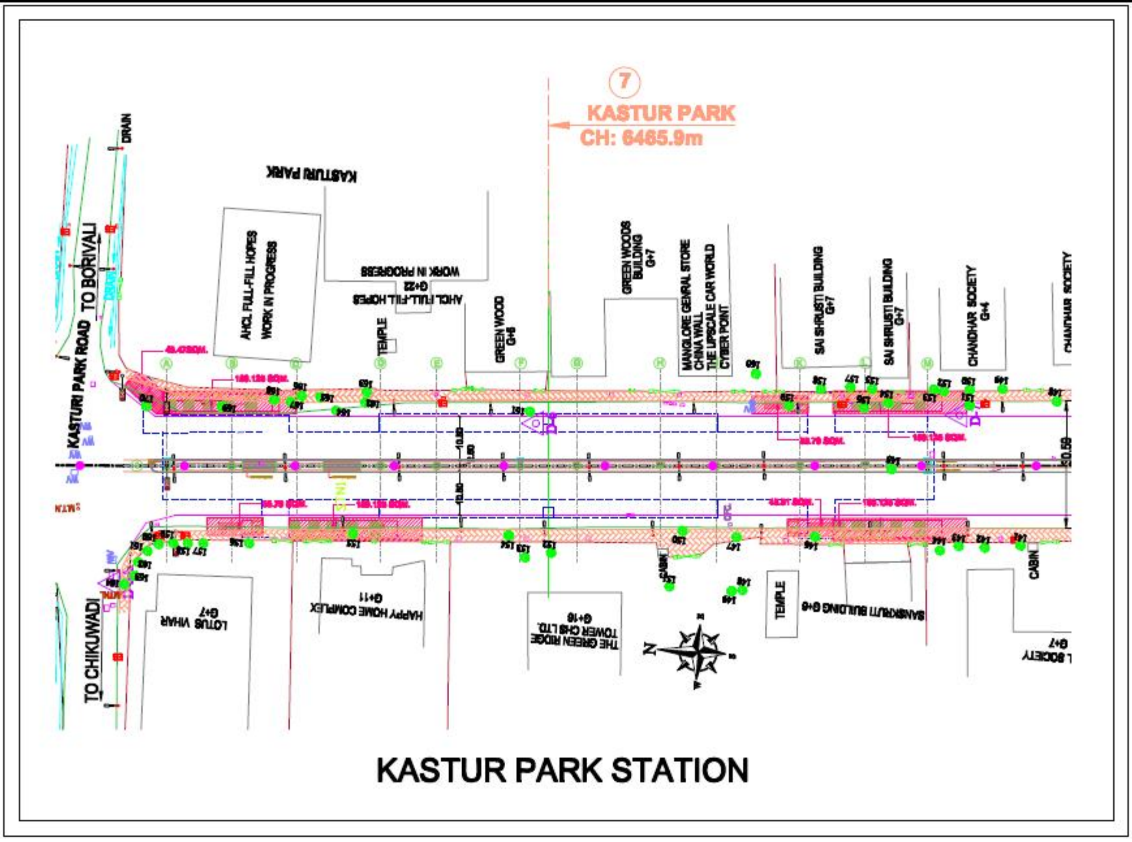


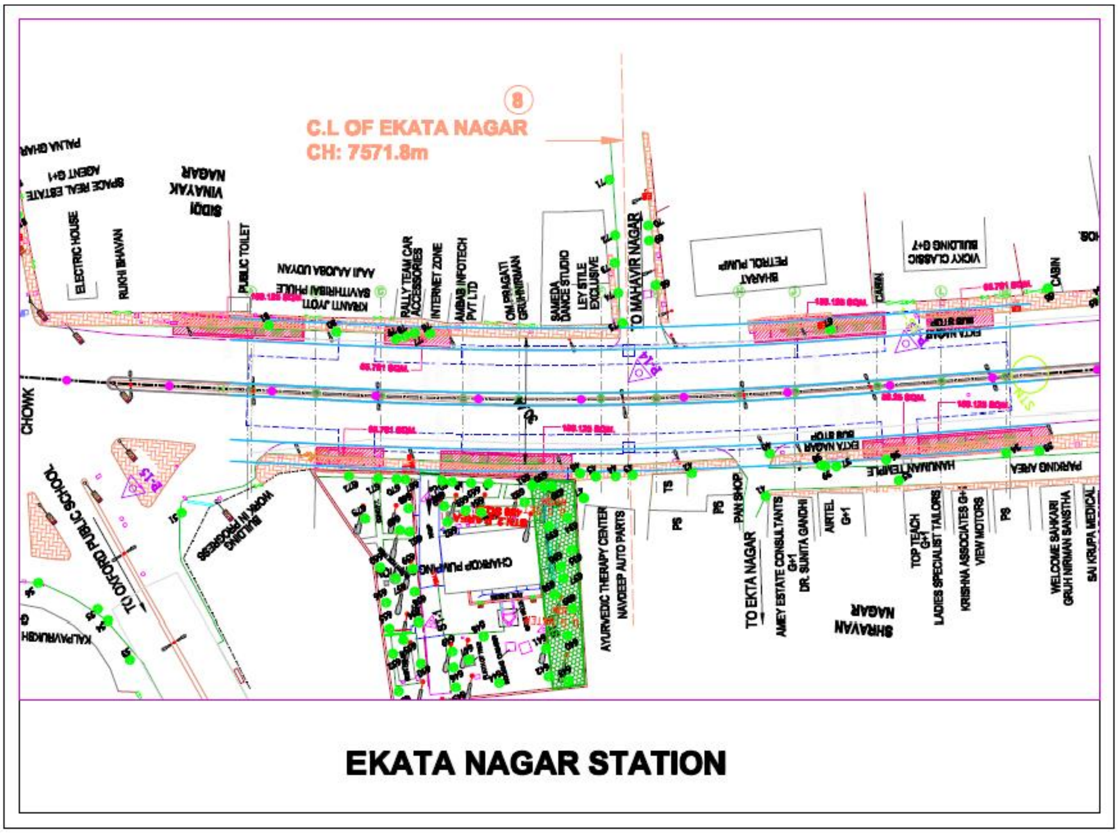
IC COLONY STATION

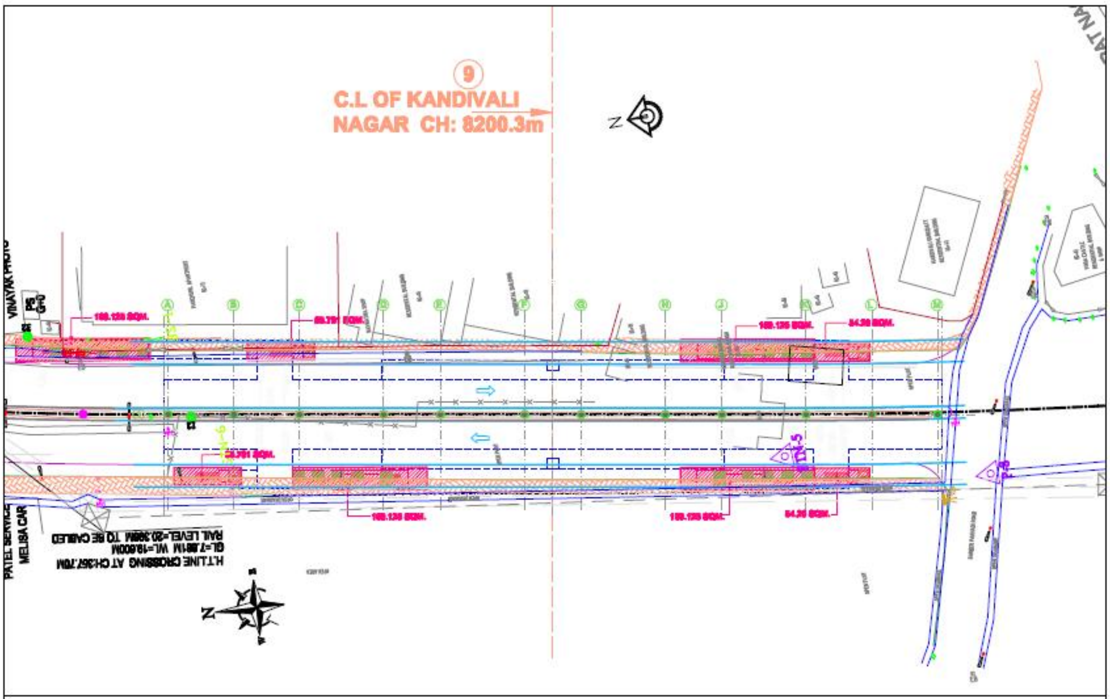


LIC COLONY STATION

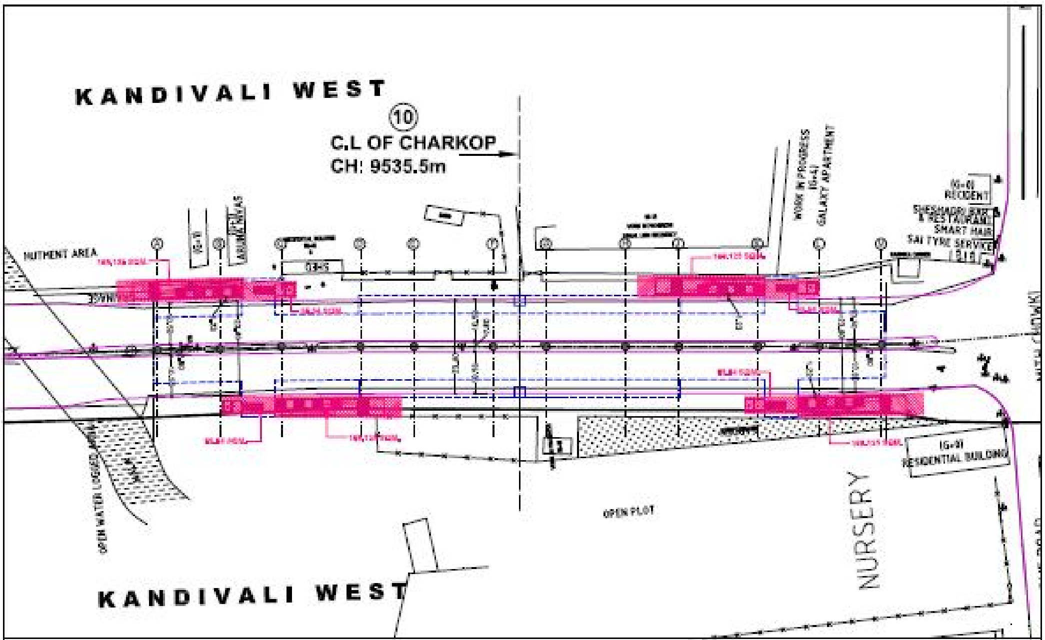
DON BOSCO STATION


7
KASTUR PARK
CH: 6465.9m
KASTURI PARK ROAD TO BORIVALI
TO CHIKUWADI
DRAIN
KASTUR PARK STATION

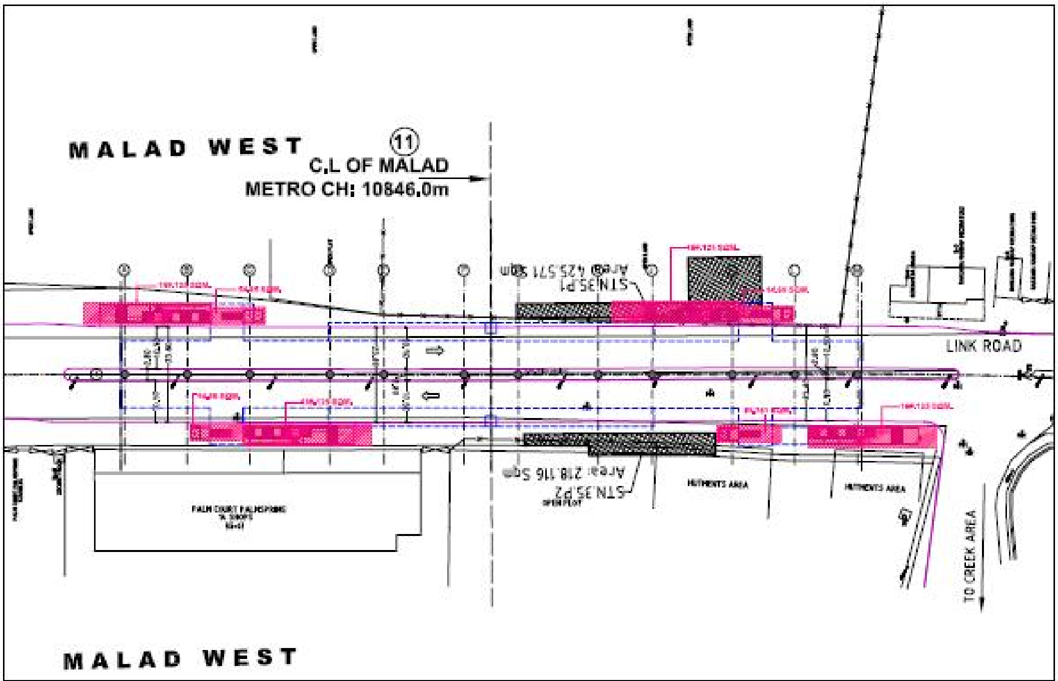

8
C.L OF EKATA NAGAR
CH: 7571.8m
TO MAHAVIR NAGAR
TO EKTA NAGAR
CHOWK
TO OXFORD PUBLIC SCHOOL
EKATA NAGAR STATION



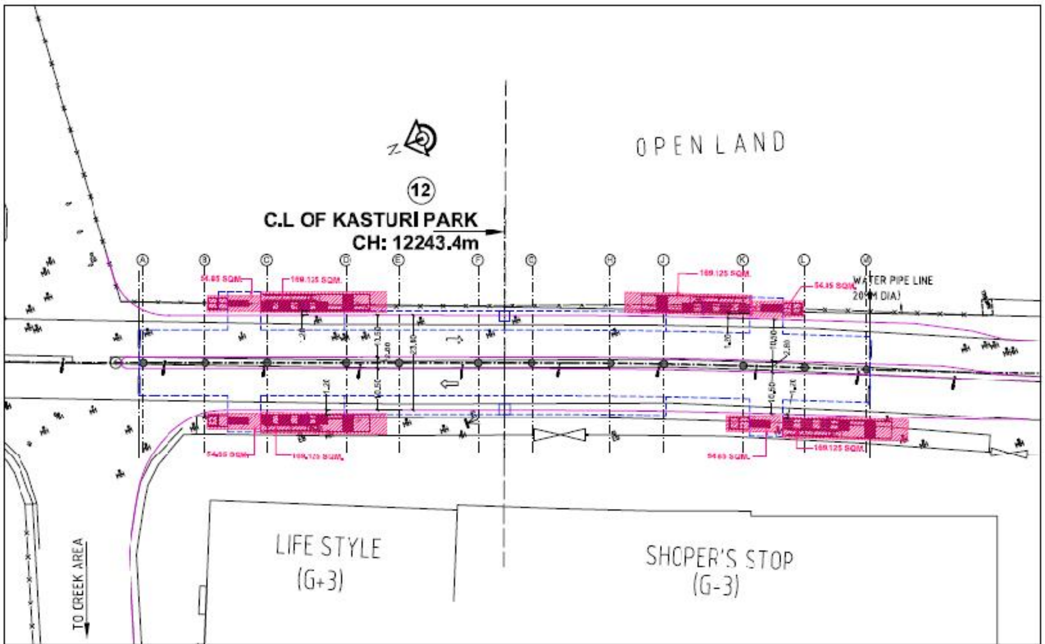
KANDIVALI NAGAR STATION



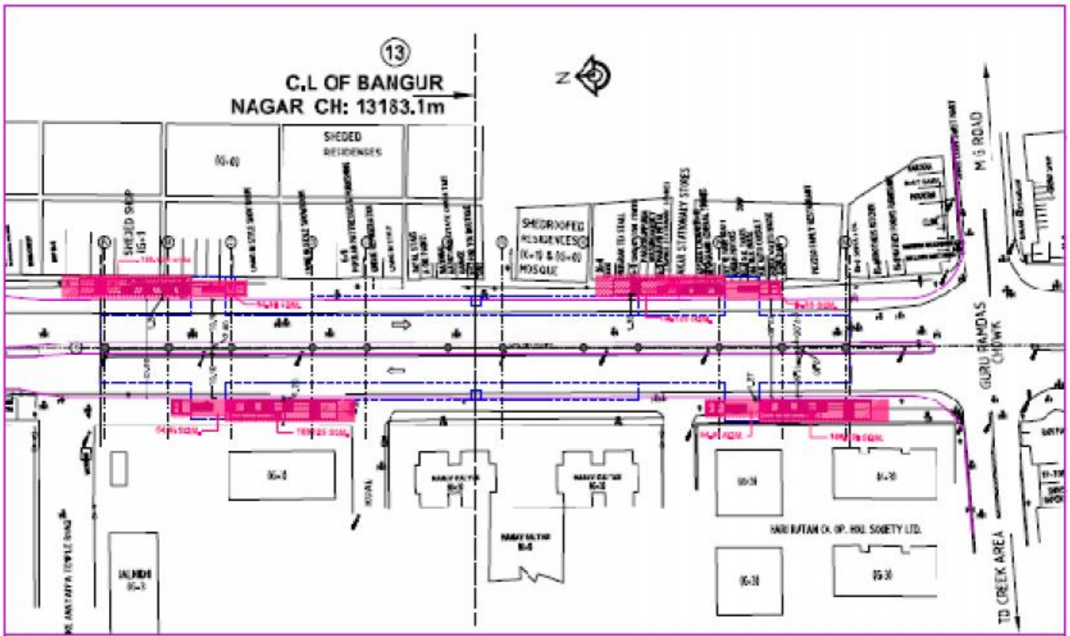
CHARKOP STATION



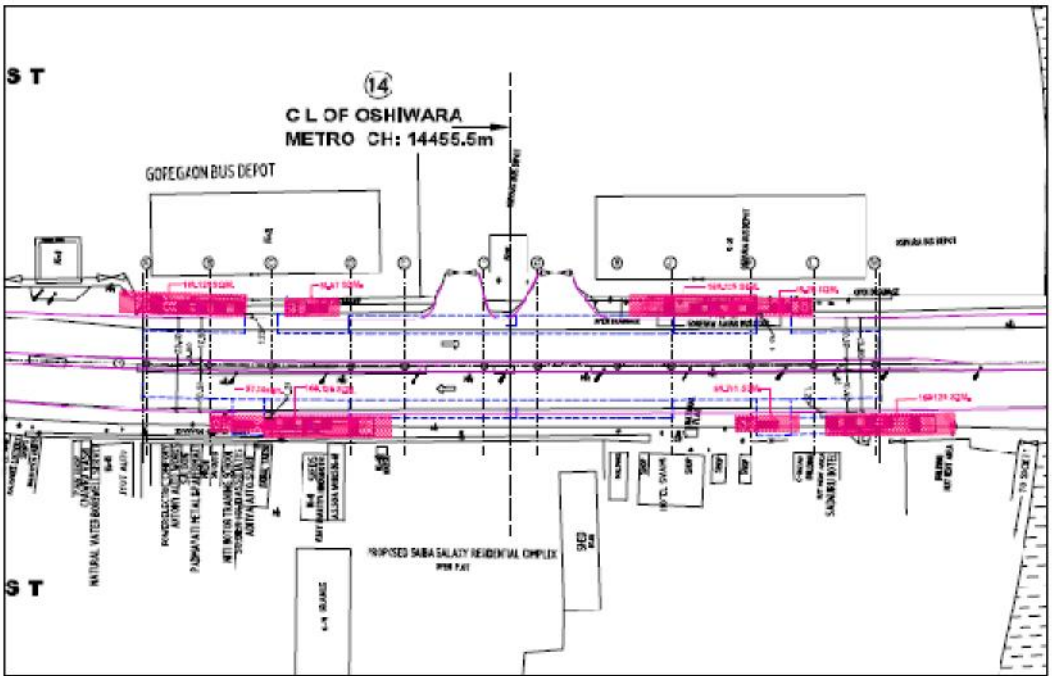
MALAD METRO STATION



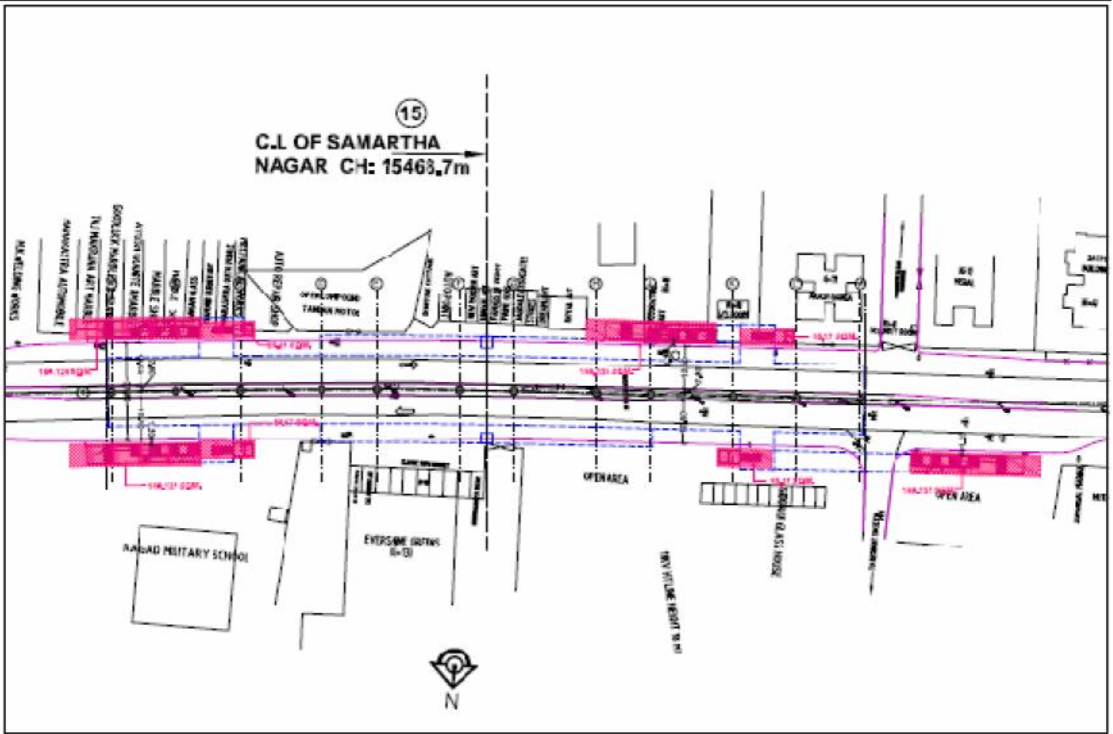
KASTURI PARK STATION



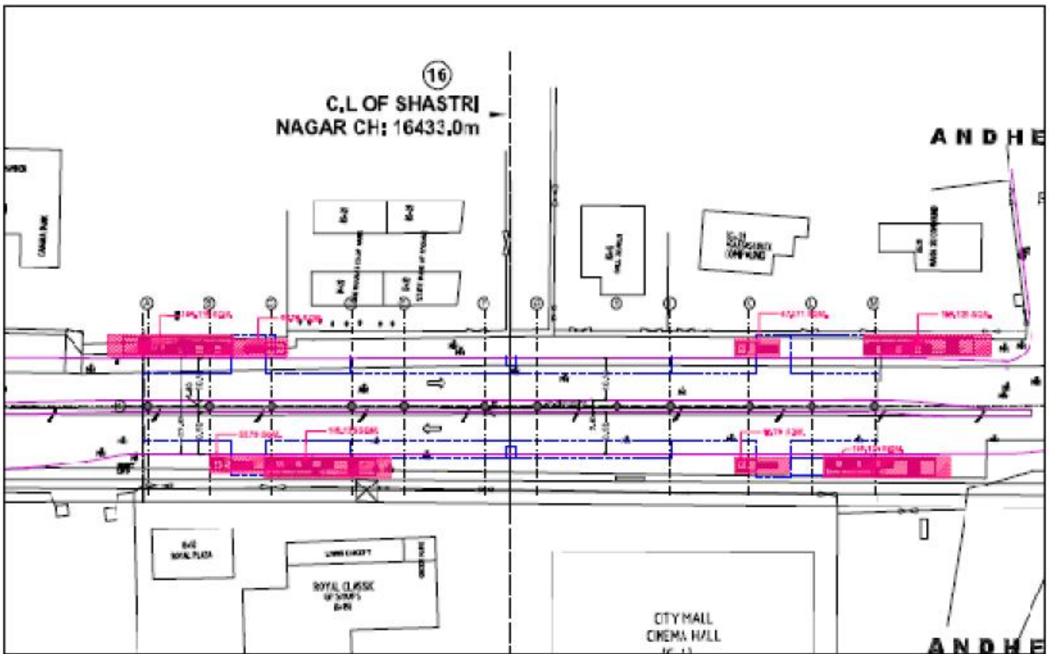
BANGUR NAGAR STATION



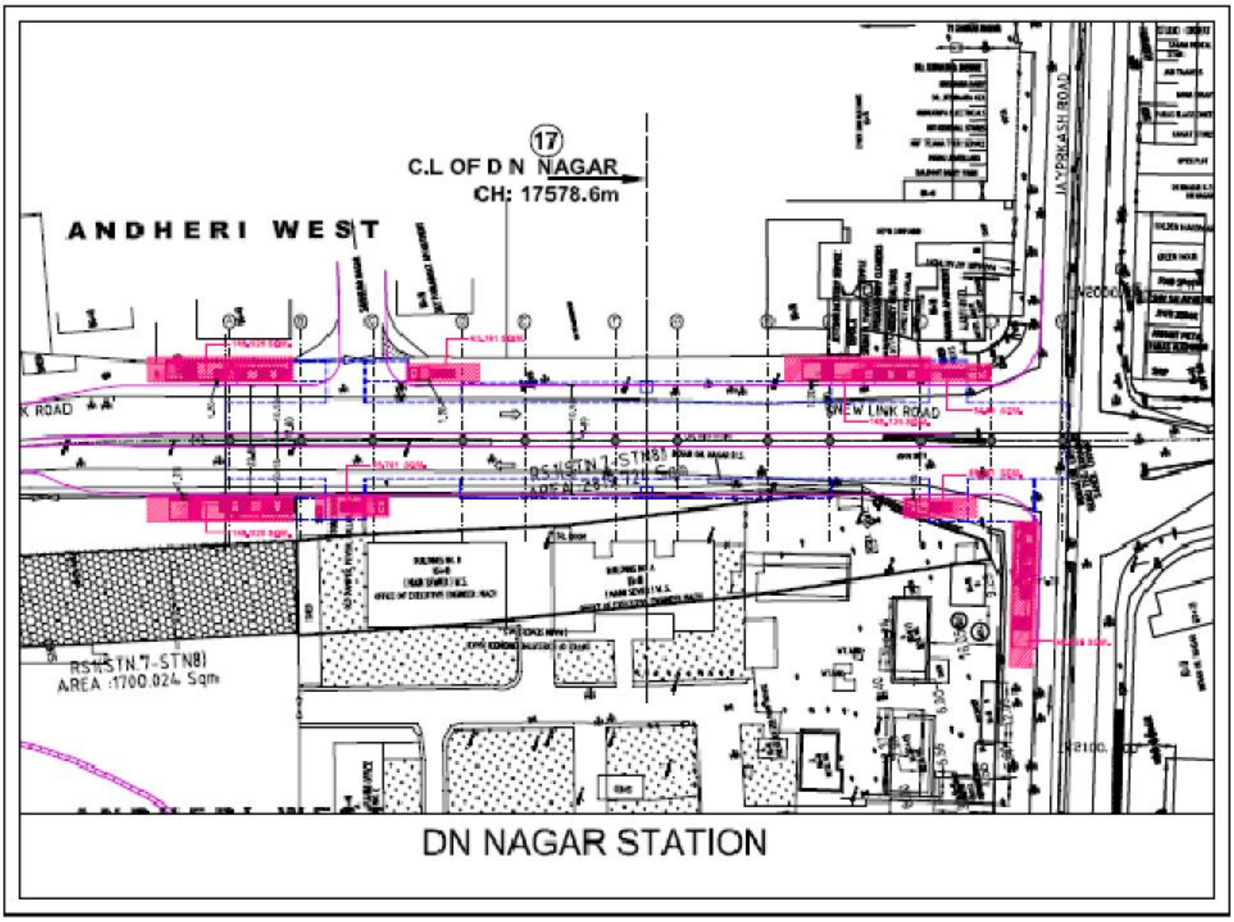
OSHIWARA STATION



SAMARTHA NAGAR STATION



SHASTRI NAGAR STATION



17
C.L OF D N NAGAR
CH: 17578.6m
ANDHERI WEST
K ROAD
NEW LINK ROAD
JAYPRKASH ROAD
RS1(STN.7-STN8)
AREA :1700.024 Sqm
DN NAGAR STATION


Index Plan
DAHISAR(W)
DAHISAR(E)
Depot
RUSHI SANKUL
DAHISAR
IC COLONY
LIC COLONY
DON BOSCO
KASTUR PARK
EKATA NAGAR
KANDIVALI NAGAR
CHARKOP
MALAD METRO
KASTURI PARK
BANGUR NAGAR
OSHIWARA METRO
SAMARTHA NAGAR
SHASTRI NAGAR
DN NAGAR
BORIVALI WEST
BORIVALI EAST
KANDIVALI EAST
MALAD EAST
GOREGAON WEST
GOREGAON EAST
JOGESHWARI EAST
WESTERN EXPRESS HIGHWAY

Appendix-I

SELECTION OF TYPE OF ALIGNMENT

The metro network may have the under-mentioned three types of alignments:

1. At-Grade
2. Elevated
3. Under-ground

1. At Grade - At-Grade type of alignment is technically feasible only in the areas where vacant land is available or a dedicated corridor of 14 meters width is provided in the mid of the road. However, the main limitation of providing At-Grade corridor is that city is divided in two parts and any crossing from one side to other side of At-Grade corridor has to be provided by grade separation i.e., either foot-over bridge or under passes. This alternative is the most economical. However, it should be noted that cost saving is only in Civil Engineering cost which is arrived if the land cost requirement for at grade alignment is taken into account and cost per km. may come even more than elevated. Therefore, At-Grade type of alignment for metro systems in cities is normally ruled out.

2. Elevated – Elevated alignment is generally provided in the cities for metro network, but the pre-requisite is the right of way (ROW) of road should minimum be 20 meters. It will enable to provide a median of about 2.8 to 3.0 meters wide road, two lane each way (7 meters width) and foot-path 1.5 meter each way. The land requirement for elevated alignment is mainly for the exit and entries for the station. As the alignment pillars located on median of the roads, a rough estimate of land requirement is about 240 sq. meters on either side of the road, wherein even underground water tank and generator rooms can be accommodated under the staircase. Construction of elevated station is much easier, 8 meter wide strip for the platform length (say 185 meters) will be required temporarily for putting the pillars on the median. Small area of about 400 sq. meters is needed for execution of the work of exit and entries on either side of the road.

4. Under-ground – This type of alignment is adopted only in case when ROW is less than 20 meters and alignment has to necessarily pass through the area where no roads are available. In this case only station locations where metro stations can conveniently located are identified and these are joined by under-ground tunnels. However, under-ground station need much ground surface area than elevated station for the reasons that in case of under-ground station, there is a space requirement for chiller plants in addition to exit and entries, which may be almost same as required for elevated station. Normally, the construction of under-ground stations require the area with 240 meters length and 24 meters width which need to be cut open. Finding out such a big space for construction of under-ground station in a congested city and even on passenger roads is very difficult if not impossible. For construction of under-ground station, the traffic is necessarily required to be diverted. Advantages and dis-advantages of these two types of alignments are given in the table below:

S.No.	Item name	Under-ground alignment	Elevated alignment
1.	Permanent land	More area required	Comparatively less area required
2.	Land requirement for construction	Much more area required. At least twice of what required for elevated station	Area requirement is much less than under-ground
3.	Construction time	At least 5 years	At least 3 and 1/2 years
4.	Cost of construction	2.25 to 2.50 times of elevated cost.	Much cheaper compared to underground
5.	Operation cost	1.25 to 1.5 times of elevated operation cost	Much cheaper compared to underground
6.	Security concern	Under-ground metro stations are more prone to terrorist attacks.	Less prone to terrorist attacks.
7.	Risk	More risk to the passengers during the disruption	Less risk compared to underground.
8.	Drainage Arrangement	Very exhaustive drainage arrangement needed	Very simple arrangement
9.	Ramp	In case of under-ground, when alignment is changes from under-ground to elevated, 11 meters width and 650 meters long land portion is needed for providing the ramp with physical barrier between 2 sides of the city.	There is no requirement of such ramp and land.

The rough estimate of under-ground and elevated alignments for 20 kms length has been made at the price level of March, 2015. The cost (without land and Taxes) of under-ground alignment comes to Rs. 412 crores and elevated Rs. 176 crores. It indicates that per kilometre of under-ground alignment replacing elevated alignment, the cost to the tune of 2.3 times has to be incurred

In view of the above, the decision for opting a particular type of alignment has to be taken on techno-economic basis. For country like India, a balance has to be kept in two types of alignments for the reasons that we are already short of funds for our infrastructure projects. It is also recommended that underground alignment be opted only in the stretches where elevated alignment is not possible to provide.

To appreciate the magnitude of land requirement, Ground Level Plans of one Typical elevated station and underground station are put up at Figure-1 & Figure-2 to this appendix.

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Figure -1 Typical Elevated Station Layout

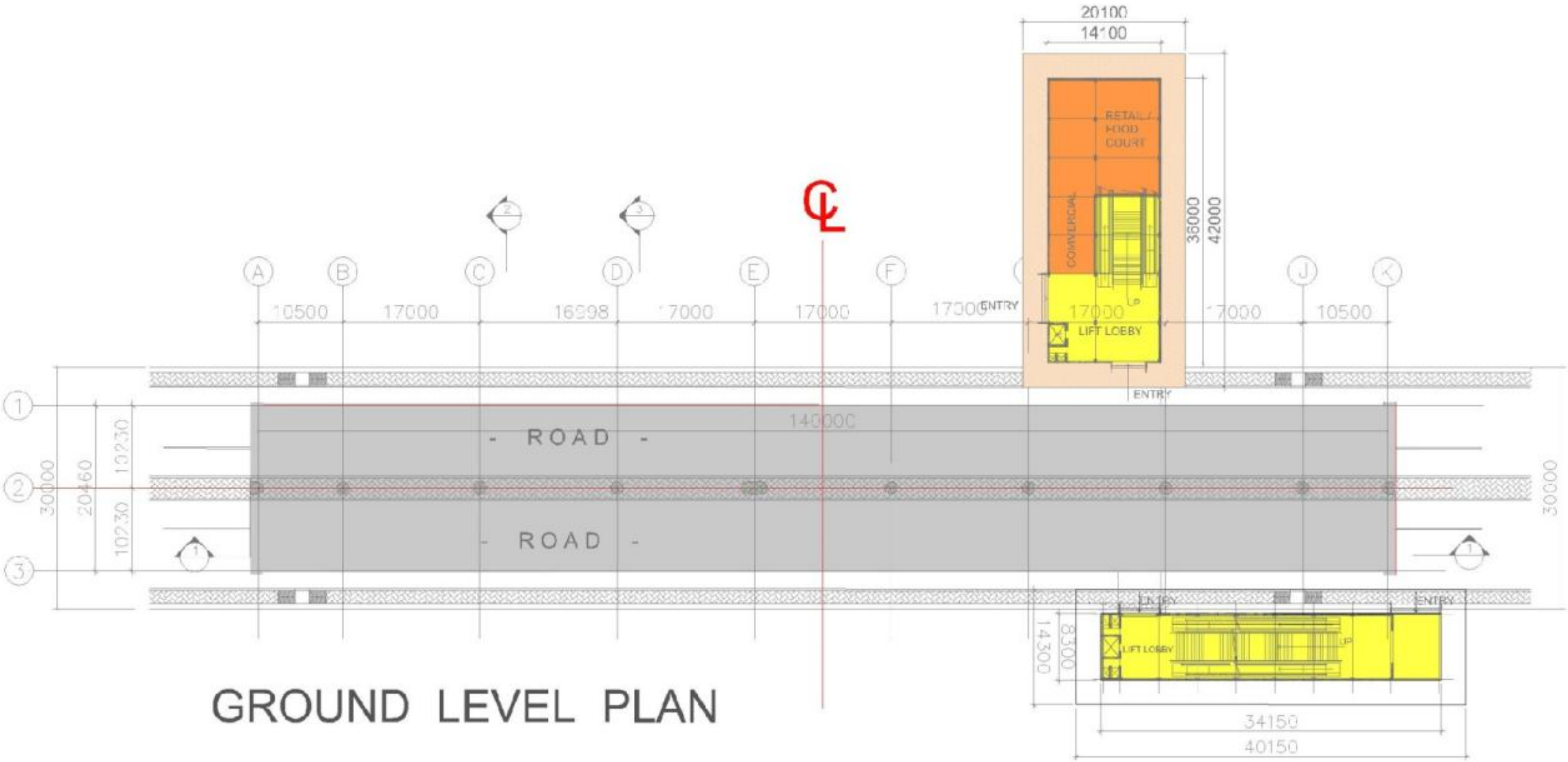
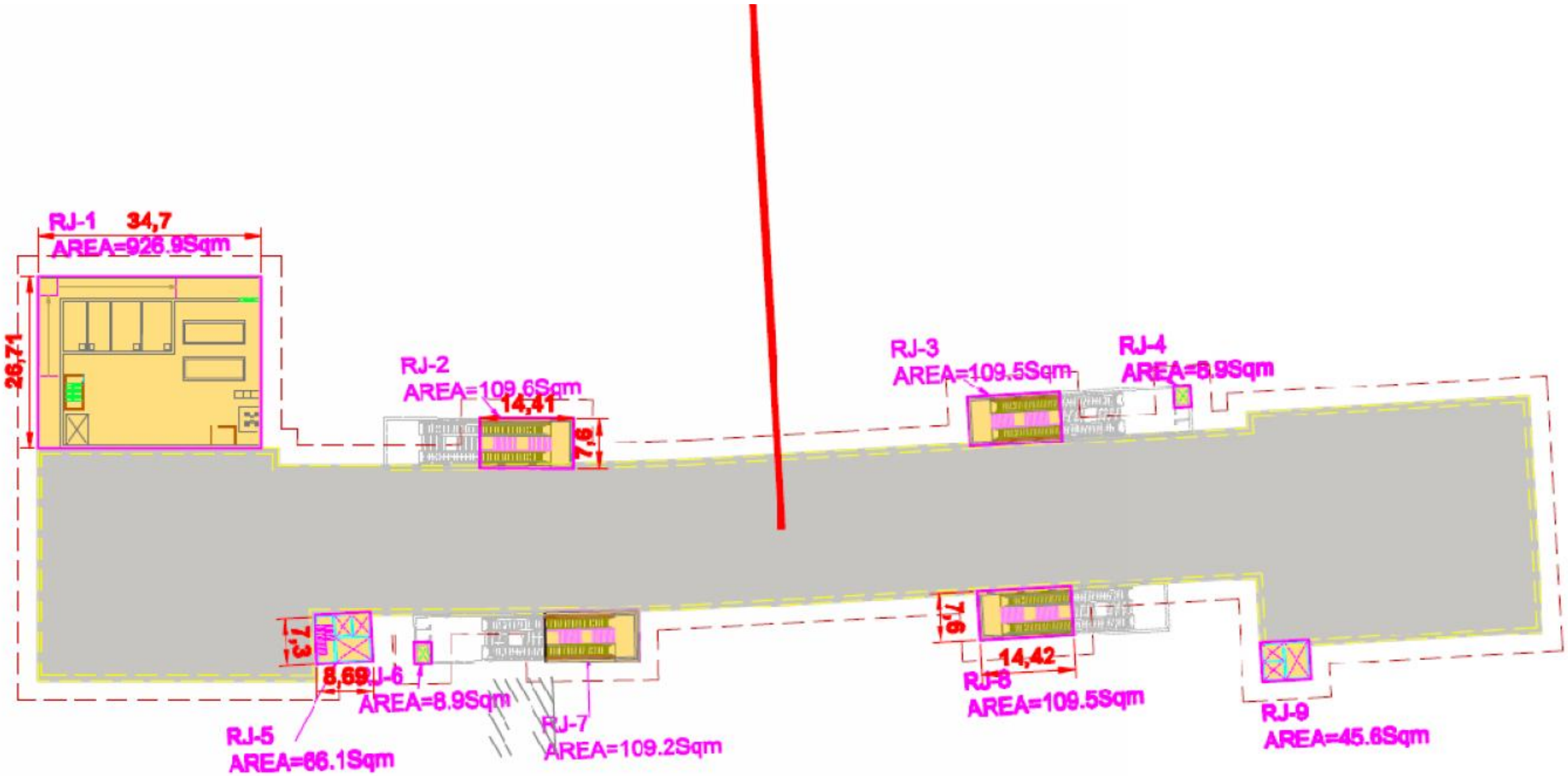


Figure 2 Typical Underground Station Layout

Ground Level Plan



CHAPTER 6A

TRAIN OPERATION PLAN AND ROLLING STOCK

6.1. OPERATION PHILOSOPHY

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

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

6.2 STATIONS

Details of stations for Mumbai Metro (Dahisar (E) – D. N. Nagar corridor) are given in table 6.1:

Table 6.1 Details of Stations

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)			
S. No.	Station Name	Chainage(m)	Inter Distance between two Stations
0	Dead End	(-)413.941	
1	Dahisar (E)	0.0	413.941
2	Dahisar (W)	711.0	711.0
3	Rishi Sankool	2422.7	1711.7
4	IC Colony	3383.1	960.4
5	LIC Colony	4468.4	1085.3
6	Don Bosco	5537.5	1069.1
7	Kasturi Park	6465.9	928.4
8	Ekata Nagar	7571.8	1105.9
9	Kandivali	8200.3	628.5
10	Charkop	9535.5	1335.2
11	Malad Metro	10846.0	1310.5
12	Kasturi Park	12243.4	1397.4
13	Bangur Nagar	13183.1	939.7
14	Oshiwara Metro	14455.5	1272.4
15	Samartha Nagar	15468.7	1013.2
16	Shastri Nagar	16433.0	964.3
17	D.N. Nagar	17578.6	1128.8
	Dead End	18175.0	596.4

6.3 TRAIN OPERATION PLAN

6.3.1 Salient Features:

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

6.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Dahisar East to D.N. Nagar for the year 2019,2021 and 2031 for the purpose of planning are indicated in Attachment I/A, I/B & I/C 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
3-car train composition: DMC+TC+DMC

Capacity@ 6 passengers per square meter of standee area

DMC : 300 passengers (Sitting-47, Standing-253)
MC : 300 passengers (Sitting-56, Standing-244)
TC : 300 passengers (Sitting-56, Standing-244)
3 Car Train : 900 Passengers (Sitting-159, Standing-741)

6.3.4 Train Operation Plan

Based on the projected PHPDT demand, train operation has been planned for Mumbai Metro (Dahisar East to D.N. Nagar corridor) for the year 2019, 2021 and 2031 as detailed below:

Train operation plan for Dahisar East to D.N. Nagar with train carrying **capacity @ 6 persons per square meter of standee area** on Mumbai Metro (Dahisar East to D.N. Nagar corridor) is given below:

- **Year 2019** (Refer **Attachment I /A**)

Train operation with **6 car Trains** with headway of **5.25 min** between Dahisar East to D.N. Nagar is planned in the first year of operation i.e. **2019** with Peak Hour Peak Direction Capacity of 10286 @ **6 persons per square meter of standee area (Capacity of 13029 @ 8 persons per square meter of standee area under dense loading conditions)**.

- **Year 2021** (Refer **Attachment I/B**)

Train operation with **6 car Trains** with headway of **4.5 min** between Dahisar East to D.N. Nagar is planned in the year **2021** with Peak Hour Peak Direction Capacity of 12000 @ **6 persons per square meter of standee area (Capacity of 15200 @ 8 persons per square meter of standee area under dense loading conditions)**.

- **Year 2031** (Refer **Attachment I/C**)

  Train operation with **6 car Trains** with headway of **3.5 min** between Dahisar East to D.N. Nagar is planned in the year **2031** with Peak Hour Peak Direction Capacity of 15429 @ **6 persons per square meter of standee area (Capacity of 19543 @ 8 persons per square meter of standee area under dense loading conditions)**.

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

Table 6.2 PHPDT Capacity Provided

	2019	2021	2031
Cars/trains	**3**	**3**	**3**
Head way (Minutes)	**5.25**	**4.50**	**3.50**
Max. PHPDT Demand	**10213**	**11560**	**15565**
PHPDT Capacity Available	**10286* (13029**)**	**12000* (15200**)**	**15429* (19543**)**

* @ 6 persons per square meter of standee area

** @ 8 persons per square meter of standee area

6.3.5 TRAIN FREQUENCY

Mumbai Metro (Dahisar East to D.N. Nagar Corridor)

The train operation Andheri- Dahisar corridor provides for the following:

a) The train operation plan provides for headway of 5.25, 4.50, and 3.50 minutes in the year 2019,2021 & 2031 respectively throughout the day except maintenance period 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 is presented in **Table 1.1,1.2 & 1.3** 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 D.N. Nagar corridor is given in **Table 3** enclosed as **Attachment IV**.

6.3.8 YEARWISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as **Attachment V** & has been tabulated below in Table 5.3 :

Table 5.3: Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	No. of car per rake	No. of Coaches
Dahisar East to D.N. Nagar corridor	2019	5.25	16	3	48
	2021	4.50	18		54
	2031	3.50	24		72

Requirement of coaches is calculated based on following assumptions:-

Assumptions -

(i) Train Composition planned as under:
3 Car Train Compositions : DMC+TC+DMC
Train Carrying Capacity of 3 Car
Train@6 person per square meter: 900 passengers
Train@8 person per square meter : 1140 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	:3
Composition	: DMC+TC+DMC(67% Motoring)
Power System[Kv/Hz]	:25 KV AC
Acceleration[m/s^2]	:1.0
Deceleration[m/s^2]	:1.0
Emergency Braking [m/s^2]	:1.35
Maximum Design speed[kmph]	:90
Track Gauge[mm]	:1435
Width over body of rolling Stock[mm]	:3200

6.5 Cost Estimate

The estimated cost per car at March’ 2015 Price level (exclusive of taxes and duties) may be assumed as Rs. 9.8 Crores per car. Total 16 rakes (48 cars) would be required in horizon year 2019 for Mumbai Metro (Dahisar East to D.N. Nagar corridor). Accordingly budget provision of INR 470.40 Crores is to be kept in the estimate for Rolling Stock, with revenue operation targeted for year 2019.

6.6 Recommendation

It is recommended that 3.2 m wide stock, suitable for SG may be adopted. Smaller rakes with 3 cars instead of 6 cars will enable us to achieve better headways for same PHPDT demand.

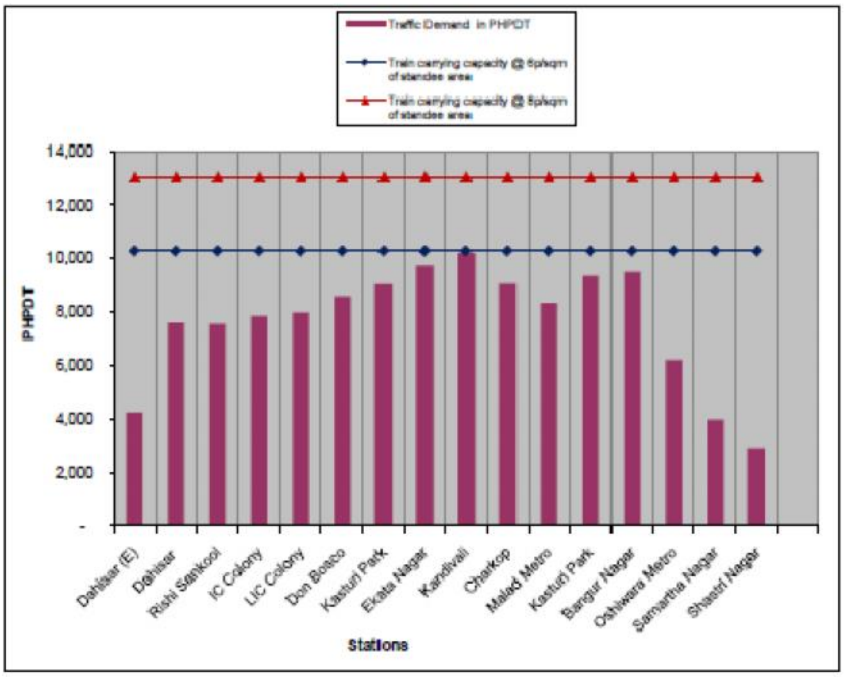
Attachment - I/A

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year:	2019
No. of cars per train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	900
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	1140
Headway (min)	5.25

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	4,231	10,286	13,029
2	Dahisar	Rishi Sankool	7,582	10,286	13,029
3	Rishi Sankool	IC Colony	7,547	10,286	13,029
4	IC Colony	LIC Colony	7,852	10,286	13,029
5	LIC Colony	Don Bosco	7,975	10,286	13,029
6	Don Bosco	Kasturi Park	8,582	10,286	13,029
7	Kasturi Park	Ekata Nagar	9,031	10,286	13,029
8	Ekata Nagar	Kandivali	9,725	10,286	13,029
9	Kandivali	Charkop	**10,213**	10,286	13,029
10	Charkop	Malad Metro	9,041	10,286	13,029
11	Malad Metro	Kasturi Park	8,330	10,286	13,029
12	Kasturi Park	Bangur Nagar	9,330	10,286	13,029
13	Bangur Nagar	Oshiwara Metro	9,484	10,286	13,029
14	Oshiwara Metro	Samartha Nagar	6,214	10,286	13,029
15	Samartha Nagar	Shastri Nagar	3,968	10,286	13,029
16	Shastri Nagar	D.N. Nagar	2,935	10,286	13,029



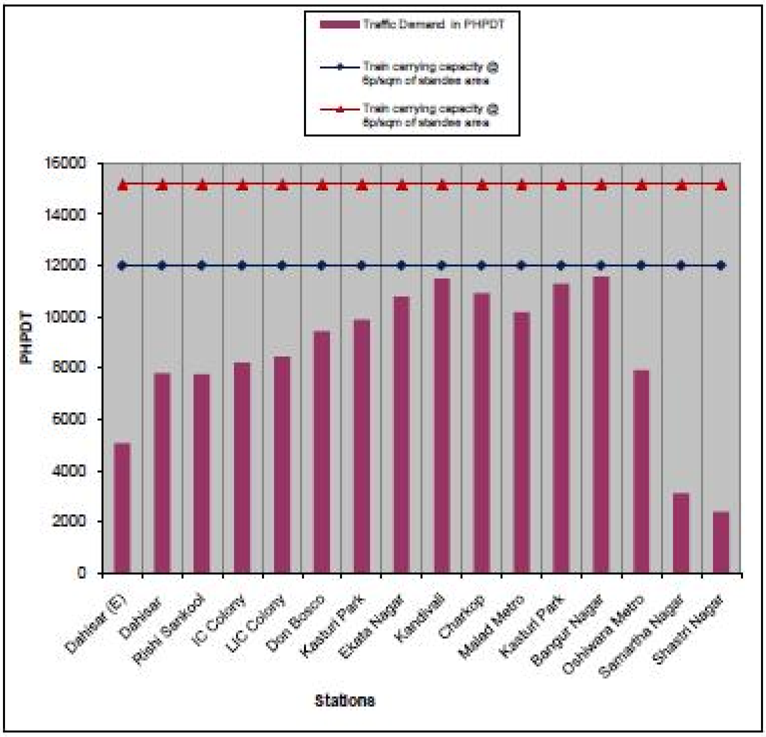
Attachment - I/B

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year:	2021
No. of cars per train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	900
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	1140
Headway (min)	4.50

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Dahisar (E)	Dahisar	5061	12,000	15,200
2	Dahisar	Rishi Sankool	7797	12,000	15,200
3	Rishi Sankool	IC Colony	7773	12,000	15,200
4	IC Colony	LIC Colony	8213	12,000	15,200
5	LIC Colony	Don Bosco	8457	12,000	15,200
6	Don Bosco	Kasturi Park	9433	12,000	15,200
7	Kasturi Park	Ekata Nagar	9885	12,000	15,200
8	Ekata Nagar	Kandivali	10788	12,000	15,200
9	Kandivali	Charkop	11502	12,000	15,200
10	Charkop	Malad Metro	10923	12,000	15,200
11	Malad Metro	Kasturi Park	10190	12,000	15,200
12	Kasturi Park	Bangur Nagar	11301	12,000	15,200
13	Bangur Nagar	Oshiwara Metro	11560	12,000	15,200
14	Oshiwara Metro	Samartha Nagar	7928	12,000	15,200
15	Samartha Nagar	Shastri Nagar	3115	12,000	15,200
16	Shastri Nagar	D.N. Nagar	2386	12,000	15,200



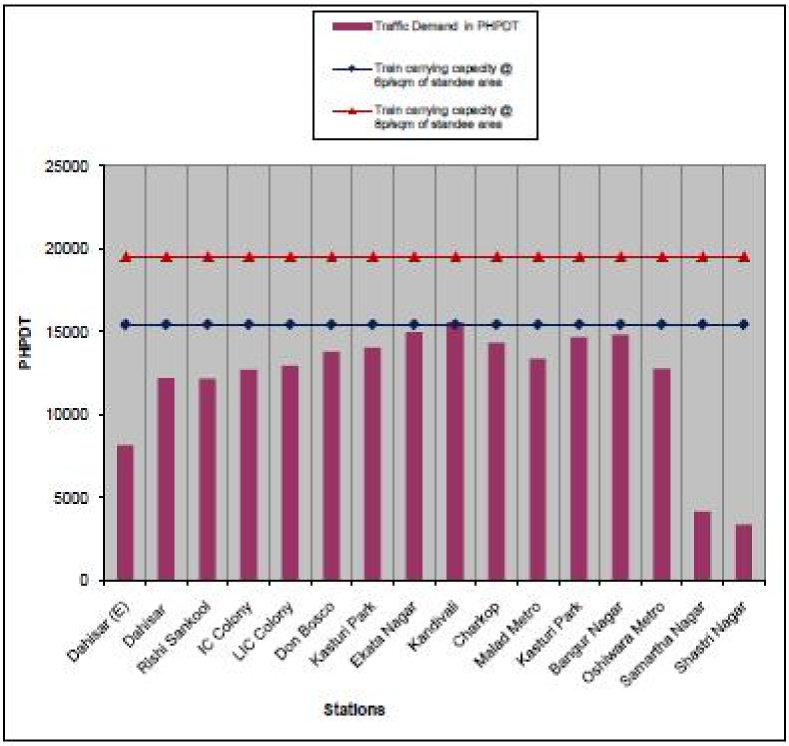
Attachment - I/C

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year:	2031
No. of cars per train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	900
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	1140
Headway (min)	3.50

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Dahisar (E)	Dahisar	8161	15,429	19,543
2	Dahisar	Rishi Sankool	12198	15,429	19,543
3	Rishi Sankool	IC Colony	12154	15,429	19,543
4	IC Colony	LIC Colony	12707	15,429	19,543
5	LIC Colony	Don Bosco	12958	15,429	19,543
6	Don Bosco	Kasturi Park	13802	15,429	19,543
7	Kasturi Park	Ekata Nagar	14034	15,429	19,543
8	Ekata Nagar	Kandivali	14958	15,429	19,543
9	Kandivali	Charkop	15565	15,429	19,543
10	Charkop	Malad Metro	14334	15,429	19,543
11	Malad Metro	Kasturi Park	13377	15,429	19,543
12	Kasturi Park	Bangur Nagar	14660	15,429	19,543
13	Bangur Nagar	Oshiwara Metro	14822	15,429	19,543
14	Oshiwara Metro	Samartha Nagar	12756	15,429	19,543
15	Samartha Nagar	Shastri Nagar	4137	15,429	19,543
16	Shastri Nagar	D.N. Nagar	3353	15,429	19,543



Attachment- II

TABLE 1.1

Hourly Train Operation Plan

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year- 2019

5.25 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	**5.25**	**11**	**11**
9 to 10	**5.25**	**11**	**11**
10 to 11	**5.25**	**11**	**11**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	16	3	3
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.25**	**12**	**12**
18 to 19	**5.25**	**11**	**11**
19 to 20	**5.25**	**12**	**12**
20 to 21	8	8	8
21 to 22	12	5	5
22 to 23	16	3	3
Total No. of train trips per direction per day		**134**	**134**

TABLE 1.2
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year- 2021
4.5 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.5**	**13**	**13**
9 to 10	**4.5**	**14**	**14**
10 to 11	**4.5**	**13**	**13**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	3	3
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4.5**	**14**	**14**
18 to 19	**4.5**	**13**	**13**
19 to 20	**4.5**	**14**	**14**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	3	3
Total No. of train trips per direction per day		**155**	**155**

TABLE 1.3
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to D.N. Nagar Corridor)
Year- 2031

3.5 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3.5**	**18**	**17**
9 to 10	**3.5**	**18**	**17**
10 to 11	**3.5**	**18**	**17**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3.5**	**17**	**18**
18 to 19	**3.5**	**17**	**18**
19 to 20	**3.5**	**17**	**18**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
Total No. of train trips per direction per day		**197**	**197**

Attachment III

TABLE 2

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

PHPDT for the year 2019

S.No	From Station	To Station	Peak hour Load	Directional Split to Dahisar (E)	Directional Split to D.N. Nagar
1	Dahisar (E)	Dahisar	4,231	50%	50%
2	Dahisar	Rishi Sankool	7,582	50%	50%
3	Rishi Sankool	IC Colony	7,547	50%	50%
4	IC Colony	LIC Colony	7,852	50%	50%
5	LIC Colony	Don Bosco	7,975	50%	50%
6	Don Bosco	Kasturi Park	8,582	50%	50%
7	Kasturi Park	Ekata Nagar	9,031	50%	50%
8	Ekata Nagar	Kandivali	9,725	50%	50%
9	Kandivali	Charkop	**10,213**	50%	50%
10	Charkop	Malad Metro	9,041	50%	50%
11	Malad Metro	Kasturi Park	8,330	50%	50%
12	Kasturi Park	Bangur Nagar	9,330	50%	50%
13	Bangur Nagar	Oshiwara Metro	9,484	50%	50%
14	Oshiwara Metro	Samartha Nagar	6,214	50%	50%
15	Samartha Nagar	Shastri Nagar	3,968	50%	50%
16	Shastri Nagar	D.N. Nagar	2,935	50%	50%

Attachment IV

TABLE 3

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Vehicle Kilometer

Year	2019	2021	2031
Section Length	17.88	17.88	17.88
No of cars per train	3	3	3
No of working Days in a year	340	340	340
Number of Trains per day each Way	134	155	197
Daily Train -KM	4792	5543	7045
Annual Train - KM (10^5)	16.29	18.85	23.95
Annual Vehicle - KM (10^5)	48.88	56.54	71.86

Attachment-V

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered * (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(3-car configuration)	
1	Mumbai Metro(Dahisar East to D.N. Nagar Corridor)	17.88	35	2019	5.25	30.65	6	0	6	67.30	13	1	2	16	**48**

Year-2021

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered * (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(3-car configuration)	
1	Mumbai Metro(Dahisar East to D.N. Nagar Corridor)	17.88	35	2021	4.50	30.65	6	0	6	67.30	15	1	2	18	**54**

Year-2031

S. No.	Section	Length (km)	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered * (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement				Total cars
											Bare	Traffic Reserve	R&M	Total No. Of Rakes(3-car configuration)	
1	Mumbai Metro(Dahisar East to D.N. Nagar Corridor)	17.88	35	2031	3.50	30.65	6	0	6	67.30	20	1	3	24	**72**

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

CHAPTER 6B

TRAIN OPERATION PLAN AND ROLLING STOCK

6.1. OPERATION PHILOSOPHY

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

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

6.2 STATIONS

Details of stations for Mumbai Metro (Dahisar East to D.N. Nagar Corridor) are given below:

Details of Stations

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)			
S. No.	Station Name	Chainage(m)	Inter Distance between two Stations
0	Dead End	(-)413.941	
1	Dahisar (E)	0.0	413.941
2	Dahisar (W)	711.0	711.0
3	Rishi Sankool	2422.7	1711.7
4	IC Colony	3383.1	960.4
5	LIC Colony	4468.4	1085.3
6	Don Bosco	5537.5	1069.1
7	Kasturi Park	6465.9	928.4
8	Ekata Nagar	7571.8	1105.9
9	Kandivali	8200.3	628.5
10	Charkop	9535.5	1335.2
11	Malad Metro	10846.0	1310.5
12	Kasturi Park	12243.4	1397.4
13	Bangur Nagar	13183.1	939.7
14	Oshiwara Metro	14455.5	1272.4
15	Samartha Nagar	15468.7	1013.2
16	Shastri Nagar	16433.0	964.3
17	D.N. Nagar	17578.6	1128.8
	Dead End	18175.0	596.4

6.3 TRAIN OPERATION PLAN

6.3.1 Salient Features:

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

6.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Dahisar East to D.N. Nagar for the year 2019,2021 and 2031 for the purpose of planning are indicated in Attachment I/A, I/B & I/C 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 D.N. Nagar corridor) for the year 2019,2021 and 2031 as detailed below:

Train operation plan for Dahisar East to D.N. Nagar with train carrying **capacity @ 6 persons per square meter of standee area** on Mumbai Metro (Dahisar East to D.N. Nagar corridor) is given below:

- **Year 2019** (Refer **Attachment I /A**)

Train operation with **6 car Trains** with headway of **3.5 min** between Dahisar East to D.N. Nagar 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/B**)

Train operation with **6 car Trains** with headway of **3 min** between Dahisar East to D.N. Nagar is planned in the year **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/C**)

Train operation with **6 car Trains** with headway of **2.75 min** between Dahisar East to D.N. Nagar is planned in the year **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 on this corridor in different years of operation is given below :

PHPDT Capacity Provided

	2019	2021	2031
Cars/trains	**6**	**6**	**6**
Head way (Minutes)	**3.5**	**3**	**2.75**
Max. PHPDT Demand	**29373**	**35142**	**38509**
PHPDT Capacity Available	**30103* (38469**)**	**35120* (44880**)**	**38313* (48960**)**

* @ 6 persons per square meter of standee area

** @ 8 persons per square meter of standee area

6.3.5 TRAIN FREQUENCY

Mumbai Metro (Dahisar East to D.N. Nagar corridor)

The train operation plan provides for headway of 3.5, 3.0, and 2.75 minutes in the year 2019,2021 & 2031 respectively throughout the day except maintenance period.

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 is presented in **Table 1.1,1.2 & 1.3** 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 D.N. Nagar corridor is given in **Table 3** enclosed as **Attachment IV**.

6.3.8 YEARWISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as **Attachment V** & has been tabulated below :

Year wise Rake requirement

Corridor	Year	Headway (min)	No. of Rakes	No. of car per rake	No. of Coaches
Dahisar East to D.N. Nagar corridor	2019	3.5	24	6	144
	2021	3	27		162
	2031	2.75	29		174

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. 9.8 Crores per car. Total 24 rakes (144 cars) would be required in horizon year 2019 for Mumbai Metro (Dahisar East to D.N. Nagar corridor). Accordingly budget provision of INR 1411.20 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(upto approximately 1,08,000), the train consist of 9 cars can be adopted in future. In case such scenario is planned, platform lengths shall be planned for 9 car trains. Also, it is recommended that 3.2 m wide stock, suitable for SG may be adopted.

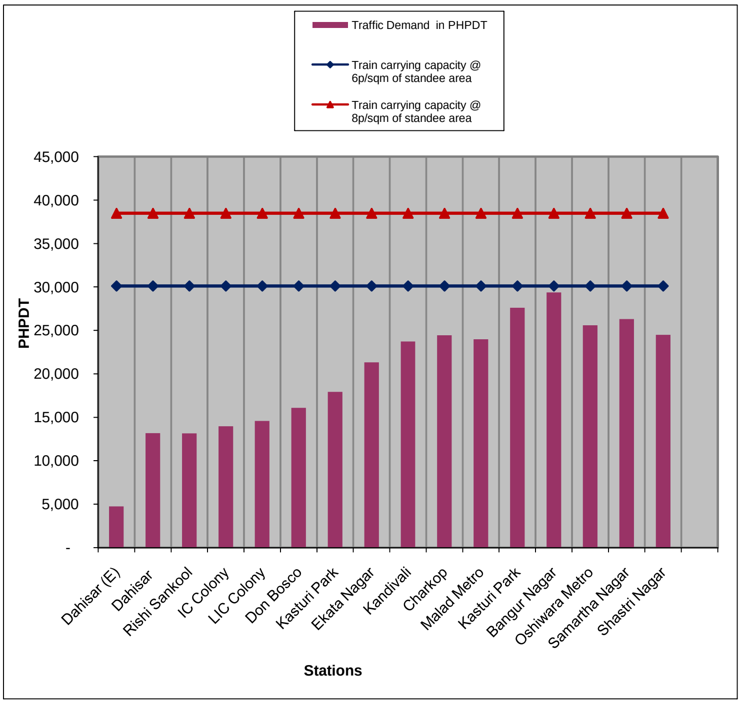
Attachment - I/A

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to D.N. Nagar 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**

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	4,744	30,103	38,469
2	Dahisar	Rishi Sankool	13,177	30,103	38,469
3	Rishi Sankool	IC Colony	13,143	30,103	38,469
4	IC Colony	LIC Colony	13,977	30,103	38,469
5	LIC Colony	Don Bosco	14,572	30,103	38,469
6	Don Bosco	Kasturi Park	16,101	30,103	38,469
7	Kasturi Park	Ekata Nagar	17,931	30,103	38,469
8	Ekata Nagar	Kandivali	21,316	30,103	38,469
9	Kandivali	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



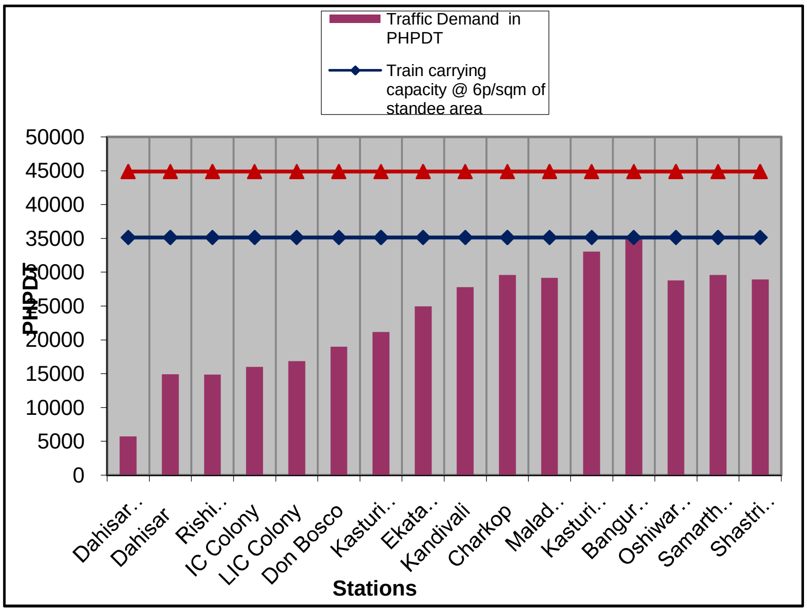
Attachment - I/B

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year:	**2021**
No. of cars per train	**6**
ssenger Capacity @ 6 persons/sqm of a 6-Car Train:	**1756**
ssenger Capacity @ 8 persons/sqm of a 6-Car Train:	**2244**
Headway (min)	**3.00**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee	Train carrying capacity @ 8p/sqm of standee area
1	Dahisar (E)	Dahisar	5709	35,120	44,880
2	Dahisar	Rishi Sankool	14907	35,120	44,880
3	Rishi Sankool	IC Colony	14883	35,120	44,880
4	IC Colony	LIC Colony	15999	35,120	44,880
5	LIC Colony	Don Bosco	16859	35,120	44,880
6	Don Bosco	Kasturi Park	18986	35,120	44,880
7	Kasturi Park	Ekata Nagar	21187	35,120	44,880
8	Ekata Nagar	Kandivali	24950	35,120	44,880
9	Kandivali	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



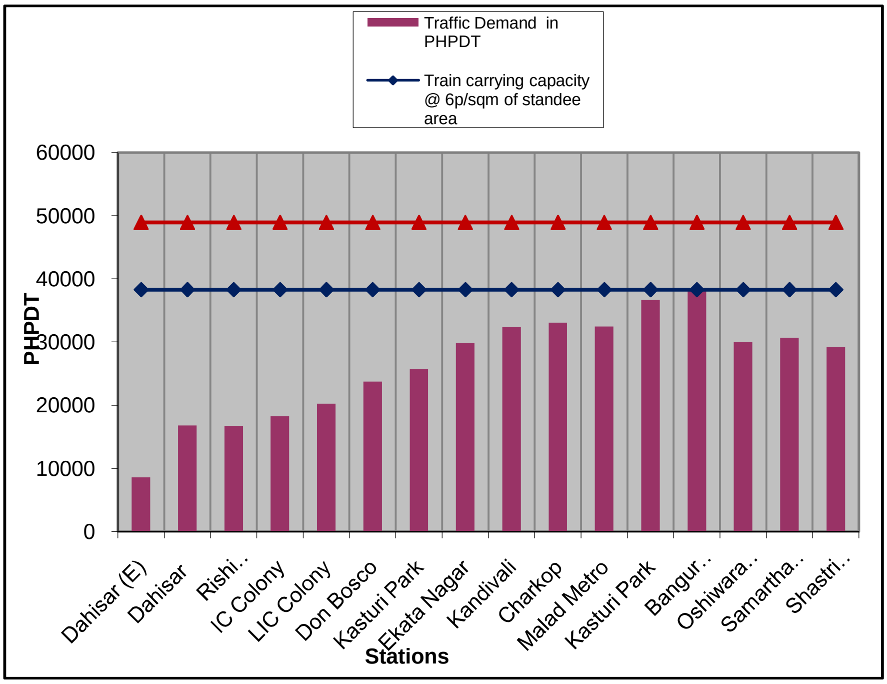
Attachment - I/C

PHPDT Demand and Capacity Chart

Mumbai Metro(Dahisar East to D.N. Nagar 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**

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	8580	38,313	48,960
2	Dahisar	Rishi Sankool	16764	38,313	48,960
3	Rishi Sankool	IC Colony	16721	38,313	48,960
4	IC Colony	LIC Colony	18282	38,313	48,960
5	LIC Colony	Don Bosco	20252	38,313	48,960
6	Don Bosco	Kasturi Park	23759	38,313	48,960
7	Kasturi Park	Ekata Nagar	25691	38,313	48,960
8	Ekata Nagar	Kandivali	29881	38,313	48,960
9	Kandivali	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



Attachment- II

TABLE 1.1
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year- 2019

3.5 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3.5**	**17**	**17**
9 to 10	**3.5**	**17**	**17**
10 to 11	**3.5**	**17**	**17**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3.5**	**18**	**18**
18 to 19	**3.5**	**17**	**17**
19 to 20	**3.5**	**18**	**18**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
Total No. of train trips per direction per day		**196**	**196**

TABLE 1.2
Hourly Train Operation Plan
Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

Year- 2021

3 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3**	**20**	**20**
9 to 10	**3**	**20**	**20**
10 to 11	**3**	**20**	**20**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3**	**20**	**20**
18 to 19	**3**	**20**	**20**
19 to 20	**3**	**20**	**20**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
Total No. of train trips per direction per day		**212**	**212**

TABLE 1.3
Hourly Train Operation Plan
Mumabi Metro(Dahisar East to D.N. Nagar Corridor)
Year- 2031

2.75 min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	8
6 to 7	6	10	10
7 to 8	4	15	15
8 to 9	**2.75**	**22**	**21**
9 to 10	**2.75**	**22**	**21**
10 to 11	**2.75**	**22**	**21**
11 to12	4	15	15
12 to 13	6	10	10
13 to 14	8	8	8
14 to 15	8	8	8
15 to 16	6	10	10
16 to 17	4	15	15
17 to 18	**2.75**	**21**	**22**
18 to 19	**2.75**	**21**	**22**
19 to 20	**2.75**	**21**	**22**
20 to 21	4	15	15
21 to 22	6	10	10
22 to 23	8	8	8
Total No. of train trips per direction per day		**261**	**261**

Attachment III

TABLE 2

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)

PHPDT for the year 2019

S.No	From Station	To Station	Peak hour Load	Directional Split to Dahisar (E)	Directional Split to D.N. Nagar
1	Dahisar (E)	Dahisar	4,744	50%	50%
2	Dahisar	Rishi Sankool	13,177	50%	50%
3	Rishi Sankool	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	Kasturi Park	16,101	50%	50%
7	Kasturi Park	Ekata Nagar	17,931	50%	50%
8	Ekata Nagar	Kandivali	21,316	50%	50%
9	Kandivali	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%

Attachment IV

TABLE 3

Mumbai Metro(Dahisar East to D.N. Nagar Corridor)
Vehicle Kilometer

Year	2019	2021	2031
Section Length	17.88	17.88	17.88
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	196	212	261
Daily Train -KM	7009	7582	9334
Annual Train - KM (10^5)	23.83	25.78	31.74
Annual Vehicle - KM (10^5)	142.98	154.67	190.41

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 D.N. Nagar Corridor)	17.88	35	2019	3.50	30.65	6	0	6	67.30	19.23	20	1	3	24	**144**

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 D.N. Nagar Corridor)	17.88	35	2021	3.00	30.65	6	0	6	67.30	22.43	23	1	3	27	**162**

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 D.N. Nagar Corridor)	17.88	35	2031	2.75	30.65	6	0	6	67.30	24.47	25	1	3	29	**174**

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

Chapter – 7A

MAINTENANCE DEPOT

7.1 General

Corridor: Dahisar (E) - D. N. Nagar corridor comprises as below:

Corridor	Route length(Km)
Dahisar(E) - D. N. Nagar corridor	18.589 Km

7.2 Depot- cum- Workshop at 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 two trains set of 3- Car each and space earmarked for future provision.
(iii) All Stabling lines are designed to accommodate two trains of 3- 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. 363 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	16	48
2021	18	54
2031	24	72

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	16	7 lines x two train of 3-car each	One bay of 3 lines each with two trains of 3- cars length. One line is required from year 2019 and catering up to 2031.Rest two lines is kept for future provision.	Two bays of 2 lines each with two trains of 3- cars length are required from year 2019 and catering up to year 2031.
2021	18	8 lines x two train of 3-car each		
2031	24	11 lines x two train of 3-car each		

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 16 TS x3 (= 48 Cars)		
'A' Checks (5000 km) approx. 15 days	(16X3) Cars = 48 Cars	1 Line x two train of 3- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(16X3) Cars = 48 Cars	
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	
Requirement		1 Bay of 3 lines. One line is required from year 2019 and catering up to year 2031.
ii) Year 2021 - Maximum no. of rake holding is 18 TS x3 (= 54 Cars)		
'A' Checks (5000 km) approx. 15 days	(18X3) Cars = 54 Cars	1 Line x two train of 3- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(18X3) Cars = 54 Cars	
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	
Requirement		1 Bay of 3 lines. One line is required from year 2019 and catering up to year 2031.

iii) Year 2031 - Maximum no. of rake holding is 24 TS x3 (= 72 Cars)		
'A' Checks (5000 km) approx. 15 days	(24X3) Cars = 72 Cars	1 Line x two train of 3- Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(24X3) Cars = 72 Cars	
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	
Requirement		1 Bay of 3 lines. One line is required from year 2019 and catering up to year 2031.

7.7 Inspection requirements at depot :

Facilities for carrying out inspection activitities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks and "B" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off peak and night. Since "B" checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for "A" checks. For "B" checks, separate line will be nominated where the rakes may be kept for long time.

7.8 Design of Depot- cum- Workshop Facilities

7.8.1 Stabling lines at depot:

As per advised dimensions of the Rolling Stock, the length of 3-Car train would be Approx.67.8 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 3- car rake= 67.8 m

(ii) Gap between two trains 3-car rakes = 10m

(iii) Free length at outer ends of two trains of 3- cars (for cross pathway, Signal and Friction buffers)= 10m each side

(iv) Total length of Stabling lines = (iii)+(i)+(ii)+(i)+(iii)= 10+ 67.8+ 10+ 67.8+ 10= 165.6m ≈ 166m

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 a 3-car rake= 67.8 m.

(ii) Gap between two trains of 3- cars= 10 m

(iii) Cross- path at each end= 10 m

(iv) Length of Inspection line= (iii)+ (i)+(ii)+ (i)+ (iii) = 10+ 67.8 + 10+ 67.8 + 10= 165.6m ≈ 166m

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the two lines= 7.5 m

(ii) Centre line of outer lines to column of Shed= 3m

(iii) Width of a 3 line Inspection Bay= (ii)+(i)+(i)+(ii)= 3+ 7.5+ 7.5+3= 21 m

a) There shall be one inspection bay of 166 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	Unscheduled repairs /lifting	Total	Remarks
2019	1	2 lines, each of 3-Car train and free space for storage of other equipment.	1 lines x 2 train of 3 Car train length.	Two bays of 2 lines each is to be required for the year 2019 and catering up to year 2031.	The size of workshop shall be the same as inspection bay i.e. 166X21 m with one working bay comprising of two trains lines capable of accommodating two trains 3-car rakes with Bogie turning facility, one line of 3-car rake length with free space of 3-car rake length for storage of wheel/bogie/ equipments etc.
2021	-do-	-do-	-do-		
2031	-do-	-do-	-do-		

(a) There shall be one bay comprising of two lines each (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 166m 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. 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 with turn tables. Each workshop bay shall be equipped with two 15T and 3T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be provided space for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AWo (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 166 x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two trains 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 depots.

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 in depots.

I. Inspection and Workshop facilities:
As indicated in 7.8.2 & 7.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 7.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.
b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated Para 7.12.1.

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 3-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 underground 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 traction supply system equipments.

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 trains 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 in Para7.12.1. 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 in Para 7.12.1, Para 7.12.2.

7.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.

b) Red flashers 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 inbuilt feature at the end of Heavy repair bay.

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 supply system 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 at least two openable 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 traction supply 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. 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	166m x 21m	Servicing of Cars for 15 days & 45 days inspection.
	Workshop Shed	166m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	166m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	166m x 37m (initial provision for 16 rakes only) for year 2019.	Additional Earmarking of area as per requirement of stabling line during years is to be made.
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	40m 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	166m 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.	Watch Tower (4 Nos.)	3.6m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 750VDC/33kV/66 kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	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.
22.	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.
23.	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 :

Sl. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Re-railing equipments	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	High capacity vacuum cleaner	2	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (including Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools	-	Set
28.	Measuring and testing equipment	-	Set
29.	Tool Kits	-	Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV for carrying of re-railing equipments including container	1	No.
34.	Road vehicles (pickup van/ truck)	1	Set

35.	Miscellaneous office equipments	-	Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.
38.	Special jigs and fixtures and test benches for Rolling Stock	1	set
39.	Stackers (1T for DCOS)	2	No.
40.	Storage Racks (W/shop & DCOS stores)	1	Set
41.	Test benches	1	Set
42.	Battery operated platform truck	1	No.
43.	Vehicle mounted crane	1	No.
44.	Impulse Tester for TMs	1	No.
45.	Bearing puller	1	No.
46.	Truck	1	No.
47.	Wheel profile meters	1	No.
48.	High rise work lift platform(HRWP)	1	No.
49.	Video Diagnostic equipments for traction motor	1	No.

Charkop Depot Location Plan 20 Ha. Land (Approx)

CHAPTER 7B

MAINTENANCE DEPOT

7.1 General

Corridor: Dahisar East-D.N.Nagar corridor comprises as below:

Corridor	Route length(Km)
Dahisar (E) - D.N.Nagar corridor	18.589 Km

7.2 Depot- cum- Workshop at 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 9- Car each and space earmarked for future provision.
(iii) All Stabling lines are designed to accommodate one trains of 9- 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. 352 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	24	144
2021	27	162
2031	29	174

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	24	22 lines x one train of 9-car length	One bay of 3 lines each with one train of 9- cars. All the three lines are required from the year 2019 and catering up to 2031.	Two bays of 2 lines each with one train of 9- car length. All the four lines are required from year 2019 and catering up to year 2031.
2021	27	25 lines x one train of 9-car length		
2031	29	27 lines x one train of 9-car length		

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 24 TS x6 (= 144 Cars)		
'A' Checks (5000 km) approx. 15 days	(24X6) Cars = 144 Cars	1 Line x one train of 9-Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(24X6) Cars = 144 Cars	1 Line x one train of 9-Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 9-Cars (with Sunken Floor)
Requirement		1 Bay of 3 lines. 3 lines are required from year 2019 and catering up to year 2021.
ii) Year 2021 - Maximum no. of rake holding is 27 TS x6 (= 162 Cars)		

'A' Checks (5000 km) approx. 15 days	(27X6) Cars = 162 Cars	1 Line x one train of 9-Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(27X6) Cars = 162 Cars	1 Line x one train of 9-Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 9-Cars (with Sunken Floor)
Requirement		No additional requirement
iii) Year 2031 -Maximum no. of rake holding is (29 x6 = 174Cars)		
'A' Checks (5000 km) 15 days	(29 X 6) Cars = 174 Cars	1 Line x one train of 9-Cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	(29 X 6) Cars = 174 Cars	1 Line x one train of 9-Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 9-Cars (with Sunken Floor)
Requirement		No additional requirement

7.7 Inspection requirements at depot :

Facilities for carrying out inspection activitities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks and "B" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off peak and night. Since "B" checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for "A" checks. For "B" checks, separate line will be nominated where the rakes may be kept for long time.

7.8 Design of Depot- cum- Workshop Facilities

7.8.1 Stabling lines at depot:

As per advised dimensions of the Rolling Stock, the length of 9- Car train would be Approx. 207 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 9- Car rake= 207 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+207+11= 229 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 9- Car rake=207 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+207+11= 229m 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 229 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	Unscheduled repairs /lifting	Total	Remarks
2019	2 lines of 9-Car train and free space for storage of other equipment.		2 lines each of 9 Car train length.	Two bays of 2 lines each with one trains of 9- cars is to be required for the year 2019 and catering up to year 2031.	The size of one workshop bay shall be 229 X 21 m comprising of two lines capable of accommodating one train of 9-Car each with Bogie turn table facility, with free space for storage of wheel/ bogie/ equipments etc.
2021	-do-	-do-	-do-		
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 229m 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 229 x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor
10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs
16. Couplers/Gangways
17. Coach Painting (Applicable only for Aluminum coaches, if any)

7.9 Car Delivery Area

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum- Workshop by rail.

However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

7.10 Operational Features

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

7.11 Infrastructure Facilities

I. Inspection and Workshop facilities:

As indicated in 7.8.2 & 7.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 7.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Annexure I.

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 9- Car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building
An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

i) Close to the depot entry.

ii) Close to the stabling lines.

iii) Close to the Workshop/IBL.

b) Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated at Para 7.12.1. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given at Paras 7.12.1 & 7.12.2.

7.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.

b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is ‘Live’.

c) Multi level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.

d) Pillars in the inspection bay & workshop should have provision for power sockets.

e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.

f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.

g) Control Centre, PPIO & store depot must be close to Workshop.

h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.

i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior of buildings for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

7.12 List of Buildings & List of Plants & Equipments at Depot-cum-workshop :

7.12.1 List of Buildings at Depot-cum-workshop :

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	229m x 21m	Servicing of Cars for 15 days & 45 days inspection.
	Workshop Shed	229 x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	229m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	229m x 117m	Initial Provision is kept for year 2019 of 24 rakes only, Future Provision is to be made upto year 2031.
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control.

			iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	60m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	160m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
12.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
13.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
14.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
15.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply

16.	Waste Collection Bin	10m x 10m	Garbage dumping
17.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
18.	Work shop Manager Office	30m x 20m	Office of Depot in charge
19.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
20.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
21.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
22.	Toilets -Gents -Ladies	 10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

7.12.2 List of Plants & Equipments at Depot-cum-Workshop :

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Re-railing equipments	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.

13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	High capacity vacuum cleaner	2	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (including Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools	-	Set
28.	Measuring and testing equipment	-	Set
29.	Tool Kits	-	Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV for carrying of rerailing equipments including container	1	No.
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments	-	Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.
38.	Special jigs and fixtures and test benches for Rolling Stock	1	set
39.	Stackers (1T for DCOS)	2	No.
40.	Storage Racks (W/shop & DCOS stores)	1	Set
41.	Test benches	1	Set
42.	Battery operated platform truck	1	No.
43.	Vehicle mounted crane	1	No.
44.	Impulse Tester for TMs	1	No.
45.	Bearing puller	1	No.
46.	Truck	1	No.
47.	Wheel profile meters	1	No.
48.	High rise work lift platform(HRWP)	1	No.
49.	Video Diagnostic equipments for traction motor	1	No.

Charkop Depot Location Plan 20 Ha. Land (Approx)

Chapter – 8A

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**
Dahisar (E) to D. N. Nagar 17 Stations (18.30 km)	Traction	11.95	13.94	17.65
	Auxiliary	7.72	10.13	13.59
	Total	**19.67**	**24.07**	**31.24**

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 15,565 passengers per direction during peak hours when trains are expected to run at 3.5 minutes intervals. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220, 110 or 66 kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

8.3 Sources of Power Supply

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

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

Table 8.2 Sources of Power Supply

S. No.	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length cables from GSS to RSS
1.	**Dahisar (E) to D. N. Nagar** 17 Stations (18.589 km)	110 kV Grid Sub Station (GSS) Near Malad	RSS at Charkop Depot.	To be confirmed by TATA Power
		110 kV Grid Sub Station (GSS) Near Borivli	*RSS Near Dahisar(E) Depot	To be confirmed by TATA Power

*This RSS already considered in Andheri to Dahisar DPR.

As per Tata Power letter No. CDD/LR-N 4040/13674 dated 04.02.2010 Tata Power Company have assured that reliable power supply from their 110 kV Borivli Sub-station will be provided for Dahisar Depot RSS and 110 kV, Malad Grid Sub Station (GSS) for Supply of Charkop Depot RSS (Annexure – 8.2). During the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 8.3.

Table 8.3 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand** – Emergency (MVA)	
		Year (2019)	Year (2031)	Year (2019)	Year (2031)
Dahisar (E) to D. N. Nagar 17 Stations (18.30 km)	**RSS at Charkop Depot**				
	Traction	6.80	9.93	11.95	17.65
	Auxiliary	5.09	8.34	7.72	13.59
	Sub-total (A)	**11.89**	**18.27**	**19.67**	**31.24**
	RSS Near Dahisar Station*				
	Traction	9.84	14.35	11.95	17.65
	Auxiliary	7.58	13.29	7.72	13.59
	Sub-total (B)	**17.42**	**27.64**	**19.67**	**31.24**

* In Normal Condition Dahisar RSS will also take half load of Andheri to Dahisar Corridor

** 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 at Charkop Depot station shall be provided with 2 Nos. (One as standby) 110/25 kV, 21 MVA (ONAN) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 110/33 kV, 15 MVA (ONAN) three phase Transformers for feeding auxiliary loads and RSS Near Dahisar Depot shall also be provided with 2 Nos. (One as standby) 110/ 25 kV, 21 MVA (ONAN) Traction Transformers for feeding Traction load and 2 Nos. (One as standby) 110/ 33 kV, 15 MVA (ONAN) three phase Transformers for feeding auxiliary loads. The capacity of transformers may be reviewed considering the load requirement/distribution of Andheri to Dahisar corridor also at the time of detailed design.

Conventional Outdoor type 110 kV Switchgear is proposed for all the RSS to be located in approx. 100 X 80 m (8000 sq. m) land plot as the availability of Land in this area may not be a constraint. If Gas Insulated Switchgear (GIS) type Switchgear will be planned in future due to less space and reduced maintenance the capital cost need to be enhanced. 110 kV GIS substation land requirement will be approx. 60 X 70 m (4200 sq. m). In that case the cost of sub-station works will increase by nearly Rs. 10 Crores per 110 kV RSS with respect to conventional substation.

8.4 Various options of Traction system:-

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

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

A sub- committee set up by "Ministry of Urban Development" on Traction system for metro railway has studies various aspects of merits and demerits of various traction system. The following are the highlights of Report:-

Merits and Demerits of various traction systems

a) **25 kV AC with OCS (Flexible/rigid):-Merits**

- **Reduced cost** – Unlike dc traction this system, does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in cost. Cost of 25 kV AC traction systems is about 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.

In view of above techno-economic considerations, 25 kV AC traction 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).

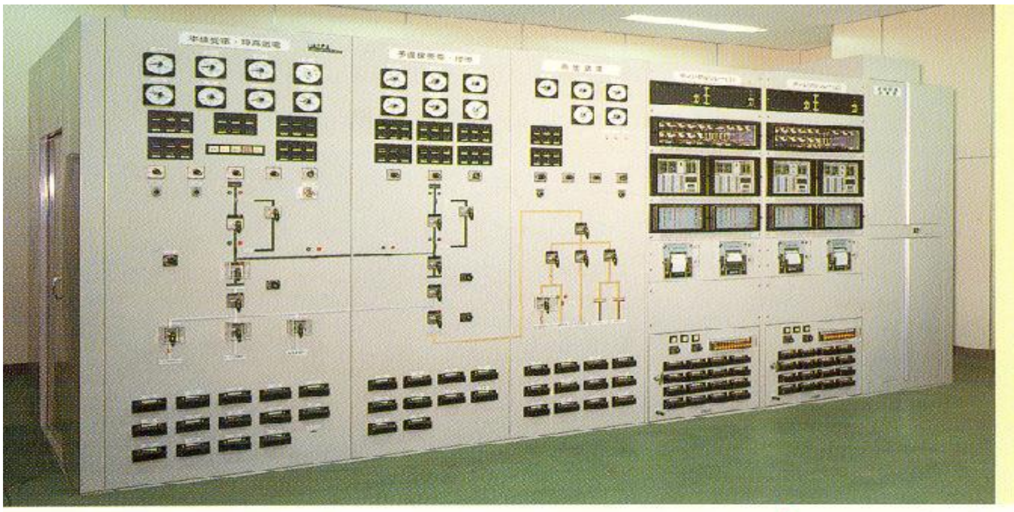
8.7 Auxiliary Supply Arrangements for DEPOT

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 107 sqmm silver copper contact wire and 65 sq.mm Cd-copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be All Aluminum Conductor (AAC) of 93.3 sq.mm cross section. For tensioning of OHE, ATD shall be a mix of spring ATD (50%) and 5 pulley ATD (balance 50%) spring ATD shall not be having counterweight and shall be provided at critical location like road crossing etc. Proven catenary fittings are proposed similar to DMRC system.

8.9 Rating of Major Equipment

Based on emergency demand expected at each RSS as shown in Table 8.3, and expected power demand during emergency, RSS at Charkop Depot shall be provided with 2 Nos. of (One to be in service and one as standby) 110/25 kV, 21 MVA Traction Transformers for feeding traction load and 2 Nos. of (One to be in service and one as standby) 110/33 kV, 15 MVA three phase transformers for feeding auxiliary loads. RSS at Dahisar Depot shall also be provided with 2 Nos. of (One to be in service and one as standby) 110/25 kV, 21 MVA Traction Transformers for feeding traction load and 2 Nos. of

(One to be in service and one as standby) 110/33 kV, 15 MVA three phase transformers for feeding auxiliary loads. The incoming cable shall be 3-phase single core XLPE insulated with 630 mm^2 Aluminum conductors to meet the normal & emergency loading requirements and fault level of the 110 kV supply.

33 kV and 25 kV switchgear shall be rated for 1250 A being standard design. 33 kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of Single core 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 59.01 million units in initial years 2019, which will be about 92.30 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 8.46 per unit**. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro.

MUMBAI METRO ANNEXURE - 8.1

DAHISAR (E) TO D. N. NAGAR

POWER REQUIREMENT

(25 kV AC TRACTION SYSTEM)

S.No	Particulars	Year 2019		Year 2021		Year 2031	
A	**Traction Power Requirements**	1	2	3	4	5	6
1	No. of cars	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)
2	Passenger Weight	145.86	T	145.86	T	145.86	T
3	Train Tare Weight	251.68	T	251.68	T	251.68	T
4	Total Train Weight	397.5	T	397.5	T	397.5	T
5	Section Length	18.30	KM	18.30	KM	18.30	KM
6	Headway	5.25	mts	4.50	mts	3.5	mts
7	Specific Energy Consumption	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM	80	KWhr/ 1000 GTKM
8	No. of Trains/hr in both directions	23	Nos.	27	Nos.	34	Nos.
9	Peak Traction Power Requirement	13.30	MW	15.52	MW	19.95	MW
10	Less Regeneration @ 30%	3.99	MW	4.65	MW	5.98	MW
11	Depot Power Requirements	1.50	MW	1.75	MW	2.00	MW
12	Total Traction Power Requirement	10.81	MW	12.61	MW	15.96	MW
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**11.95**	**MVA**	**13.94**	**MVA**	**17.65**	**MVA**
B	**Aux. Power Requirements**						
1	Elevated/at-grade Station Power Consumption	0.25	MW	0.35	MW	0.50	MW
2	Underground station Power Consumption	2.00	MW	2.25	MW	2.50	MW
3	No. of Elevated/at-grade Stations	17	Nos.	17	Nos.	17	Nos.
4	No. of Underground stations	0	No.	0	No.	0	No.
5	Total Station Aux Power Requirement	4.25	MW	5.95	MW	8.50	MW
6	Depot Aux Power Requirement	2.00	MW	2.25	MW	2.50	MW
7	Total Aux Power Requirement	6.25	MW	8.20	MW	11.0	MW
	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for aux loads	**7.72**	**MVA**	**10.13**	**MVA**	**13.59**	**MVA**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**19.67**	**MVA**	**24.07**	**MVA**	**31.23**	**MVA**

Note: The requirement of PD load is not consided in estimation of power calculation.

MUMBAI METRO ANNEXURE - 8.1 A

DAHISAR (E) TO D. N. NAGAR

ENERGY CONSUMPTION

(25 kV AC TRACTION SYSTEM)

S.No.	Year	Year 2019		Year 2021		Year 2031	
A	**Traction Energy**	1	2	3	4	5	6
1	Section Length	18.30	KM	18.30	KM	18.30	KM
2	No. of Trains per direction in a day*	134	Nos.	155	Nos.	197	Nos.
3	Weight of Train & Passenger	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
	Yearly Traction Energy consumption with 365 days working with 30% regen	**39.84**	**million units**	**46.09**	**million units**	**58.58**	**million units**
B	**Station Aux. Energy**						
1	Elevated/at-grade Station	0.25	MW	0.35	MW	0.50	MW
2	Underground Station	2.00	MW	2.25	MW	2.50	MW
3	No. of Eevated/at-grade Stations	17	Nos.	17	Nos.	17	Nos.
4	No. of Underground Stations	0	No.	0	No.	0	No.
5	Total Station Aux. Power Requirement	4.25	MW	5.95	MW	8.50	MW
6	Depot Aux power requirement	2.00	MW	2.25	MW	2.50	MW
7	Total Aux. Power Requirement	6.25	MW	8.20	MW	11.00	MW
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	**7.72**	**MVA**	**10.13**	**MVA**	**13.59**	**MVA**
9	Diversity Factor of Aux. loads	0.40		0.40		0.40	
	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**19.16**	**million units**	**25.14**	**million units**	**33.73**	**million units**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**59.01**	**million units**	**71.23**	**million units**	**92.30**	**million units**

Note: The requirement of PD load is not consided in energy calculation.

ANNEXURE-8.2

TATA

4th February, 2010
CDD / LR-N 4040 / 13674

SPAN Consultants Pvt. Ltd.
C-505 to 508, Kukreja Centre
Sector 11, CBD Belapur
Navi Mumbai 400 614

Kind Attn: Mr R S Gupta
Sr Associate Director

Dear Sir,

Sub: Mumbai Metro Rail Project Phase II & III –
Requirement of power supply to two Metro Corridors

With reference to your letter No SCPL/ MUM/ C-843/ MMRDA / 40 dated 2nd February, 2010 we agree to supply the load from our Borivli and Malad 110kV Substation as per your requirements. The approx. cost of making available this power supply at Charkop and Dahisar Receiving Substations will be issued after conducting technical feasibility and preparation of cost estimate.

Tariff as approved by MERC from time to time will be applicable and copy of the tariff for FY10 is attached herewith for your perusal.

Thanking you and assuring you of our best attention at all times,

Yours faithfully,
THE TATA POWER COMPANY LTD.

4/2/2010
(H D THAKER)
CHIEF MANAGER

Encl: As above

TATA POWER
The Tata Power Company Limited
Consumer Development and Engineering Department Technopolis Knowledge Park Mahakali Caves Road Andheri East Mumbai 400 093
Tel 91 22 5668 8357 5668 8360 Fax 91 22 5668 8363
Registered Office Bombay House 24 Homi Mody Street Mumbai 400 001

Annexure - C-I

CHAPTER 8 B

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**
Dahisar (E) to D. N. Nagar 17 Stations (18.589 km)	Traction	17.09	19.94	21.85
	Auxiliary	7.72	10.13	13.59
	Total	**24.81**	**30.07**	**35.44**

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, 110 or 66 kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

8.3 Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in brief. The city has 220, 110 and 33 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.	**Dahisar (E) to D. N. Nagar** 17 Stations (18.589 km)	110 kV Grid Sub Station (GSS) Versova	RSS at DN Nagar	1 km approx.
		110 kV Grid Sub Station (GSS) Near Borivli	*RSS Near Dahisar(E) Depot	2 km approx.

*This RSS already considered in Andheri to Dahisar DPR.

M/s TATA Power Company vide their letter No. CDD/LR-N 4040/13674, dated 04.02.2010 has confirmed that they will provide two No, 110 kV bay from their 110 kV Malad Grid Substation to Charkop Receiving Substation (RSS) (Annexure – 8.2). M/s TATA Power Company has shown their inability in the meeting held on 03.09.2015 for providing two No. 110 kV bay from Malad Grid Substation in present situation. They indicated that there is no spare bay & space presently. M/s TATA Power Company has confirmed that they will provide two No. 110 kV bay from their 110 kV Versova Grid Substation to DN Nagar Receiving Substation (RSS). (Annexure–8.3). During the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of TATA Power Company Limited. The summary of expected power demand at various sources is given in table 8.3.

Table 8.3 – Power Demand projections for various sources

Corridor	**Input Source**	**Peak demand – Normal (MVA)**		**Peak demand** – Emergency (MVA)**	
		Year (2019)	Year (2031)	Year (2019)	Year (2031)
Dahisar (E) to D. N. Nagar 17 Stations (18.589 km)	**RSS at D N Nagar**				
	Traction	9.38	12.03	17.09	21.85
	Auxiliary	5.09	8.34	7.72	13.59
	Sub-total (A)	**14.47**	**20.27**	**21.81**	**35.44**
	RSS Near Dahisar Station*				
	Traction	12.42	16.45	17.09	21.85
	Auxiliary	7.57	13.29	7.72	13.59
	Sub-total (B)	**19.99**	**29.64**	**21.81**	**35.44**

* In Normal Condition Dahisar RSS will also take half load of Andheri to Dahisar Corridor

** 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 at DN Nagar 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, 15 MVA three phase Transformers for feeding auxiliary loads and RSS Near Dahisar Depot shall also be provided with 2 Nos. (One as standby) 110/ 25 kV, 21.6/30 MVA (ONAN/ONAF) Traction Transformers for feeding Traction load and 2 Nos. (One as standby) 110/ 33 kV, 15 MVA three phase Transformers for feeding auxiliary loads. The capacity of transformers may be reviewed considering the load requirement/distribution of Andheri to Dahisar corridor also at the time of detailed design.

Conventional Outdoor type 110 kV Switchgear is proposed for all the RSS to be located in approx. 100 X 80 m (8000 sq. m) land plot as the availability of Land in this area may not be a constraint. If Gas Insulated Switchgear (GIS) type Switchgear will be planned in future due to less space and reduced maintenance the capital cost need to be enhanced. 110 kV GIS substation land requirement will be approx. 60 X 70 m (4200 sq. m). In that case the cost of sub-station works will increase by nearly Rs. 10 Crores per 110 kV RSS with respect to conventional substation.

8.4 Various options of Traction system:-

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

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

A sub- committee set up by “Ministry of Urban Development” on Traction system for metro railway has studies various aspects of merits and demerits of various traction system. The following are the highlights of Report:-

Merits and Demerits of various traction systems

a) **25 kV AC with OCS (Flexible/rigid):-Merits**

- **Reduced cost** – Unlike dc traction this system, does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in cost. Cost of 25 kV AC traction systems is about 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.

In view of above techno-economic considerations, 25 kV AC traction 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).

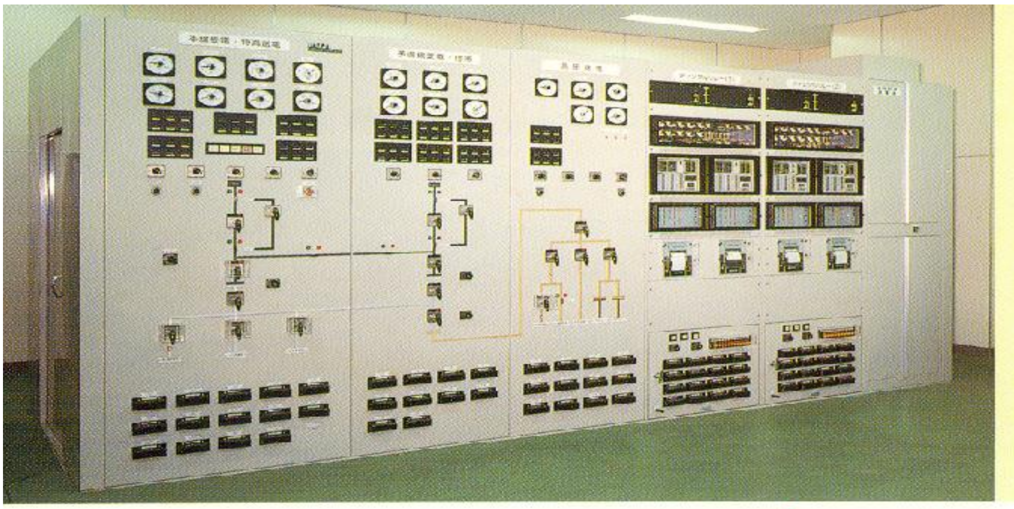
8.7 Auxiliary Supply Arrangements for DEPOT

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 107 sqmm silver copper contact wire and 65 sq.mm Cd-copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be All Aluminum Conductor (AAC) of 93.3 sq.mm cross section. For tensioning of OHE, ATD shall be a mix of spring ATD (50%) and 5 pulley ATD (balance 50%) spring ATD shall not be having counterweight and shall be provided at critical location like road crossing etc. Proven catenary fittings are proposed similar to DMRC system.

8.9 Rating of Major Equipment

Based on emergency demand expected at each RSS as shown in Table 8.3, and expected power demand during emergency, RSS at DN Nagar 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, 15 MVA three phase transformers for feeding auxiliary loads. RSS at Dahisar 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, 15 MVA three phase transformers for feeding auxiliary loads. The incoming cable shall be 3-phase single core XLPE insulated with 630 mm^2 Aluminum conductors to meet the normal & emergency loading requirements and fault level of the 110 kV supply.

33 kV and 25 kV switchgear shall be rated for 1250 A being standard design. 33 kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of Single core 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 77.44 million units in initial years 2019, which will be about 111.33 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.

MUMBAI METRO ANNEXURE - 8.1

DAHISAR (E) TO D. N. NAGAR

ENERGY CONSUMPTION

(25 kV AC TRACTION SYSTEM)

S.No.	Year	Year 2019		Year 2021		Year 2031	
A	**Traction Energy**	1	2	3	4	5	6
1	Section Length	18.30	KM	18.30	KM	18.30	KM
2	No. of Trains per direction in a day*	196	Nos.	212	Nos.	261	Nos.
3	Weight of Train & Passenger	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
	Yearly Traction Energy consumption with 365 days working with 30% regen	**58.28**	**million units**	**63.04**	**million units**	**77.60**	**million units**
B	**Station Aux. Energy**						
1	Elevated/at-grade Station	0.25	MW	0.35	MW	0.50	MW
2	Underground Station	2.00	MW	2.25	MW	2.50	MW
3	No. of Eevated/at-grade Stations	17	Nos.	17	Nos.	17	Nos.
4	No. of Underground Stations	0	No.	0	No.	0	No.
5	Total Station Aux. Power Requirement	4.25	MW	5.95	MW	8.50	MW
6	Depot Aux power requirement	2.00	MW	2.25	MW	2.50	MW
7	Total Aux. Power Requirement	6.25	MW	8.20	MW	11.00	MW
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	**7.72**	**MVA**	**10.13**	**MVA**	**13.59**	**MVA**
9	Diversity Factor of Aux. loads	0.40		0.40		0.40	
	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**19.16**	**million units**	**25.14**	**million units**	**33.73**	**million units**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**77.44**	**million units**	**88.18**	**million units**	**111.33**	**million units**

Note: The requirement of PD load is not consided in energy calculation.

MUMBAI METRO ANNEXURE - 8.1

DAHISAR (E) TO D. N. NAGAR

POWER REQUIREMENT

(25 kV AC TRACTION SYSTEM)

S.No	Particulars	Year 2019		Year 2021		Year 2031	
A	**Traction Power Requirements**	1	2	3	4	5	6
1	No. of cars	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)	6	(2DMC +2TC +2MC)
2	Passenger Weight	145.86	T	145.86	T	145.86	T
3	Train Tare Weight	251.68	T	251.68	T	251.68	T
4	Total Train Weight	397.5	T	397.5	T	397.5	T
5	Section Length	18.30	KM	18.30	KM	18.30	KM
6	Headway	3.5	mts	3.0	mts	2.75	mts
7	Specific Energy Consumption	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.
9	Peak Traction Power Requirement	19.95	MW	23.27	MW	25.39	MW
10	Less Regeneration @ 30%	5.98	MW	6.98	MW	7.62	MW
11	Depot Power Requirements	1.50	MW	1.75	MW	2.00	MW
12	Total Traction Power Requirement	15.46	MW	18.04	MW	19.77	MW
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**17.09**	**MVA**	**19.94**	**MVA**	**21.85**	**MVA**
B	**Aux. Power Requirements**						
1	Elevated/at-grade Station Power Consumption	0.25	MW	0.35	MW	0.50	MW
2	Underground station Power Consumption	2.00	MW	2.25	MW	2.50	MW
3	No. of Elevated/at-grade Stations	17	Nos.	17	Nos.	17	Nos.
4	No. of Underground stations	0	No.	0	No.	0	No.
5	Total Station Aux Power Requirement	4.25	MW	5.95	MW	8.50	MW
6	Depot Aux Power Requirement	2.00	MW	2.25	MW	2.50	MW
7	Total Aux Power Requirement	6.25	MW	8.20	MW	11.0	MW
	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for aux loads	**7.72**	**MVA**	**10.13**	**MVA**	**13.59**	**MVA**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**24.81**	**MVA**	**30.07**	**MVA**	**35.44**	**MVA**

Note: The requirement of PD load is not consided in estimation of power calculation.

ANNEXURE – B.2

TATA

4th February, 2010
CDD / LR-N 4040 / 13674

SPAN Consultants Pvt. Ltd.
C-505 to 508, Kukreja Centre
Sector 11, CBD Belapur
Navi Mumbai 400 614

Kind Attn: Mr R S Gupta
Sr Associate Director

Dear Sir,

Sub: Mumbai Metro Rail Project Phase II & III –
Requirement of power supply to two Metro Corridors

With reference to your letter No SCPL/ MUM/ C-843/ MMRDA / 40 dated 2nd February, 2010 we agree to supply the load from our Borivli and Malad 110kV Substation as per your requirements. The approx. cost of making available this power supply at Charkop and Dahisar Receiving Substations will be issued after conducting technical feasibility and preparation of cost estimate.

Tariff as approved by MERC from time to time will be applicable and copy of the tariff for FY10 is attached herewith for your perusal.

Thanking you and assuring you of our best attention at all times,

Yours faithfully,
THE TATA POWER COMPANY LTD.

4/2/2010

(H D THAKER)
CHIEF MANAGER

Encl: As above

TATA POWER
The Tata Power Company Limited
Consumer Development and Engineering Department Technopolis Knowledge Park Mahakali Caves Road Andheri East Mumbai 400 093
Tel 91 22 5668 8357 5668 8360 Fax 91 22 5668 8363
Registered Office Bombay House 24 Homi Mody Street Mumbai 400 001

Annexure – 8.3

CIN : U74899DL1995GOI068150

दूरभाष Tel. : 23417910/12
फैक्स Fax : 23417921

दिल्ली मेट्रो रेल कॉर्पोरेशन लि०
DELHI METRO RAIL CORPORATION LTD.
(भारत सरकार एवं दिल्ली सरकार का संयुक्त उपक्रम)
(A JOINT VENTURE OF GOVERNMENT OF INDIA AND GOVT. OF DELHI)

AID-MEMOIRE OF THE MEETING/JOINT SURVEY DONE WITH MMRDA AND THE TATA POWER COMPANY LIMTED

Date: 03.09.15 & 04.09.15 Place: Mumbai

Present:-

	MMRDA & The Tata Power Company Limited		**DMRC**
1.	Mr. Sanjay Yadav, Dy. Metropolitan Commissioner (Project Coordinator) - MMRDA	1.	Mr. A.K. Singh, ED/Electrical-II
2	Mr. Manoj Dandare (Sr.Transport Planner - MMRDA)	2	Mr. Ved Mitra, CEE/UD
3.	Mr. Sachin Majumdar, Group Head – Electrical – Project Engineering - TATA Power	3.	Mr. Chandrakant Shrivas, DGM/Elect/Plg-II
4	Mr. A. K. Singh, Chief Transmission Engineer - TATA Power		
5	Mr. Manoj D Salvi, Head – Commercial (DCS) - TATA Power		
6	Mr. Sunil Joglekar, Chief – Distribution Customer Services - TATA Power		
7	Mr. C V Niranjan, Group Head – Customer Acquisition, DCS - TATA Power		

The meeting/Joint survey was done with MMRDA and TATA Power Company Limited officer's and following conclusions were made on the two corridors of Mumbai Metro Rail.

1) DMRC explained the alignment and need of common source approx 32 MVA at Dahisar Depot and 32 MVA power at Charkop Depot & 24 MVA power at Andheri. Each source having two bays.
2) After discussions for the power supply of the Andheri to Dahisar and Dahisar to DN Nagar, the following sources were identified and agreed by M/s TATA Power Company Limited.

(मेट्रो भवन, फायर ब्रिगेड लेन, बाराखम्बा रोड, नई दिल्ली–110001)

A. Corridor – I: - Andheri to Dahisar.(16.48 Km)

a) TATA Power Company vide their letter no CDD/LR-N 4040/13674, dated:- 04.02.2010 had confirmed that they will provide two no. 110 KV bay from their 110 KV Borivali Grid substation to Dahisar Receiving Substation.

The same has been confirmed during the meeting.

b) TATA power company has confirmed that at Andheri site there is No Grid Substation of them. TATA Power Company has suggested that they will provide two nos. 110 KV bay from their 110 KV Versova Grid substation to DN Nagar Receiving Substation and by LILO arrangement feed extension can be taken for Andheri Receiving substation also by DMRC.

B. **Corridor – II: - Dahisar to DN Nagar (18.30 Km)**

a) TATA Power Company vide their letter no CDD/LR-N 4040/13674, dated:- 04.02.2010 had confirmed that they will provide two no. 110 KV bay from their 110 KV Malad Grid substation to Charkop Receiving Substation. Based on this,DPR has been made in the month of August-2015.

In the meeting TATA company shown their inability in present situation for providing two no 110 KV bay from Malad Grid substation. They indicated that there is no spare bay & space presently. They will provide supply in the Year 2021 after converting AIS Grid Substation into GIS substation.

TATA Power Company has confirmed that they will provide two no. 110 KV bay from their 110 KV Versova Grid substation to DN Nagar Receiving Substation.

C. As per plan of MMRDA, In future Dahisar to DN Nagar corridor will get extended up to Mankhurd thereafter DN Nagar Receiving substation will be used for extended corridor and Malad Grid substation may be used for supply to Charkop Receiving Substation.

3) Detailed survey will be done after finalisation of tender by the concerned authority.

(A.K. Singh)
Executive Director/electrical-II
Telefax: 011-23417920

No.DMRC/Elect/DPR-MUMBAI/PART/IV Dated: - 07.09.2015

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: dmc.pc@gmail.com

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. 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 Charkop 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 438 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 9.2
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.

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
	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 9.3.7
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 Charko	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)
	Kantha pada Charko	Hindustan Naka (DB Realty)	John Bosco School	Dahisar (Police Chowky			
Respirable Particulate Matter	84	64	6	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	4	48	120	µg/m3	IS-5182 (part- 6)

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 (B)
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	16-18hr	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

9.1.6 Flora

Separate Environmental Impact Assessment Study is being done 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 no much acquisition of properties is needed.

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 etc.,

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 22.1584 ha of land will have to be permanently acquired for the proposed project. Out of this 22.15 ha of land, about 21.65 ha of land is the government land and 0.5 ha is estimated to be private land. Socio Economic Survey is being done separately. However, prime facie, it is noticed that no much acquisition of properties is needed.

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.

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 120-litres and equipped with side handles will be appropriately designed and installed at stations and platforms.

e) **Visual Impacts:** The construction of Charkop-Bandra-Kurla-Mankhurd 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 9.12.**

Table 9.12
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	□□		

Parameter		Negative Impact	Positive Impact	No Impact
		□□		
C)	**Impact Due To Project Operation**			
i) ii) iii) iv) v) vi)	Oil Pollution Noise and Vibration Accidental Hazards Water Supply Railway Station Refuse Visual Impacts	□□ □□ □□ □□□ □□□ □□□		
D)	**Positive Impacts**			
i) ii) iii) iv) v)	Traffic Congestion Reduction, Quick Service and Safety, Less Fuel Consumption, Reduction in Air Pollution, Reduction in number of busses Improvement in roads		□□□ □□□ □□□ □□□ □□□ □ □ □	

19 - Yes

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:

a) Compensation for Loss of Land,
b) Compensation for Loss of Trees,
c) Compensatory Afforestation and Fencing,
d) Compensation for Relocation/Resettlement,

e) Water Supply & Sanitation,
f) Noise Control
g) Vibration Control

a) Compensation for Loss of Land: The land likely to come under project is 22.15 ha. The cost of land for compensation is taken under the project cost.

b) Compensation for Relocation/Resettlement: The project involves relocation of shops, commercial cum residential buildings and hutments along the alignment. As per Resettlement & Rehabilitation policy for Mumbai Urban Transport Project (MUTP) March 1997 and as amended in December 2000, the principles of resettlement are as follows:

(i) Project affected structures shall be categorized by referring to ownership, land use and type of construction:
Ownership:
1 Land and building owned by the same person,
2 Land owned by one person and building owned by the lessee,
3 Land and building both leased to lessee,
4 Land and building occupied by statutory tenants with owner occupant or where owner is a absentee,

(ii) Land occupied by squatters without any legal title. Category of squatters includes-non-resident structure owners, resident structure.

(iii) Selection of Resettlement Site: The site for resettlement shall be selected out of the feasible options in consultation with the affected community as a part of the RAP preparation. The principal criteria for site selection shall include access to employment opportunities, infrastructure and social services. Environmental assessment of the resettlement site shall be carried out as part of the preparation of EMP. Since, the above R&R policy does not specify the compensation cost, market survey data have been taken wherever found appropriate.

For rehabilitation and resettlement the lump sum provision @ Rs 3.52 crores/km has been made based on the experience at Delhi. The exact R&R cost will however be available in the report on Social Impact Assessment under preparation.

c) Water Supply & Sanitation: The public health facilities, such as water supply, sanitation and toilets are much needed at project location. Water should be treated before use upto WHO/ Indian drinking water standards. In addition, water will be required for contractor's camps during construction, for which additional arrangements have to be made in consultation with the Mumbai Municipal Corporation &

Mumbai Development Authority. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage solves the excreta disposal problems. The sewerage disposal systems should be adopted for sewage disposal.

d) **Noise Control:** There may be an increase in noise level in ambient air due to construction and operation of this corridor. However, noise levels in the core city may slightly go down. The increase in levels is marginal; hence, local population will not be adversely affected. However the exposure of workers to high noise levels especially, near the engine, vent shaft etc. need to be minimized. This can be achieved by job rotation, automation, protective devices, noise barriers, and soundproof compartments, control rooms etc.

The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible.

Pile driving operation can produce noise levels upto 100 dB (A) at a distance of 25-m from site. The noise levels could be reduced by using a suitable sound absorbent, which can reduce the noise levels upto 70 dB (A) at a distance of 15m from the piles. Safety precautions 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. Sound barriers are usually effective along route having fast traffic. The reduction in noise level increases with height of barrier. Ballast-less track supported on two layers of rubber pads reduces track noise and ground vibrations.

e) **Vibration Control:** Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

While designing track structure for Mass Rapid Transit System, all the above points have been taken into consideration in the following ways:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 60-kg/m, UIC-60, supported at every 60-cm. has been proposed. Further, rail grinding at regular intervals by Rail grinding machine and also lubrication of rail by vehicle-mounted lubricator have been contemplated.

- Rail will be continuously welded and also will be laid to fine tolerances, so that any noise/vibration on account of irregular track geometry could be reduced.

- The vibration generated from rail-wheel interaction will be greatly absorbed by the elastic fastening system proposed to be used.

1 In sensitive areas, track on floating slab can be provided so as to avoid propagation of noise/vibration to adjacent structures. Additional screening of noise/vibration can be arranged by providing parabolic noise/vibration reflecting walls on each sides of the track, as being provided by DMRC in Delhi.

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.

Cost of Air quality monitoring at the rate of Rs. 10,000/per sample:
1x3x12x7x10,000=**Rs. 25.2 lacs**

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.

Cost of Noise Level monitoring at the rate of Rs. 1,000/per sample:
1x3x12x7x1,000=Rs. 2.52 lacs

9.7.1.2 Total cost of Environmental Monitoring = Rs31.92 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.

CHAPTER 10

MULTI MODEL TRAFFIC INTEGRATION AT METRO STATIONS

10.1 INTRODUCTION

The Metro Rail System in Mumbai Dahisar (E) - D.N. Nagar corridor will cover a length of approximately 18.589 kms. It will be augmented through enhanced flexibility of criss-cross interchanges to other modes and reduce the travel time of commuters. While Metro is a high capacity mode of transport, the need for integration with other secondary/intermediate transport mode is getting highlighted more than ever to ensure a seamless journey. This concept is to provide first mile and last mile connectivity to the commuters with their places of stay. With top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Rail Systems. (Ref: MoUD (Urban Transport Wing) Advisory Circular No. K-14011/1/2007-UT-IV dated 30.08.2013).

The share of various modes of secondary/intermediary mode of travel is complex and debatable issue which is dependent on a large number of variables like available road width, penetration in the residential areas, Road condition, distance from the Metro Stations, availability of parking and lay out and availability of circulating areas at the Metro Rail Stations, Business centre or Market & existing traffic densities. These factors relate with each other and evolve with development of new model mix of transport, infrastructure and changes with the passage of time. Even though for a given urban transport scenario, optimal mode share may be determined from computer based models but actual **optimal mode share** is never achievable on the road due to dynamic nature of demand and supply of transport modes.

10.2 PRESENT CONDITION OF TRANSPORT ON CITY ROADS

At present the various modes coming to Metro Stations comprise of State Transport buses, Mini buses, Auto-rickshaws, Private cars, Two Wheelers and Bi-cycles. These can be classified in three groups of transport modes namely Public, IPT and Private.

In public transport group there are Mini Buses (20 Seaters), and large buses of State Transport (50 Seaters) and Charted Buses hired by Schools and private offices.

Generally the public transport in Mumbai comprises of the buses which are operated by the Transport Corporation.

Auto-rickshaws are also an important part of public transports at Mumbai. After bus, it is these auto rickshaws which are the most important modes of public transport in Mumbai even though they are little expensive. Auto rickshaws are Intermediate Public Transport (IPT) Modes. Another public transport at Mumbai which can be ranked third among all is the cabs or taxis that run on the streets of Mumbai.

In the personalised transport modes, there are Cars, Two Wheelers and Bicycles of all possible sizes.

A chaotic situation is observed when all the above mentioned transport vehicles are seen jostling to each other for space for moving forward. More pathetic conditions are seen at the Road Intersections.

The solution lies in the showcasing a workable arrangement of co-existence through identification of good points of each mode and then utilise the same to get the attention and embedding it in public psyche.

Because of high traffic and less capacity as well as length of the roads, average distance between two consecutive vehicles becomes very less. Such situation does not permit speed higher than 15-20 km/hr. This indicates that unless there is some solution to reduce this unmanageable mix of the vehicle fleet, real transport integration may not be possible. While the Road length on main & arterial Roads may not be seen significant increase and relieve the congestive/chaotic/slow moving road traffic, a divergent policy of linking commuters directly through E-Rickshaw or Mini Buses using the service/inner road length to supplement the main road traffic will impact the congestion and provide relief to the Metro commuters in reaching out to Metro Stations.

10.3 IMPACT OF BUS/CLUSTERS IN MODE SHARE

Primary reasons for using personal vehicle (for buying vehicle) is **to save travel time** during journey. On the other hand, Government has tried to increase number of public buses on the road in many different ways.

Government has tried hard to popularise public buses by subsidising the fare but could not bring higher (and middle) income group to use public bus simply because it is slow. Therefore objective of achieving optimal mode share remained elusive than reality.

10.4 BALANCING ACT OF METRO

After introduction of Metro Rail System in the city, Traffic and Transportation scenario will significantly change. People will no longer be afraid to travel a much longer distance. With Metro in place, longer distances can be travelled in shortest time.

10.5 WAY FORWARD

In view of above deliberations in back ground, along with planning for Metro System in any city, there is a need for providing a transportation system which is seamlessly integrated across all modes and provides first mile as well as last mile connectivity. It is also necessary that various public transportation modes including Inter-mediate Public Transport (IPT) and feeder buses etc. work together in order to facilitate increase in ridership to the Metro/Metro system and provide ease of using Metro system by the public at large.

Therefore, there is a need for doing more scientific study exclusively for this. To achieve this goal, Metro Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. Detailed Study is required to be done in this influenced zone of a Metro station for following aspects mainly:

i) Availability and review of existing public and IPT facilities, in terms of motorized and non-motorised mode with main consideration of the streets/roads adjoining to the stations and also to examine adequacy of availability of pedestrians/cycle paths in the influenced zone.

ii) Analysis and identification of gaps between supply and demand in terms of feeder facilities and other requirements for better first and last mile connectivity.

iii) Proposal for introduction/enhancement of feeder buses and cycle/pedestrians tracks, bike sharing arrangement for each Metro station to be finalised.

iv) Proposal for better integration of Metro station with other mode of transport, such as relocation of existing bus stop, introduction of new bus stop, bus base etc.

v) Cost of the requirements namely road widening including roads for pedestrian/cycle paths, feeder buses based on the outcome of the study.

The detailed study and requirement for providing first mile as well as last mile connectivity to the Metro users will be carried out separately and the same should be in place before the commercial operation of the Metro services for the benefit of the users as well as for better ridership and the financial viability of the project.

Since, it is envisaged that detailed study for provision of feeder buses, public bike sharing and pedestrianisation in the influence zone of Metro stations will be done and put in place by the time commercial operation of the Metro services, a lump-sum cost of Rs. 2.31 crores per station has been considered sufficient and included in the project cost of proposed Metro System. If at any stage more feeder services etc. will be required, same can be augmented by concerned city transportation authorities.

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CHAPTER 11

FRIENDLY FEATURES FOR DIFFERENTLY ABLED

11.1 INTRODUCTION

The objective of making this chapter is to create a user-friendly mass transport system in India which can ensure accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems (e.g. a leg in plaster) and the elderly persons.

The design standards for universal access to Public Transport Infrastructure including related facilities and services, information, etc. would benefit people using public transport.

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons", 1998 and 2013 edition (under revision by MoUD), and international best practices / standards

Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around Metro stations.

11.2 CONTENT

1. Rail Transport
2. Light Metro Station
    - Way finding
    - Signage
    - Automated Kiosks
    - Public Dealing Counters
    - Audio-visual Displays
    - Public Telephones
    - Rest Areas/Seating
    - Tactile Paving - Guiding & Warning

- Doors
- Steps & Stairs
- Handrails
- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

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

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

11.3 RAIL TRANSPORT

1. General
   - Whether over-ground or underground, rail travels is a highly effective mode of transport.
   - Every train should contain fully accessible carriages.
   - Staff should be trained in methods of assistance and be at hand on request.
   - Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways
   - Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
   - All new railway stations should be designed to be fully accessible.
   - For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
   - For persons with visual impairments audio system announcing the station names and door location should be available.

2. Accessible Railway Cars

The railway cars should have the following features:

- Railway car doors should be at least 900 mm wide;
- The gap between the car doors and the platform should preferably be less than 12 mm;
- Identification signage should be provided on the doors of wheelchair accessible coach
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

3. Wheel Chair Space
    - Space for a wheel chair should be available at the side of the door:-
    - The space should be indicated inside and outside the car by using the international symbol of access; and
    - Wheel stoppers and ring-strap or other appropriate safety grip should be provided for wheelchair users.

4. Seats
    - An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles
    - Aisles should be at least 900 mm wide.

11.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

11.5 METRO STATIONS

1. LEVEL APPROACH
    - Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should have a ramp.
    - Walkway surfaces should be non-slip.
    - Approach walkway should have tactile pavements for persons with visual impairments.

2. STATION ENTRANCES AND EXITS
    - These should have a minimum width of 1800mm and is level or ramped.

3. RESERVATION AND INFORMATION COUNTERS

- Should have clear floor space of at least 900 mm x 1200 mm in front of the counters;
- There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
- At least one of the counters should have an induction loop unit to aid people with hearing impairments; and
- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

4. TOILET FACILITIES

- There should be at least one unisex accessible toilet
- Ticket Gates

At least one of the ticket gates should:

- Be minimum 900 mm wide to allow a wheelchair user through; and
- Have a continuous line of guiding paver for people with visual impairments.

5. PLATFORMS

The Platforms should:

- Have a row of warning paver installed 600mm before the track edge (photo 6);
- Have non-slip and level flooring;
- Have seating areas for people with ambulatory disabilities;
- Be well illuminated lux level 35 to 40;
- There should be no gap or difference in level between the train entry door and the platform.
- All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

- Way finding references should be available at decision points.
- Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.

- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travellers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille)

8. SIGN DESIGN SPECIFICATIONS

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.
- Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
- The colour of the text should be in a colour that contrasts with the sign board.
- The sign board should also contrast with the wall on which it is mounted.
- The surface of the sign should not be reflective.
- Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
- Illuminated signs should not use red text on a dark background.
- Signs should be supplemented by Braille where possible.

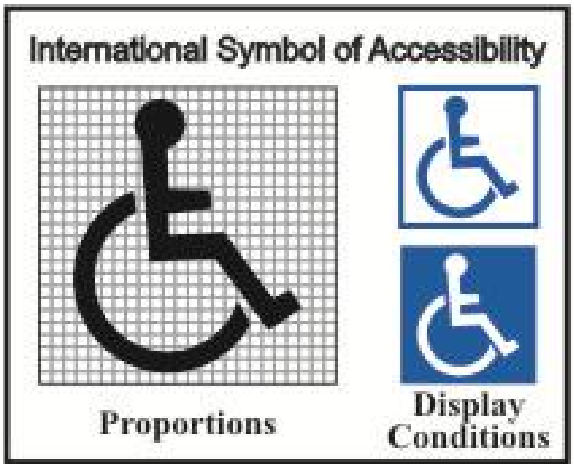


Fig. 11.1 - Way finding signage   Fig. 11.2 - International Symbol of Accessibility

9. AUTOMATED KIOSKS

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. PUBLIC DEALING COUNTERS

- Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.
- Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
- It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.
- Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
- Staff manning the counters should know sign language.
- Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
- Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
- Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
- There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
- One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep.

11. AUDIO-VISUAL DISPLAYS

- Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
- Enable captioning at all times on all televisions and other audio-visual displays that are capable of displaying captions and that are located in any portion of the terminal.
- The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING

- Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
- Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
- Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.
- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. Tactile Paving- Guiding & Warning

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. Places to install warning paver

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

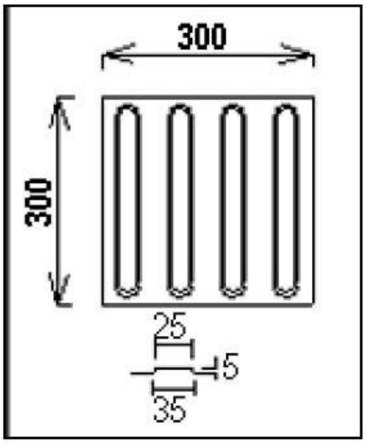


Fig. 11.3 - Guiding paver

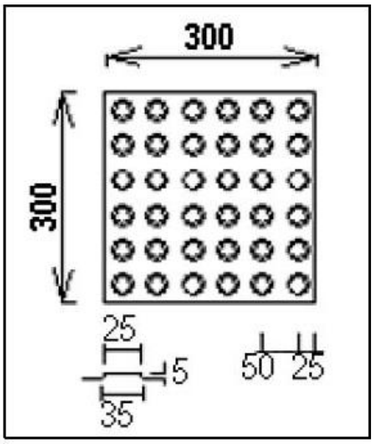


Fig. 11.4 - Warning paver

15. DOORS

Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.

- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).
  - Also be fitted with vision panels at least between 900mm and 1500mm from floor level.
  - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
  - Lever handles and push type mechanisms are recommended. When a sliding door is fully open, handles should be usable from both sides.

- Where revolving doors or turnstiles are used, an alternative wheelchair-
- Accessible entrance must also be provided.
- A distance of 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, colour (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor (figure 28).
- Operable devices such as handles, pulls, latches and locks should:
  - Be operable by one hand
  - Not require fine finger control, tight grasping, pinching or twisting to operate
- Glazed doors and fixed glazed areas should be made visible by use of a clear, colour and tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

16. STEPS & STAIRS

- Steps should be uniform with the tread not less than 300mm and the risers 150mm.
- The risers should not be open.
- The steps should have an unobstructed width of 1200mm minimum.
- All steps should be fitted with a permanent colour and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both tread and riser.
- Have continuous handrails on both sides including the wall (if any) at two levels
- Warning paver to be placed 300mm at the beginning and at the end of all stairs.
- Nosing to be avoided.
- The staircase should be adequately and uniformly illuminated during day and night (when in use). The level of illumination should preferably fall between 100-150 lux.
- The rise of a flight between landings must be no more than 1200mm.
- There should be no more than 12 risers in one flight run.
- The stair covering and nosing should be slip-resistant, non-reflective, firmly-fixed and easy to maintain.
- Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

17. HANDRAILS

- Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
- The handrail should contrast in colour (preferably yellow/orange) with surrounding surfaces.
- At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
- The handrail should be positioned at two levels- 760mm and 900mm above the pitch-line of a flight of stairs.
- Handrail at foot of the flight of stairs should extend 300mm beyond the stairs in the line of travel and returning to the wall or floor or rounded off, with a positive end that does not project into the route of travel.

18. RAMPS

- Ramps gradient should ideally be 1 in 20 and no greater than 1 in 12.
- Width of the ramp should not be less than 1200mm and preferred width is 1800mm.
- The steeper the gradient, the shorter the length of ramp between landings.
- On long ramps, a horizontal resting space should be provided every 6 meters.
- Surface materials should be slip-resistant, non-reflective, firmly-fixed and easily maintained
- The edge of the ramp should have an edge protection with a minimum height of 100mm.
- Landings every 750mm of vertical rise.
- A tapping or lower rail should be positioned so that its bottom edge is no higher than 200mm above ground level.
- Handrails on the ramps should be on both sides at two levels: upper at 900mm and lower at 760mm; both end to be rounded and grouted; extend 300 mm beyond top and bottom of ramp .
- A row of tactile warning paver should be placed 300mm beginning and end of each run.
- Landings should be provided at regular intervals as indicated in the table (Table 11.1).

Table 11.1 - Specifications for Ramps

Level difference	Minimum Gradient.of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	√	
≥ 300 mm ≤ 750 mm	1:12	1500 mm	√	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	√	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	√	Landings every 9 meters of ramp run.

19. LIFTS/ELEVATORS

A carefully designed lift makes a huge contribution to the accessibility of a multi-storied terminal building for persons with disabilities.

- Lift locations should be clearly signposted from the main pedestrian route and recognizable through design and location.
- The colour and tone of the lift doors should contrast with the surrounding wall finish to assist in their location. Lift doors with metallic finishes such as steel grey and silver should be avoided as they are difficult to identify by persons with low vision.
- The lift lobby shall be of an inside measurement of 1800mm X 2000mm or more. A clear landing area in front of the lift doors of minimum dimensions 1500mm x 1500mm should be provided.
- By making the landing area distinguishable by floor surface and contrast, it will aid location and recognition of core areas. This could comprise a change in floor finish from thin carpet to vinyl/PVC, or cement/mosaic floor to carpet.
- Changes in floor finish must be flushed. There should be no level

  difference between lift door and the floor surface at each level; the gap if unavoidable should not be more than 12mm.
- The floor level/location should be indicated on the wall adjacent to or just above the call buttons, and opposite the lift doors where possible.

20. Lift Dimensions

- Provisions of at least one lift shall be made for people using wheelchairs with the following car dimensions:
  - Clear internal depth -1500 mm minimum
  - Clear internal width - 1500 mm minimum
  - Entrance door width - 900 mm minimum

21. LIFT CONTROLS

- The lift call button should be wall-mounted adjacent to the lift and should contrast with wall finish, either by using a contrasting panel, or a contrasting border around the button panel.
- The call buttons should be located within the range 800-1000mm above floor finish.
- Buttons should not be touch sensitive, but should require a light positive pressure and should ideally be large enough to be operable by the palm of the hand if required.
- The control buttons inside the lift should be positioned on the side wall rather than front wall to allow access from the back and front of the lift car, by mobility aid users like wheelchair users.
- The control buttons should contrast with their surroundings and illuminate when pressed and should incorporate highly visible tactile embossed (NOT engraved) characters and in Braille.
- Time of closing of an automatic door should be more than 5 seconds and the closing speed should not exceed 25 meters per second. There should be a provision of censor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

22. CAR DESIGN

- Internal walls should have a non-reflective, matt finish in a colour and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.
- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, in order to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

11.6 INFORMATION SYSTEMS

- Lifts should have both visual and audible floor level indicators
- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 50 decibel.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

11.7 GENERAL ACCESSIBLE TOILETS

1. SIGNAGES
   - All signage of general toilets should be in bold and contrasting colors.
   - For persons with low vision and vision impairments: male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
   - Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.
   - Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.
2. ACCESSIBLE TOILETS
   - Should have the international symbol of accessibility displayed outside for wheelchair access.
   - The toilet door should be an outward opening door or two way opening or a sliding type and should provide a clear opening width of at least 900mm.
   - It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.
3. WC COMPARTMENT DIMENSIONS
   - The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
   - Layout of the fixtures in the toilet should be such that a clearing maneuvering space of 1500mm x 1500mm in front of the WC and washbasin.
4. WATER CLOSET (WC) FITTINGS
   - Top of the WC seat should be 450-480mm above finished floor level, preferably be of wall hung or corbel type as it provides additional space at the toe level.

- An unobstructed space 900mm wide should be provided to one side of the WC for transfer, together with a clear space 1200mm deep in front of the WC.
- WC should be centred 500mm away from the side wall, with the front edge of the pan 750mm away from the back wall. Have a back support. The WC with a back support should not incorporate a lid, since this can hinder transfer.
- L-shape grab bar at the adjacent wall and on the transfer side (open side) swing up grab bar shall be provided.
- The cistern should have a lever flush mechanism, located on the transfer side and not on the wall side and not more than 1000mm from the floor.

5. GRAB BARS

- Grab bars should be manufactured from a material which contrasts with the wall finish (or use dark tiles behind light colored rails), be warm to touch and provide good grip.
- It is essential that all grab rails are adequately fixed, since considerable pressure will be placed on the rail during maneuvering. Grab bars should sustain weight of 200kgs minimum.
- A hinged type moveable grab bar should be installed adjacent to the WC on the transfer side. This rail can incorporate a toilet tissue holder. A distance of 320mm from the centre line of the WC between heights of 200-250mm from the top of the WC seat. It should extend 100-150mm beyond the front of the WC.
- A fixed wall-mounted L- shape grab bar (600mm long horizontal and 700mm long vertical) on the wall side should be provided. It should be placed at a height of 200-250mm above the WC seat level.

6. WASHBASINS

- Hand washbasins should be fitted on cantilevered brackets fixed to the wall.
- The basin should be fixed no higher than 750mm above the finished floor level.
- Be of dimensions 520mm and 410mm, mounted such that the top edge is between 800- 900mm from the floor; have a knee space of at least 760mm wide by 200mm deep by 650-680mm high.
- The position of the basin should not restrict access to the WC i.e. it should be located 900mm away from the WC.
- A lever operated mixer tap fitted on the side of the basin closest to the WC is useful as it allows hot and cold water to be used from a seated position on the WC.
- The hand drying facilities should be located close to the hand washbasin

  between 1000-1200mm.
- Lever type handles for taps are recommended.

- Mirror's bottom edge to be 1000mm from the floor and may be inclined at an angle.

7. FIXTURES AND FITTINGS

- Contrast between fittings and fixtures and wall or floor finishes will assist in their location. For example, using contrasting fittings, or dark tiles behind white hand washbasins and urinals, contrasting soap dispensers and toilet roll holders.
- Contrast between critical surfaces, e.g. floors, walls and ceilings helps to define the dimensions of the room.
- Towel rails, rings and handrails should be securely fixed to the walls and positioned at 800-1000mm from the floor.
- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights-1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.
- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish

8. SIGNAGE OF ACCESSIBLE TOILETS

- All unisex accessible toilets to have access symbol in contrast colours. A distinct audio sound (beeper/clapper) may be installed above the entrance door for identification of the toilets.

Fig. 11.5 - Signage for accessible washroom

9. Accessible Urinal

- At least one of the urinals should have grab bars to support ambulant persons with disabilities (for example, people using mobility aids like crutches).
- A stall-type urinal is recommended.
- Urinals shall be stall-type or wall-hung, with an elongated rim at a maximum of 430mm above the finish floor. This is usable by children, short stature persons and wheelchair users.
- Urinal shields (that do not extend beyond the front edge of the urinal rim) should be provided with 735mm clearance between them.
- Grab bars to be installed on each side, and in the front, of the urinal.
- The front bar is to provide chest support; the sidebars are for the user to hold on to while standing.

11.8 DRINKING WATER UNITS

- Drinking water fountains or water coolers shall have up front spouts and control.
- Drinking water fountains or water coolers shall be hand-operated or hand and foot-operated.
- Conventional floor mounted water coolers may be convenient to individuals in wheelchairs if a small fountain is mounted on the side of the cooler 800mm above the floor.
- Fully recessed drinking water fountains are not recommended.
- Leg and knee space to be provided with basin to avoid spilling of water. This allows both front and parallel access to taps for persons using mobility aids like wheel chair, crutches etc.

11.9 VISUAL CONTRASTS

- Visual contrasts means adequate contrast created by difference of at least 30 LRV (Light Reflectance Value) of the two surfaces/ objects and it helps everyone especially persons with vision impairments.
- Visual contrast should be provided between:
  - Critical Surfaces (walls, ceiling and floor),
  - Signage and background sign frame/ wall,
  - Step edges and risers/ treads on steps,
  - Handrails and background walls,
  - Doors and surrounding walls,
  - Switches/ sockets and background wall,
  - Toilet fixtures and critical surfaces in toilet.

- Barriers and hazards should be highlighted by incorporating colours and luminance contrast.

11.10 EMERGENCY EGRESS/EVACUATION

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.

- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a 'hotkey' on the phone keypad. This 'hotkey' should be distinct from the rest of the keypad.

11.11 ALERTING SYSTEMS

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.

- Consider having audible alarms with 'voice instructions' that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.

- Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).

  Non-auditory alarms include:
  - Flashing beacons
  - Vibrating pillows and vibrating beds.
  - Pagers or mobile phones that give out a vibrating alarm along with a flashing light (these may be issued to persons with vision or hearing impairments at the time of check-in or boarding the vehicle.)

11.12 WRITTEN EVACUATION PROCEDURE

A written evacuation procedure that details the egress plan for people with disability should be installed behind the entrance door in the accessible rest rooms. The evacuation procedure should be detailed in large print letters that contrast strongly against the background. Where possible, it should also incorporate raised letters and Braille. The evacuation route should be displayed on a high contrast tactile map for benefit of persons with vision impairments.

11.13 EMERGENCY EVACUATION ROUTE

- Designate routes that are at least 1200mm wide, to ensure that a person using a wheelchair and a non-disabled person are able to pass each other along the route. The route should be free of any steps or sudden changes in level and should be kept free from obstacles such as furniture, coolers, AC units and flower pots.

- Use Exit signage along the route. Orientation and direction signs should be installed frequently along the evacuation route and these should preferably be internally illuminated. The exit door signage should also be internally illuminated.
- A 'way guidance lighting system' consisting of low mounted LED strips to outline the exit route (with frequent illuminated direction indicators along the route) should be installed along the entire length of the evacuation route. Way guidance systems allow persons with vision impairments to walk significantly faster than traditional overhead emergency lighting. Moreover, emergency exit lights in green color and directional signals mounted near the floor have been found to be useful for all people in cases where a lot of smoke is present.

11.14 WAY GUIDENCE SYSTEM

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.
- Install clear illuminated sign above exit and also directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

11.15 Fire Resistant Doors

- Fire resistant doors and doors used along the emergency evacuation route are generally heavy and the force required to open these is much higher than 25 Newton, making it difficult for people with disability to negotiate these doors independently. There are, however, magnetic and other types of door holders available that can be connected to fire alarms so that they will hold the doors open normally but will release the doors when the fire alarm is activated.

11.16 STREET DESIGN

(a) Footpath (Sidewalk)

Footpaths should be regarded as a transportation system which is connected and continuous, just like roadways and railways. They should not be sporadically placed where ever convenient, but instead should be provided consistently between all major attractions, trip generators, and other locations where people walk.

Footpath should

- Be along the entire length of the road;
- Have height of a standard public step riser i.e. 150 mm maximum;
- Be at least 1800 mm wide;
- Have non-slip surface;
- Have tactile guiding paver for persons with visual impairments;
- Preferably have well defined edges of paths and routes by use of different colours and textures;
- Have no obstacles or projections along the pathway. If this is unavoidable, there should be clear headroom of at least 2200 mm from the floor level;
- The minimum 1.8m (width) x 2.2m (Height) Walking Zone should be clear of all obstructions – both horizontally and vertically.

Footpath should have:

- Have kerb ramps where ever a person is expected to walk into or off the pathway; and
- Have tactile warning paver installed next to all entry and exit points from the footpath.

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.
- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

(c) Road Intersections

- Pedestrian crossings should be equipped with traffic control signal.
- Traffic islands to reduce the length of the crossing are recommended for the safety of all road users.
- Warning pavers should be provided to indicate the position of pedestrian crossings for the benefit of people with visual impairments.
- Table tops (raised road level to the sidewalk height) are helpful in reducing the speed of traffic approaching the intersection

(d) Median/Pedestrian Refuge

Raised islands in crossings should:

- Cut through and level with the street; or
- Have kerb ramps on both the sides and have a level area of not less than 1500 mm long in the middle; and
- A colored tactile marking strip at least 600 mm wide should mark the beginning and end of a median/ pedestrian refuge to guide pedestrian with visual impairments to its location.

11.17 TRAFFIC SIGNALS

- Pedestrian traffic lights should be provided with clearly audible signals for the benefit of pedestrians with visual impairments;
- Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination;
- The installation of two adjacent acoustic devices such as beepers is not recommended in order to avoid disorientation;
- The time interval allowed for crossing should be programmed according to the slowest crossing persons; and
- Acoustical signals encourage safer crossing behavior among children as well.

11.18 SUBWAY AND FOOT OVER BRIDGE

Subways and foot over bridges should be accessible for people with disabilities. This may be achieved by:

- Provision of signage at strategic location;
- Provision of slope ramps or lifts at both the ends to enable wheelchair accessibility ;
- Ensuring that the walkway is at least 1500 mm wide;
- Provision of tactile guiding and warning paver along the length of the walkway;
- Keeping the walkway; free from any obstructions and projections; and
- Providing for seats for people with ambulatory disabilities at regular intervals along the walkway and at landings.

11.19 ALIGHTING AND BOARDING AREAS

- All areas and services provided in the Mass Rapid Transit System (Metro/subway), bus terminuses, etc. that are open to the public should be accessible.

11.19.1 APPROACH

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.

- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions or areas requiring maintenance should be white cane detectable1.
- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

11.19.2 CAR PARK

(A) SIGNAGE

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be

at a minimum height of 2100 mm .

(B) SYMBOL

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the centre of the lot; and
- The colour of the symbol should be white on a blue background.

(C) CAR PARK ENTRANCE

The car park entrance should have a height clearance of at least 2400 mm.

LOCATION

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.

- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) ACCESSIBLE CAR PARKING LOT

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm;
- Have a firm, level surface without aeration slabs;
- Wherever possible, be sheltered;
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings;
- Two accessible parking lots shall be provided for every 25 no of car spaces.

(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

CHAPTER 12

SECURITY MEASURES FOR A METRO RAIL SYSTEM

12.1 INTRODUCTION

Metro Rail System is emerging as the most favoured mode of urban transportation system. The inherent characteristics of Metro Rail System make it an ideal target for terrorists and miscreants. Metro Rail System is typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic importance, being the life line of city high news value, fear & panic and human casualties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

12.2 NECESSSITY OF SECURITY

It is well known that public transportation is increasingly important for urban areas to prosper in the face of challenges such as reducing congestion and pollution. Therefore, security places an important role in helping public transport system to become the mode of choice. Therefore, excellence in security is a prerequisite for Metro Rail System for increasing its market share. Metro Rail System administration must ensure that security model must keep pace rapid expansion of the Metro Rail System and changing security scenario.

12.3 THREE PILLARS OF SECURITY

Security means protection of physical. Human and intellectual assets either from criminal interference, removal of destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. There are three important pillars of security as mentioned under:

((i) The human factor;
(ii) Procedures; and
(iii) Technology

Staff engaging with the passengers creates a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective staff has to be qualified, trained, well equipped and motivated. They should be trained, drilled and tested. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed communicated and drilled in advance.

There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems are to differ i.e., making planning or execution of on attack too difficult, detect the planned evidence before it occurs deny the access after in plan of attack has been made and to mitigate i.e. lessen the impact severity as the attack by appropriate digits.

12.4 PHASES OF SECURITY

There are three phases of security as under:

(i) Prevention

These are the measures which can prevent a security incidence from taking place. These can be identified by conducting a risk assessment and gathering intelligence. Prevention begins with the daily operational security -problems.

Uncared for dirty, damaged property is a breeding ground for more serious crime.

(ii) Preparedness

Plans must be prepared to respond to incidents, mitigate the impact. Train staff accordingly and carry out exercises. The results of the risk assessment give a basis for such plans.

(iii) Recovery

Transport system must have laid down procedures/instructions for the quick recovery of normal service after an incident. Recovery is important for the financial health of the operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should also include an evaluation process for the lessons learnt.

12.5 RESPONSIBILITIES AND PARTNERSHIPS

Security is a sovereign function and hence is the responsibility of the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the Government of Maharashtra to ensure secured travelling to the public including Metro Rail System.

12.6 PROPOSED PROVISIONS FOR SECURITY SYSTEM

1. CCTV coverage of all Metro Rail System stations. With a provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations. Cost of this is included in Telecom estimate.

2. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required. Cost of one baggage scanner is Rs. 15.0 Lacs approximately, on 2013 prices.

3. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations. Cost of one Multi-zone DFMD is Rs 2.15 Lacs approximately.

4. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station. Cost of one HHMD is Rs 6000/- approximately at 2012 prices.

5. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of DMRC. Cost 1.25 crores including vehicle.

6. Bomb Blanket at least one per station and Depots. Cost is Rs. 50,000/- per bomb blanket.

7. Wireless Sets (Static and Hand Held) as per requirement of security agency.

8. Dragon light at least one per station and vital installation.

9. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.

10. Dog Squads (Sniffer Dog), at least one dog for 4 Metro Rail System stations which is at par with current arrangement of Delhi Metro. Cost of one trained sniffer dog is Rs 1.25 Lacs approximately. Dog Kennels along with provision for dog handlers and MI room will also be provided by Metro Rail System train depot administration including land at suitable places line wise.

11. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of Metro Rail System train depot administration Metro Rail System station.

12. Bullet proof jackets and helmets for QRTs and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 Metro Rail System

stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.

13. Furniture to security agency for each security room, and checking point at every entry point at stations. Scale is one office table with three chairs for security room and office of GO and one steel top table with two chairs for checking point.

14. Ladies frisking booth - 1 per security check point (AFC Array)
    Wooden Ramp - 1 per DFMD for security check points.

15. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof Morcha, as per requirement.

16. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.

20. The provision procurement of all the above hardware is included in the cost of Stations.

CHAPTER 13

DISASTER MANAGEMENT MEASURE

13.1 INTRODUCTION

“Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation.” Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area”. As per World Health Organization (WHO):

“Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area.”

A disaster is a tragic event, be it natural or manmade, which brings sudden and immense agony to humanity and disrupts normal life. It causes large scale human suffering due to loss of life, loss of livelihood, damages to property and persons and also brings untold hardships. It may also cause destruction to infrastructure, buildings, communication channels essential services, etc.

13.2 NEED FOR DISASTER MANAGEMENT MEASURES

The effect of any disaster spread over in operational area of Metro Rail System is likely to be substantial as Mumbai Metro will be dealing with thousands of passengers daily. Disaster brings about sudden and immense misery to humanity and disrupts normal human life in its established social and economic patterns. It has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro Rail System. Therefore there is an urgent need to provide for an efficient disaster management plan.

13.3 OBJECTIVES:

The main objectives of this Disaster Management Measures are as follows:

- Save life and alleviate suffering.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instill a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation.
- Lay down the actions required to be taken by staff in the event of a disaster in VMRT in order to ensure handling of crisis situation in coordinated manner.
- To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

13.4 LIST OF SERIOUS INCIDENTS REQUIRING USE OF PROVISIONS OF THE DISASTER MANAGEMENT MEASURES

Medium Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

- **Man Made Disaster**

    1. Terrorist attack
    2. Bomb threat/ Bomb blast
    3. Hostage
    4. Release of Chemical or biological gas in trains, stations or tunnels
    5. Fire in Metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
    6. Train accident and train collision/derailment of a passenger carrying train.
    7. Sabotage
    8. Stampede

- **Natural Disaster**
    1. Earthquakes
    2. Floods

13.5 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

A. The National Disaster Management Authority (NDMA)
Establishment of National Disaster Management Authority:-

(1) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (The Disaster Management Act, 2005), an authority to be known as the National Disaster Management Authority.

(2) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:-

(a) The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;
(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disaster Management Authority:

Establishment of State Disaster Management Authority:-

(1) Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(2) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:-

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;
(b) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;
(c) The Chairperson of the State Executive Committee, ex officio.

(3) The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the State Authority.

(4) The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, ex officio: Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority: Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary
(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.
(3) State Level Committee under the chairmanship of Chief Secretary.
(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(iii) The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan and of any amendment thereto, to the District Authority.

13.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

To prevent emergency situations and to handle effectively in case 'one arises' there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

(A) FIRE DETECTION AND SUPPRESSION SYSTEM

(B) SMOKE MANAGEMENT

(C) ENVIRONMENTAL CONTROL SYSTEM (ECS)

(D) TRACK-WAY EXHAUST SYSTEM (TES)

(E) STATION POWER SUPPLY SYSTEM

(F) DG Sets & UPS

(G) LIGHTING SYSTEM

(H) STATION AREA LIGHTS

(I) SEEPAGE SYSTEM

(J) WATER SUPPLY AND DRAINAGE SYSTEM

(K) SEWAGE SYSTEM

(L) ANY OTHER SYSTEM DEEMED NECESSARY

The above list is suggestive not exhaustive actual provisioning has to be done based on site conditions and other external and internal factors.

13.7 PREPAREDNESS FOR DISASTER MANAGEMENT

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their wellbeing seeking their cooperation.

Since learning can only be perfected by 'doing' the following Mock Drills is considered essential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train
f. Hot line telephone communication with state disaster management authority.

13.8 Communication with State Disaster Management Cell.

Operation Control Centre will have a hotline connection with the State Disaster Management cell so as to avoid any time loss in communication of the information.

Chapter – 14 A

COST ESTIMATES

14.1 INTRODUCTION

Project Cost estimates for the Dahisar (E) - D. N. Nagar 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/km basis. The cost of elevated stations includes civil work for station structures, architectural finishes, platform roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc, have been worked out separately. These rates do not include cost of permanent way, O.H.E., power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, etc, costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-II, Phase-III. A suitable escalation factor has been applied to bring these costs to July 2015 price level. In addition the rates of Civil works have been escalated by 10% to compensate the higher costs in Mumbai compared to Delhi. Taxes & Duties such as Customs Duty, Excise Duty, Sales Tax, Works Tax, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the Dahisar (E) - D. N. Nagar Metro Corridor of Mumbai at July 2015 price level works out to **Rs. 4226 Crores** excluding applicable Taxes & Duties of **Rs. 768 crores** as tabulated hereunder.

Table 14.1 – Corridor-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Dahisar (E) - D. N. Nagar Metro Corridor (18.589 Km, 17 stations)	4226	768	4994

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 of Link Road. 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 1894. The average rate of private land has been worked out to be Rs.100 Crore per hectare on the basis of latest information available. Similarly average rate for govt. land has been taken 20 Crore per hectare to work out the cost of land.

Provision for Rehabilitation and Resettlement is made separately.

In addition to the lands required permanently, some areas of land (mainly Govt.) are proposed to be taken over temporarily for construction depots. Ground rent charges @ 6% per year for a period of 4 years have been provided for in project cost estimates.

Details of the lands with their costs have been shown in corridor cost estimate.

14.2.2 Formation and Alignment

Elevated section: A good portion of alignment is proposed with elevated viaduct and the rates adopted are based on the completion cost for these works of Phase-II and ongoing Phase-III works, duly updated to July 2015 price level and enhanced by 10% for the higher cost at Mumbai as compared to Delhi.

14.2.3 Stations

Elevated Stations: Rates adopted for elevated stations cover works of station structures, platforms, architectural finishes, covering, etc. Provisions for Electrical and Mechanical works have been made separately. Also provisions for Lifts and Escalators, Viaduct, P-way, O.H.E., Signalling & Telecommunication works, Automatic fare collection installations, etc, have been summed up in the cost estimates.

Mainly three type of stations are proposed for elevated alignment & rates are proposed accordingly.

Type A: Wayside station
Type B: Wayside with Signalling
Type C: Terminal Station

Rates for stations have also been arrived based on Delhi Phase-II and Phase-III accepted rates added by 10% more for higher cost at Mumbai compared to Delhi

14.2.4 Permanent way

For elevated alignment ballastless track and for depot, ballasted track is proposed. Rates adopted are based on similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.3 DEPOT

Maintenance Depot have been planned near Charkop Station at about 1.5 km away from 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 underground alignment, elevated and at-grade section as the requirements are different and costs are more for underground section.

Provisions towards cost of lifts, escalators for underground, elevated and at-grade stations have been made in the cost estimates. Rates provided are based on cost of similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level. Provision for mid section shaft is made separately.

14.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based on the completion cost of similar works for Delhi Metro under Phase-II and ongoing Phase-III works. These rates include escalation during manufacturing and supply of equipment and their installation at site.

14.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on accepted rates for similar work of Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.9 ROLLING STOCK

Adopted rates are based on awarded rates of similar works of Phase-II and ongoing Phase-III works duly updated to July 2015 price level considering likely indigenization.

14.10 SECURITY

A lump sum provision for providing security infrastructure in the station premises has been made on running kilometre basis. Adopted rates are as taken in phase III DPR suitably escalated to current price level.

14.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 2.31 Crore per station has been made to have seamless integration of metro stations with other modes of transport. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

14.12 GENERAL CHARGES AND CONTINGENCES

Provision @ 7% has been made towards general charges on all items, except cost of land, which also includes the charges towards Detailed Design Charges (DDC), etc. Provision for contingencies @ 3 % has been made on all items including general charges.

14.13 CAPITAL COST ESTIMATES

14.13.1 Dahisar(E) to D. N. Nagar Corridor

The overall Capital Cost for this corridor estimated at July 2015 price level, based on the above considerations works out to **Rs. 4226Crores** without Taxes & Duties. Taxes & Duties such as Customs Duty (CD), Excise Duty (ED), Sales Tax (ST), Works Tax (WT), VAT, etc, have been worked out as **Rs. 768 Crores.**

Mumbai Metro Rail Project
Dahisar (E) to DN Nagar Corridor

Capital Cost Estimate **July 2015 level**

Total length = 18.589 km (Elevated =18.589 km, Underground = Nil)					
Total Station (All Elevated) =17					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	21.65	433.00
b	Private	ha	100.00	0.50	50.00
1.2	Temporary Land for Construction Depot	Ha.	5.00	8.00	40.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.52	18.59	65.46
	Subtotal (1)				**588.46**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	18.59	686.25
2.2	Depot entry connection	R. Km.	36.92	1.50	55.38
	Subtotal (2)				**741.62**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	14.00	407.22
b	Type (A) way side- EM works etc	Each	8.06	14.00	112.86
c	Type (B) Way side with signalling-civil works	Each	28.48	1.00	28.48
d	Type (B) Way side with signalling-EM works etc	Each	8.06	1.00	8.06
a	Type (C), Terminal station -civil works	Each	32.45	2.00	64.90
b	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	2.00	16.12
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	34.00	83.30
3.3	Metro bhawan, OCC bldg.				
a	civil works	LS			50.00
b	EM works etc	LS			25.00
	Subtotal (3)				**795.94**
4.0	**Maintenance Depot at Charkop**	LS			
4.1	Depot				
a	Civil works	LS			90.00
b	EM works etc	LS			60.00
	Subtotal (4)				**150.00**

5.0	**P-Way**				
5.1	Ballast less track (Including Depot Connection)	R. Km.	**8.58**	20.09	172.36
5.2	Ballasted track for Depot	R. Km.	**4.72**	5.00	23.60
	Subtotal (5)				**195.96**
6.0	**Traction & power supply incl. Third Rail, ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R. Km.	10.50	20.09	210.93
	Subtotal (6)				**210.93**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	20.09	321.30
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	5.50	17.00	93.50
	Subtotal (7)				**414.80**
9.0	**Misc. Utilities, road works, 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	20.09	160.71
	Subtotal (9)				**160.71**
10.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	48.00	470.40
	Subtotal (10)				**470.40**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.30	20.09	6.00
b	EM works etc	R.Km.	0.06	20.09	1.24
	Subtotal (11)				**7.24**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.32	20.09	26.60
b	EM works etc	R.Km.	0.28	20.09	5.70
	Sub Total (12)				**32.30**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	17.00	39.27
	Sub Total (13)				**39.27**
14.0	**Total of all items except Land**				**3284.64**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**229.92**
16.0	**Total of all items including G. Charges except land**				**3514.56**
17.0	**Contingencies @ 3 %**				**105.44**
18.0	**Gross Total**				**3620.00**
	Cost without land			=	**3620**
	Cost with land including contingencies on land			=	**4226**

Details of Taxes and Duties

Dahisar(E) to D. N. Nagar Corridor

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT(Cr.)		
1	**Alignment & Formation**						
	Underground	0.00	0.00	0.00	0.00		**0.00**
	Elevated, at grade & entry to Depot	741.62		64.89	73.00	16.13	**137.90**
2	**Station Buildings**						
	Elevated station - civil works	583.89		51.09	57.48	12.70	**108.57**
	Elevated station-EM works	137.05	6.42	11.65	13.11	4.34	**31.17**
	OCC bldg-civil works	50.00		4.38	4.92	1.09	**9.30**
	OCC bldg-EM works	25.00	1.17	2.13	2.39	0.79	**5.69**
3	**Depot**						
	Civil works	90.00	6.32	5.51	6.20	2.04	**18.04**
	EM works	60.00	2.81	5.10	5.74	1.90	**13.65**
4	**P-Way**	195.96	36.71	4.16	4.68	6.63	**45.56**
5	**Traction & power supply**						
	Traction and power supply	210.93	19.76	13.45	15.13	6.84	**48.33**
6	**S and T Works**						
	S & T	321.30	60.19	8.03	9.04	10.91	**77.26**
	AFC	93.50	16.42	2.92	3.29	3.16	**22.63**
	PSD	0.00	0.00	0.00	0.00	0.00	**0.00**
7	**R & R hutments**	65.46			4.09	1.31	**4.09**
8	**Misc.**						
	Civil works	182.58		15.98	17.97	3.97	**33.95**
	EM works	56.93		6.05	6.81	1.76	**12.85**
9	**Rolling stock**	470.40	96.93	4.59	5.16	18.30	**106.68**
	Total	**3284.64**	**246.72**	**199.92**	**229.00**	**91.87**	**767.52**
	Total taxes & Duties						**768**

Chapter – 14 B

COST ESTIMATES

14.1 INTRODUCTION

Project Cost estimates for the Dahisar (E) - D. N. Nagar 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/km basis. The cost of elevated stations includes civil work for station structures, architectural finishes, platform roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc, have been worked out separately. These rates do not include cost of permanent way, O.H.E., power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, etc, costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-II, Phase-III. A suitable escalation factor has been applied to bring these costs to July 2015 price level. In addition the rates of Civil works have been escalated by 10% to compensate the higher costs in Mumbai compared to Delhi. Taxes & Duties such as Customs Duty, Excise Duty, Sales Tax, Works Tax, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the Dahisar (E) - D. N. Nagar Metro Corridor of Mumbai at July 2015 price level works out to **Rs. 5263 Crores** excluding applicable Taxes & Duties of **Rs. 1017 crores** as tabulated hereunder.

Table 14.1 – Corridor-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Dahisar (E) - D. N. Nagar Metro Corridor (18.589 Km, 17 stations)	5263	1017	6270

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 of Link Road. 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 1894. The average rate of private land has been worked out to be Rs.100 Crore per hectare on the basis of latest information available. Similarly average rate for govt. land has been taken 20 Crore per hectare to work out the cost of land.

Provision for Rehabilitation and Resettlement is made separately.

In addition to the lands required permanently, some areas of land (mainly Govt.) are proposed to be taken over temporarily for construction depots. Ground rent charges @ 6% per year for a period of 4 years have been provided for in project cost estimates.

Details of the lands with their costs have been shown in corridor cost estimate.

14.2.2 Formation and Alignment

Elevated section: A good portion of alignment is proposed with elevated viaduct and the rates adopted are based on the completion cost for these works of Phase-II and ongoing Phase-III works, duly updated to July 2015 price level and enhanced by 10% for the higher cost at Mumbai as compared to Delhi.

14.2.3 Stations

Elevated Stations: Rates adopted for elevated stations cover works of station structures, platforms, architectural finishes, covering, etc. Provisions for Electrical and Mechanical works have been made separately. Also provisions for Lifts and Escalators, Viaduct, P-way, O.H.E., Signalling & Telecommunication works, Automatic fare collection installations, etc, have been summed up in the cost estimates.

Mainly three types of stations are proposed for elevated alignment & rates are proposed accordingly.

Type A: Wayside station
Type B: Wayside with Signalling
Type C: Terminal Station

Rates for stations have also been arrived based on Delhi Phase-II and Phase-III accepted rates added by 10% more for higher cost at Mumbai compared to Delhi

14.2.4 Permanent way

For elevated alignment ballastless track and for depot, ballasted track is proposed. Rates adopted are based on similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.3 DEPOT

Maintenance Depot have been planned near Charkop Station at about 1.5 km away from 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 underground alignment, elevated and at-grade section as the requirements are different and costs are more for underground section.

Provisions towards cost of lifts, escalators for underground, elevated and at-grade stations have been made in the cost estimates. Rates provided are based on cost of similar works done in Phase-II and ongoing Phase-III works duly updated to July 2015 price level. Provision for mid section shaft is made separately.

14.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based on the completion cost of similar works for Delhi Metro under Phase-II and ongoing Phase-III works. These rates include escalation during manufacturing and supply of equipment and their installation at site.

14.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on accepted rates for similar work of Phase-II and ongoing Phase-III works duly updated to July 2015 price level.

14.9 ROLLING STOCK

Adopted rates are based on awarded rates of similar works of Phase-II and ongoing Phase-III works duly updated to July 2015 price level considering likely indigenization.

14.10 SECURITY

A lump sum provision for providing security infrastructure in the station premises has been made on running kilometre basis. Adopted rates are as taken in phase III DPR suitably escalated to current price level.

14.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 2.31 Crore per station has been made to have seamless integration of metro stations with other modes of transport. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

14.12 GENERAL CHARGES AND CONTINGENCES

Provision @ 7% has been made towards general charges on all items, except cost of land, which also includes the charges towards Detailed Design Charges (DDC), etc. Provision for contingencies @ 3 % has been made on all items including general charges.

14.13 CAPITAL COST ESTIMATES

14.13.1 Dahisar (E) to D. N. Nagar Corridor

The overall Capital Cost for this corridor estimated at July 2015 price level, based on the above considerations works out to **Rs. 5263 Crores** without Taxes & Duties. Taxes & Duties such as Customs Duty (CD), Excise Duty (ED), Sales Tax (ST), Works Tax (WT), VAT, etc, have been worked out as **Rs. 1017 Crores.**

Mumbai Metro Rail Project

Dehisar (E)to DN Nagar Corridor

Capital Cost Estimate **July 2015 level**

Total length = 18.589 km **Elevated (including elevated ramp) =18.589 km**					
Total Station (All Elevated) =17					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	20.00	21.65	433.00
b	Private	ha	100.00	0.50	50.00
1.2	Temporary Land for Construction Depot	Ha.	5.00	8.00	40.00
1.3	**R & R incl. Hutments etc.**	R. Km.	3.52	18.59	65.46
	Subtotal (1)				**588.46**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	36.92	18.59	686.25
2.2	Depot entry connection	R. Km.	36.92	1.50	55.38
	Subtotal (2)				**741.62**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	29.09	14.00	407.22
b	Type (A) way side- EM works etc	Each	8.06	14.00	112.86
c	Type (B) Way side with signalling-civil works	Each	28.48	1.00	28.48
d	Type (B) Way side with signalling-EM works etc	Each	8.06	1.00	8.06
a	Type (C), Terminal station -civil works	Each	32.45	2.00	64.90
b	Type (c), Terminal station -EM works including lifts and escalators	Each	8.06	2.00	16.12
3.2	Providing half height platform Screen Doors (PSD) at all Stations	Each	2.45	34.00	83.30
3.2	Metro bhawan, OCC bldg.				
a	civil works	LS			50.00
b	EM works etc	LS			25.00
	Subtotal (3)				**795.94**
4.0	**Maintenance Depot at Charkop**	LS			
4.1	Depot				
a	Civil works	LS			90.00
b	EM works etc	LS			60.00

	Subtotal (4)				**150.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	**8.58**	20.09	172.36
5.2	Ballasted track for Depot	R. Km.	**4.72**	5.00	23.60
	Subtotal (5)				**195.96**
6.0	**Traction & power supply incl. Third Rail , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated section	R.Km.	10.50	20.09	210.93
	Subtotal (6)				**210.93**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.99	20.09	321.30
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	5.50	17.00	93.50
	Subtotal (7)				**414.80**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(4.5 cr/km)** + EM works (3.5 cr/km)	R. Km.	8.00	20.09	160.71
	Subtotal (9)				**160.71**
10.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.80	144.00	1411.20
	Subtotal (10)				**1411.20**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.30	20.09	6.00
b	EM works etc	R.Km.	0.06	20.09	1.24
	Subtotal (11)				**7.24**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.32	20.09	26.60
b	EM works etc	R.Km.	0.28	20.09	5.70
	Sub Total (12)				**32.30**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.31	17.00	39.27
	Sub Total (13)				**39.27**
14.0	**Total of all items except Land**				**4225.44**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**295.78**
16.0	**Total of all items including G. Charges except land**				**4521.22**
17.0	**Contingencies @ 3 %**				**135.64**
18.0	**Gross Total**				**4656.85**
	Cost without land			=	**4657**
	Cost with land including contingencies on land			=	**5263**

Table 0.13 Details of Taxes and Duties

Dahisar (E) to D. N. Nagar Corridor

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties			Octroi	Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	VAT(Cr.)		
1	**Alignment & Formation**						
	Underground	0.00	0.00	0.00	0.00		**0.00**
	Elevated, at grade & entry to Depot	741.62		64.89	73.00	16.13	**137.90**
2	**Station Buildings**						
	Elevated station - civil works	583.89		51.09	57.48	12.70	**108.57**
	Elevated station-EM works	137.05	6.42	11.65	13.11	4.34	**31.17**
	OCC bldg-civil works	50.00		4.38	4.92	1.09	**9.30**
	OCC bldg-EM works	25.00	1.17	2.13	2.39	0.79	**5.69**
3	**Depot**						
	Civil works	90.00	6.32	5.51	6.20	2.04	**18.04**
	EM works	60.00	2.81	5.10	5.74	1.90	**13.65**
4	**P-Way**	195.96	36.71	4.16	4.68	6.63	**45.56**
5	**Traction & power supply**						
	Traction and power supply	210.93	19.76	13.45	15.13	6.84	**48.33**
6	**S and T Works**						
	S & T	321.30	60.19	8.03	9.04	10.91	**77.26**
	AFC	93.50	16.42	2.92	3.29	3.16	**22.63**
	PSD	0.00	0.00	0.00	0.00	0.00	**0.00**
7	**R & R hutments**	65.46			4.09	1.31	**4.09**
8	**Misc.**						
	Civil works	182.58		15.98	17.97	3.97	**33.95**
	EM works	56.93		6.05	6.81	1.76	**12.85**
9	**Rolling stock**	1411.20	290.79	13.76	15.48	54.90	**320.03**
	Total	**4225.44**	**440.58**	**209.09**	**239.32**	**128.47**	**1017.47**
	Total taxes & Duties						**1017**

Chapter 15A

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

15.1 INTRODUCTION

The Mumbai Metro Rail Project (Dahisar (E) to DN Nagar) is proposed to be constructed at an estimated cost of Rs 4673.00 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	Dahisar(E) to D N Nagar	18.589	4226.00	4673.00	4994.00

The estimated cost at July-2015 price level includes an amount of Rs.7.24 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 consist of Custom Duty (CD), Excise Duty (ED), State Value Added Tax (VAT) and Octroi levied by the Brihanmumbai Municipal Corporation (BMC). Mumbai Metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective CD works out to 23.4155% (Basic CD (5%), Countervail Duty (CVD) + Additional Custom Duty (ACD)) on the imported portions, ED @ 12.50% and VAT @ 12.50% on indigenously manufactured items and Octroi @ 4% on supply items, which have been considered for working out the estimated taxes and duties. Service Tax on "Works Contract Services" on new construction pertaining to Metro and Mono Rail Projects is exempted from the Service Tax on date and therefore the same has been considered as Nil in the estimated cost. It has been assumed that Maharashtra State Government will exempt the local taxes or reimburse the same (Sate VAT, Octroi etc) and provide the land worth Rs. Rs. 665 crore on completion cost basis free of cost or shall provide Interest Free Subordinate Debt.

It is assumed that the construction work will start on 01.10.2015 and is expected to be completed on 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2019 for the corridor. The total completion costs duly escalated and shown in the table 15.2 have been taken as the initial investment. The cash flow of investments separately is placed in Table –15.2 as below.

Table 15.2 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost including land cost and central taxes
2015-16	243.00	247.00
2016-17	609.00	667.00
2017-18	1178.00	1386.00
2018-19	1017.00	1286.00
2019-20	813.00	1106.00
2020-21	407.00	595.00
2021-22	406.00	638.00
Total	**4673.00**	**5925.00**

15.2.1.2 Although the construction is expected to get over by 31st March 2019, the cash flow spill over up to March 2022 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

15.2.1.3 The cost of Land of Rs. 665 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	6	102.00
2031-32	18	496.00
TOTAL	**24**	**598.00**

15.2.3 Operation & Maintenance (O&M) Costs

The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs
(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables
(iii) Energy costs

The requirement of staff has been assumed @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The prevailing rate of electricity in Mumbai is Rs. 8.46 per unit which has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 7.50% per annum. The O&M costs have been tabulated in Table 15.4.1as below.:

Table 15.4 Operation and Maintenance Costs

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2019	-	2020	41.03	27.88	66.68	135.59
2020	-	2021	44.72	29.97	71.68	146.38
2021	-	2022	48.75	32.22	93.02	173.99
2022	-	2023	53.14	34.64	99.99	187.77
2023	-	2024	57.92	37.24	107.49	202.65
2024	-	2025	63.13	40.03	115.55	218.71
2025	-	2026	68.81	43.03	124.22	236.06
2026	-	2027	75.00	46.26	133.54	254.80

YEAR			Staff	Maintenance Expenses	Energy	Total
2027	-	2028	81.75	49.73	143.55	275.04
2028	-	2029	89.11	53.46	154.32	296.89
2029	-	2030	97.13	57.47	165.89	320.49
2030	-	2031	105.87	61.78	178.33	345.99
2031	-	2032	115.40	66.41	248.42	430.23
2032	-	2033	125.79	71.39	267.05	464.23
2033	-	2034	137.11	76.75	287.08	500.94
2034	-	2035	149.45	82.50	308.61	540.56
2035	-	2036	162.90	88.69	331.75	583.35
2036	-	2037	177.56	95.34	356.64	629.54
2037	-	2038	193.54	102.49	383.38	679.42
2038	-	2039	210.96	110.18	412.14	733.28
2039	-	2040	229.95	118.44	443.05	791.44
2040	-	2041	250.64	127.33	476.28	854.25
2041	-	2042	273.20	136.88	512.00	922.08
2042	-	2043	297.79	147.14	550.40	995.33
2043	-	2044	324.59	158.18	591.68	1074.45
2044	-	2045	353.80	170.04	636.05	1159.90
2045	-	2046	385.65	182.80	683.75	1252.20

15.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

15.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years.

15.3 REVENUES

The Revenue of Mumbai Metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

15.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on trip distribution at different distance zones.

15.3.2 Traffic

15.3.2.1 a. The projected ridership figures years are as indicated in table 15.5 as below: -

Table 15.5 Projected Ridership

Financial Year	Trips per day (lakhs)
2019-20	3.53
2021-22	4.08
2031-32	6.09
2041-42	7.80

b. The growth rate for traffic is assumed @7.50% Per Annum upto 2021-22, and @ 4.10% per annum upto 2031-32, @2.50% per annum upto 2041-42 thereafter 1% per annum.

15.3.2.2 Trip Distribution

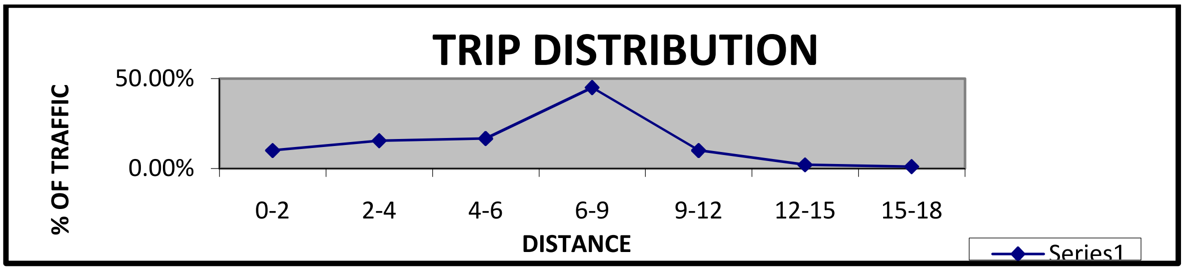
The trip distribution has been worked out by considering average lead of 6.25 KM which is shown in Table 15.6 below: -

Table 15.6 Trip Distribution

Distance in km	Percent distribution
0-2	10.00%
2-4	15.40%
4-6	16.60%
6-9	45.00%
9-12	10.00%
12-15	2.00%
15-18	1.00%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-15.1.

Figure 15.1 –Trip Distribution



Fare Structure

The fare structure for the FY 2019-20 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 15.7 below:

Table 15.7 Fare Structure in 2019-20

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

The above fare structure has been taken as furnished by MMRDA since it has been approved by GOM. DMRC proposed that the under mentioned fare structure in a multiple of Rs. 10 be adopted in 2019-20 at the time of commissioning of this Line.

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

The proposed Fare Structure will have convenience in making use of ticket vending machine and 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 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.

SPV/BOT operator will engage a developer/Concessionaire for generating rental income. It is assumed that about 10.00 Hectare. i.e., 40,00,000 square feet area will be available for property development with a FAR of 4. The developer will bring equity to the extent of Rs.220.00 crore and the balance amount towards construction shall be raised by SPV as 12% Market Debt. The estimated development cost will be Rs.883.00 crore. It is assumed that the rental revenue will accrue to the developer from the FY 2019-20 which has been escalated @5% every year. Out of the estimated rental income, apart from meeting maintenance expenditure, the developer will repay the loan and interest. After meeting these obligations and retaining 14% return on his equity with an escalation @5% every year, the residual rental earnings will accrue to SPV, which has been taken into account in the FIRR calculations. The details of PD income accrue to SPV is tabulated as under; -

Table 15.8 Estimated generation of Rental Income from PD

Rs. in Crore

Year			Construction cost	Rental Income	Maintenance Expenditure	Loan	IDC	Loan repayment	Bal Loan Amount	Interest on Loan @12%	Return @14% to the developer	Residual rental income to SPV
2014	-	2015	160			105	6		111		-55	
2015	-	2016	168			113	14		238		-55	
2016	-	2017	176			121	16		375		-55	
2017	-	2018	185			130	19		524		-55	
2018	-	2019	194			194	24		742		0	
2019	-	2020		61	6			74	668	89	31	-139
2020	-	2021		84	8			74	594	80	33	-111
2021	-	2022		118	12			74	520	71	35	-74
2022	-	2023		186	19			74	446	62	37	-6
2023	-	2024		313	31			74	372	54	39	115
2024	-	2025		328	33			74	298	45	41	135
2025	-	2026		345	34			74	224	36	43	158
2026	-	2027		362	36			74	150	27	45	180
2027	-	2028		380	38			74	76	18	47	203
2028	-	2029		399	40			76	0	9	49	225
2029	-	2030		419	42						51	326
2030	-	2031		440	44						54	342
2031	-	2032		462	46						57	359
2032	-	2033		485	49						60	376
2033	-	2034		509	51						63	395
2034	-	2035		535	53						66	416
2035	-	2036		562	56						69	437
2036	-	2037		590	59						72	459
2037	-	2038		619	62						76	481
2038	-	2039		650	65						80	505
2039	-	2040		683	68						84	531
2040	-	2041		717	72						88	557
2041	-	2042		753	75						92	586
2042	-	2043		790	79						97	614
2043	-	2044		830	83						102	645
Total			**883**	**11621**	**1161**	**663**	**79**	**742**		**491**	**1291**	**7715**

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 followings:-

Corridor	FIRR
FIRR without PD	6.41%
FIRR with PD	8.65%

The FIRR with central taxes & duties is produced in Table 15.9.1 & Table 15.9.2

Table 15.9.1 –FIRR with Central Taxes (Without Property Development)

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
2015	-	2016	247				247			0	-247
2016	-	2017	667				667			0	-667
2017	-	2018	1386				1386			0	-1386
2018	-	2019	1286				1286			0	-1286
2019	-	2020	1106		136		1242	212	21	233	-1009
2020	-	2021	595	0	146		741	228	23	251	-490
2021	-	2022	638	102	174		914	281	28	309	-605
2022	-	2023	0	0	188		188	293	29	322	134
2023	-	2024	0	0	203		203	348	35	383	180
2024	-	2025	0	0	219		219	362	72	434	215
2025	-	2026	0	0	236		236	435	87	522	286
2026	-	2027	0	0	255		255	453	91	544	289
2027	-	2028	0	0	275		275	546	109	655	380
2028	-	2029	0	0	297		297	568	114	682	385
2029	-	2030	0	0	320		320	676	135	811	491
2030	-	2031	0	0	346		346	704	141	845	499
2031	-	2032	0	496	430		926	845	169	1014	88
2032	-	2033	0	0	464		464	866	173	1039	575
2033	-	2034	0	0	501		501	1027	205	1232	731
2034	-	2035	0	0	541		541	1052	210	1262	721
2035	-	2036	0	0	583		583	1237	247	1484	901
2036	-	2037	0	0	630		630	1268	254	1522	892
2037	-	2038	0	0	679		679	1491	298	1789	1110
2038	-	2039	0	0	733		733	1529	306	1835	1102
2039	-	2040	0	0	791		791	1812	362	2174	1383
2040	-	2041	0	0	854	725	1579	1857	371	2228	649
2041	-	2042	0	0	922	761	1683	2178	436	2614	931
2042	-	2043	0	0	995	0	995	2199	440	2639	1644
2043	-	2044	0	0	1074	0	1074	2566	513	3079	2005
2044	-	2045	0	0	1160	0	1160	2591	518	3109	1949
Total			**5925**	**598**	**13152**	**1486**	**21161**	**27624**	**5387**	**33011**	**6.41%**

Table 15.9.2 –FIRR with Central Taxes (With Property Development)

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
2015	-	2016	247				247			0	-247
2016	-	2017	667				667			0	-667
2017	-	2018	1386				1386			0	-1386
2018	-	2019	1286				1286			0	-1286
2019	-	2020	1106		136		1242	212	21	233	-1009
2020	-	2021	595	0	146		741	228	-116	112	-629
2021	-	2022	638	102	174		914	281	-83	198	-716
2022	-	2023	0	0	188		188	293	-45	248	60
2023	-	2024	0	0	203		203	348	29	377	174
2024	-	2025	0	0	219		219	362	187	549	330
2025	-	2026	0	0	236		236	435	222	657	421
2026	-	2027	0	0	255		255	453	249	702	447
2027	-	2028	0	0	275		275	546	289	835	560
2028	-	2029	0	0	297		297	568	317	885	588
2029	-	2030	0	0	320		320	676	360	1036	716
2030	-	2031	0	0	346		346	704	467	1171	825
2031	-	2032	0	496	430		926	845	511	1356	430
2032	-	2033	0	0	464		464	866	532	1398	934
2033	-	2034	0	0	501		501	1027	581	1608	1107
2034	-	2035	0	0	541		541	1052	605	1657	1116
2035	-	2036	0	0	583		583	1237	663	1900	1317
2036	-	2037	0	0	630		630	1268	691	1959	1329
2037	-	2038	0	0	679		679	1491	757	2248	1569
2038	-	2039	0	0	733		733	1529	787	2316	1583
2039	-	2040	0	0	791		791	1812	867	2679	1888
2040	-	2041	0	0	854	725	1579	1857	902	2759	1180
2041	-	2042	0	0	922	761	1683	2178	993	3171	1488
2042	-	2043	0	0	995	0	995	2199	1026	3225	2230
2043	-	2044	0	0	1074	0	1074	2566	1127	3693	2619
2044	-	2045	0	0	1160	0	1160	2591	1163	3754	2594
Total			**5925**	**598**	**13152**	**1486**	**21161**	**27624**	**13102**	**40726**	**8.65%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 15.10 below : -

Table 15.10 –FIRR (With PD)
Sensitivity Analysis

Capital Cost with Central Taxes but without land cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
8.01%	7.44%	9.36%	10.17%
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**
6.58%	7.66%	9.55%	10.38%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
8.24%		**9.04%**	

These sensitivities have been carried out independently for each factor.

15.5 FINANCING OPTIONS

Objectives of Funding: - The objective of funding metro rail systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
  - Low infrastructure maintenance costs
  - Longer life span
  - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai, Bengaluru and Mumbai Line-3 projects are funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

15.5.1 Alternative Models Of Financing

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

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

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

SPV Model: - The State Government has already formed a fully owned SPV in the name of Mumbai Metro Rail Corporation (MMRC), which is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The issue of extending JICA loan for the project was discussed informally with JICA India Office. It was told that an informal understanding between GOI & GOJ has taken place. According to which JICA will extend only modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan will be 40 years with 10 years moratorium period. JICA shall fund to the extent of 85% of the cost of project excluding cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. However, pending formal notification from the MOF, GOI, the existing terms applicable for JICA loan have been assumed except the quantum of project cost eligible for funding. The funding pattern under this model (SPV) is placed in table 15.11 as under: -

Table 15.11 Funding pattern under SPV model (with central taxes and land) (Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	759.50	14.44%
Equity By GOM	759.50	14.44%
SD for CT by GOM	292.50	5.56%
SD for CT by GOI	292.50	5.56%
1.40% Loan from JICA / 12% Market Borrowings	3156.00	60.00%
Total	5260.00	100.00%
SD for Land by GOM	665.00	
Total	5925.00	
Interest During Construction	20.00	
Grand Total	5945.00	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.465.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in table 15.12.1 & 15.12.2 tabulated as under: -

Table 15.12.1 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost and without Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1052.00	20.00%
VGF by GOM	2217.00	42.15%
Equity by Concessionaire	664.00	12.62%
Concessionaire's debt @12% PA	1327.00	25.23%
Total	5260.00	100.00%
Land Free by GOM	665.00	
Total	5925.00	
IDC	18.00	
Total	5943.00	

Table 15.12.2 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost and with Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1052.00	20.00%
VGF by GOM	1708.00	27.18%
Equity by Concessionaire	664.00	14.37%
Concessionaire's debt @12% PA	1837.00	38.45%
Total	5261.00	100.00%
Land Free by GOM	665.00	
Total	5926.00	
IDC	56.00	
Total	5982.00	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.465.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

15.6. RECOMMENDATIONS

The FIRR of the corridor with central taxes and land is 8.65% with revenue from additional property development on 10 hectares of land. The pre-tax Equity FIRR to the BOT operator worked out to 18% with total VGF of Rs.3425.00 crore excluding the cost of 10 hectare Land. Since the Maharashtra State Government is providing land parcels for PD, it is advisable to take up the job on DMRC/BMRCL/CMRL model. Accordingly, the corridors are recommended for implementation.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 15.13 excluding state taxes.

Table 15.13

Rs. In crore

Particulars	SPV Model	BOT Model without PD	BOT Model with PD
GOI	1052.00	1052.00	1052.00
GOM	1717.00	2882.00	2373.00
Total	**2769.00**	**3934.00**	**3425.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.465.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Considering the difference, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern given in Table 15.11.

The detailed cash flow statements under various alternatives are enclosed as per detail given below:-

Option	Table No.
SPV Model with JICA Loan without PD	15.14
SPV Model with Market Borrowings without PD	15.15
BOT Model without PD	15.16
SPV Model with JICA Loan with PD	15.17
SPV Model with Market Borrowings with PD	15.18
BOT Model with PD	15.19

The funding pattern assumed under SPV model & BOT model with PD is depicted in the pie chart i.e., Figure 15.2.1 & 15.2.2 as under: -

Figure 15.2.1

Funding pattern under SPV Model with PD

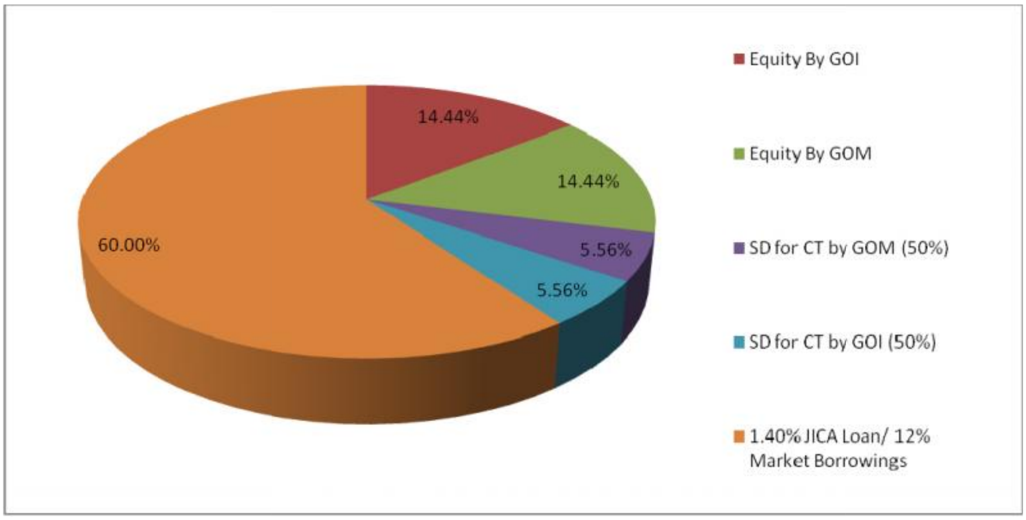
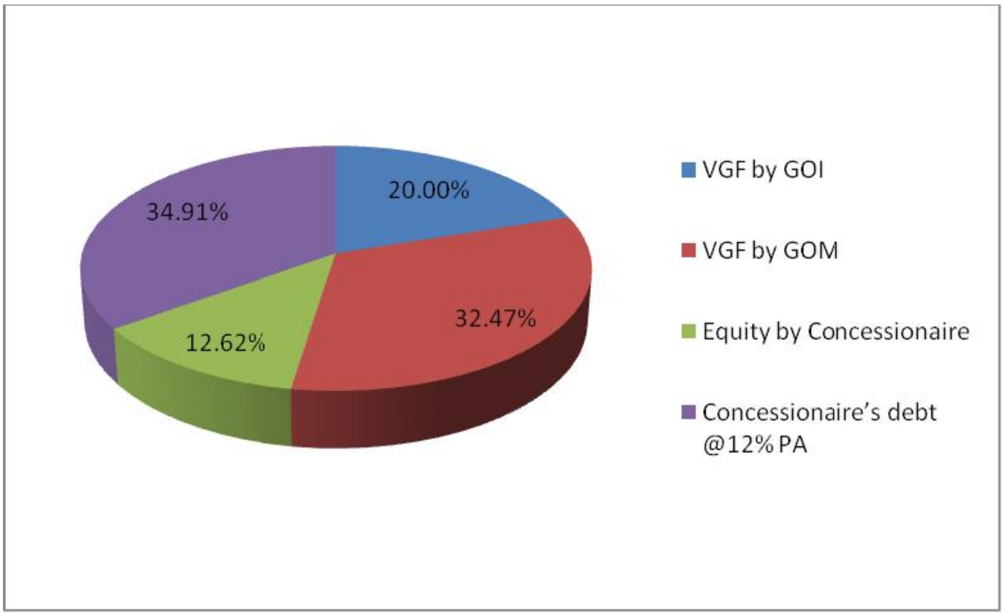


Figure 15.2.2

Funding pattern under BOT Model with PD



	Mumbai Metro (Dehisar to DN Nagar) Corridor													1208	JICA ELIGIBIITY		1948	3156	61.72%			Table 15.14
	CAPITAL COST-FIXED		4673												MB		12%	0.00%	0.00%			
	CAPITAL COST - CURRENT		5925												JICA Loan		1.40%	100.00%	1.40%			
	DOMESTIC FUNDING - BASE CASE														Front end Fee (one time)		0.20%		1.40%			
	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	247					247			0	-247	356	109	109	0	0	0	6	6				
2	2016 - 2017	667					667			0	-667	748	81	190	0	0	0	0	6				
3	2017 - 2018	1386					1386			0	-1386	765	-621	-431	431	431	0	3	440				
4	2018 - 2019	1286					1286			0	-1286	527	-759	-1190	1190	759	0	11	1210				
5	2019 - 2020	1106		136	178		1242	212	21	233	-1009	373	-733	-1923	1923	733	0		1943	22	-103	75	75
6	2020 - 2021	595	0	146	178		741	228	23	251	-490	0	-595	-2518	2518	595	0		2538	31	-104	74	149
7	2021 - 2022	638	102	174	181		914	281	28	309	-605		-638	-3156	3156	638	0		3176	40	-86	-7	142
8	2022 - 2023	0	0	188	181		188	293	29	322	134		0	0	0	0	0		3176	44	-91	90	231
9	2023 - 2024	0	0	203	181		203	348	35	383	180		0	0	0	0	0		3176	44	-45	136	367
10	2024 - 2025	0	0	219	181		219	362	72	434	215		0	0	0	0	0		3176	44	-10	171	537
11	2025 - 2026	0	0	236	181		236	435	87	522	286		0	0	0	0	218		2958	44	61	23	561
12	2026 - 2027	0	0	255	181		255	453	91	544	289		0	0	0	0	218		2740	41	67	29	590
13	2027 - 2028	0	0	275	181		275	546	109	655	380		0	0	0	0	218		2521	38	161	123	713
14	2028 - 2029	0	0	297	181		297	568	114	682	385		0	0	0	0	218		2303	35	169	132	845
15	2029 - 2030	0	0	320	181		320	676	135	811	491		0	0	0	0	218		2085	32	278	241	1085
16	2030 - 2031	0	0	346	181		346	704	141	845	499		0	0	0	0	218		1867	29	289	252	1337
17	2031 - 2032	0	496	430	196		926	845	169	1014	88		0	0	0	0	218		1649	26	362	-156	1181
18	2032 - 2033	0	0	464	196		464	866	173	1039	575		0	0	0	0	218		1430	23	356	334	1514
19	2033 - 2034	0	0	501	196		501	1027	205	1232	731		0	0	0	0	218		1212	20	515	493	2007
20	2034 - 2035	0	0	541	196		541	1052	210	1262	721		0	0	0	0	218		994	17	508	486	2493
21	2035 - 2036	0	0	583	196		583	1237	247	1484	901		0	0	0	0	97		897	14	691	790	3283
22	2036 - 2037	0	0	630	196		630	1268	254	1522	892		0	0	0	0	97		799	13	683	782	4065
23	2037 - 2038	0	0	679	196		679	1491	298	1789	1110		0	0	0	0	97		702	11	903	1001	5066
24	2038 - 2039	0	0	733	196		733	1529	306	1835	1102		0	0	0	0	97		604	10	896	995	6061
25	2039 - 2040	0	0	791	196		791	1812	362	2174	1383		0	0	0	0	97		507	8	1179	1277	7338
26	2040 - 2041	0	0	854	218	725	1579	1857	371	2228	649		0	0	0	0	97		410	7	1149	545	7883
27	2041 - 2042	0	0	922	241	761	1683	2178	436	2614	931		0	0	0	0	97		312	6	1445	828	8710
28	2042 - 2043	0	0	995	241	0	995	2199	440	2639	1644		0	0	0	0	97		215	4	1399	1542	10253
29	2043 - 2044	0	0	1074	241	0	1074	2566	513	3079	2005		0	0	0	0	97		117	3	1761	1905	12157
30	2044 - 2045	0	0	1160	241	0	1160	2591	518	3109	1949		0	0	0	0	97		20	2	1706	1850	14007
		5925	**598**	**13152**	**5112**	**1486**	**21161**	**27624**	**5387**	**33011**	**6.41%**	**2769**				**3156**	**3156**	**20**		**612**	**14135**	**14007**	
											11850												

Mumbai Metro (Dehisar to DN Nagar) Corridor																							Table 15.15
CAPITAL COST-FIXED		4673																					
CAPITAL COST - CURRENT		5925														MARKET BORROWING		12.00%					
DOMESTIC FUNDING - BASE CASE																							
	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertiseme nt	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	247					247			0	-247	356	109	109	0	0	0	0	0				
2	2016 - 2017	667					667			0	-667	748	81	190	0	0	0	0	0				
3	2017 - 2018	1386					1386			0	-1386	765	-621	-431	431	431	0	26	457				
4	2018 - 2019	1286					1286			0	-1286	527	-759	-1190	1190	759	0	97	1313				
5	2019 - 2020	1106		136	181		1242	212	21	233	-1009	373	-733	-1923	1923	733	0		2046	202	-286	-105	-105
6	2020 - 2021	595	0	146	181		741	228	23	251	-490	0	-595	-2518	2518	595	0		2641	281	-357	-176	-281
7	2021 - 2022	638	102	174	184		914	281	28	309	-605		-638	-3156	3156	638	0		3279	355	-404	-322	-603
8	2022 - 2023	0	0	188	184		188	293	29	322	134		0	0	0	0	0		3279	393	-443	-259	-862
9	2023 - 2024	0	0	203	184		203	348	35	383	180		0	0	0	0	0		3279	393	-397	-213	-1076
10	2024 - 2025	0	0	219	184		219	362	72	434	215		0	0	0	0	0		3279	393	-362	-178	-1254
11	2025 - 2026	0	0	236	184		236	435	87	522	286		0	0	0	0	164		3115	393	-291	-271	-1526
12	2026 - 2027	0	0	255	184		255	453	91	544	289		0	0	0	0	164		2951	374	-269	-249	-1775
13	2027 - 2028	0	0	275	184		275	546	109	655	380		0	0	0	0	164		2787	354	-158	-138	-1913
14	2028 - 2029	0	0	297	184		297	568	114	682	385		0	0	0	0	164		2623	334	-133	-113	-2026
15	2029 - 2030	0	0	320	184		320	676	135	811	491		0	0	0	0	164		2459	315	-8	12	-2014
16	2030 - 2031	0	0	346	184		346	704	141	845	499		0	0	0	0	164		2295	295	20	40	-1974
17	2031 - 2032	0	496	430	199		926	845	169	1014	88		0	0	0	0	164		2131	275	110	-351	-2325
18	2032 - 2033	0	0	464	199		464	866	173	1039	575		0	0	0	0	164		1967	256	120	155	-2170
19	2033 - 2034	0	0	501	199		501	1027	205	1232	731		0	0	0	0	164		1803	236	296	331	-1839
20	2034 - 2035	0	0	541	199		541	1052	210	1262	721		0	0	0	0	164		1640	216	306	341	-1498
21	2035 - 2036	0	0	583	199		583	1237	247	1484	901		0	0	0	0	164		1476	197	505	540	-958
22	2036 - 2037	0	0	630	199		630	1268	254	1522	892		0	0	0	0	164		1312	177	516	551	-407
23	2037 - 2038	0	0	679	199		679	1491	298	1789	1110		0	0	0	0	164		1148	157	754	789	382
24	2038 - 2039	0	0	733	199		733	1529	306	1835	1102		0	0	0	0	164		984	138	765	800	1182
25	2039 - 2040	0	0	791	199		791	1812	362	2174	1383		0	0	0	0	164		820	118	1066	1101	2283
26	2040 - 2041	0	0	854	221	725	1579	1857	371	2228	649		0	0	0	0	164		656	98	1055	387	2670
27	2041 - 2042	0	0	922	244	761	1683	2178	436	2614	931		0	0	0	0	164		492	79	1369	688	3358
28	2042 - 2043	0	0	995	244	0	995	2199	440	2639	1644		0	0	0	0	164		328	59	1341	1421	4779
29	2043 - 2044	0	0	1074	244	0	1074	2566	513	3079	2005		0	0	0	0	164		164	39	1722	1802	6581
30	2044 - 2045	0	0	1160	244	0	1160	2591	518	3109	1949		0	0	0	0	164		0	20	1685	1765	8346
		5925	**598**	**13152**	**5190**	**1486**	**21161**	**27624**	**5387**	**33011**	**6.41%**	**2769**				**3156**	**3279**	**123**		**6150**	**8519**	**8346**	
											11850												

	Mumbai Metro (Dehisar to DN Nagar) Corridor																							Table 15.16
	CAPITAL COST-FIXED			4673														12.00%						
	CAPITAL COST - CURRENT			1991																				
	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
1	2015 - 2016	42					42			0	-42	166	124	124	0	0	0	0	0					-166
2	2016 - 2017	119					119			0	-119	166	47	171	0	0	0	0	0					-166
3	2017 - 2018	331					331			0	-331	166	-165	7	0	0	0	0	0					-166
4	2018 - 2019	469					469			0	-469	166	-303	-296	296	296	0	18	314					-166
5	2019 - 2020	289		136	60		425	212	21	233	-192		-289	-585	585	289	0		603	38	-1	59	59	59
6	2020 - 2021	268	0	146	60		414	228	23	251	-163		-268	-853	853	268	0		871	72	-27	33	92	33
7	2021 - 2022	475	102	174	63		751	281	28	309	-442		-475	-1327	1327	475	0		1345	104	-32	-71	21	-71
8	2022 - 2023	0	0	188	63		188	293	29	322	134		0	0	0	0	135		1211	161	-90	-162	-141	-162
9	2023 - 2024	0	0	203	63		203	348	35	383	180		0	0	0	0	135		1076	145	-28	-100	-241	-100
10	2024 - 2025	0	0	219	63		219	362	72	434	215		0	0	0	0	135		942	129	23	-49	-290	-49
11	2025 - 2026	0	0	236	63		236	435	87	522	286		0	0	0	0	135		807	113	110	39	-251	39
12	2026 - 2027	0	0	255	63		255	453	91	544	289		0	0	0	0	135		673	97	129	58	-194	58
13	2027 - 2028	0	0	275	63		275	546	109	655	380		0	0	0	0	135		538	81	236	165	-29	165
14	2028 - 2029	0	0	297	63		297	568	114	682	385		0	0	0	0	135		404	65	257	186	157	186
15	2029 - 2030	0	0	320	63		320	676	135	811	491		0	0	0	0	135		269	48	380	308	465	308
16	2030 - 2031	0	0	346	63		346	704	141	845	499		0	0	0	0	135		135	32	404	332	798	332
17	2031 - 2032	0	496	430	78		926	845	169	1014	88		0	0	0	0	135		0	16	490	-63	735	-63
18	2032 - 2033	0	0	464	78		464	866	173	1039	575		0	0	0	0	0		0	0	497	575	1310	575
19	2033 - 2034	0	0	501	78		501	1027	205	1232	731		0	0	0	0	0		0	0	653	731	2041	731
20	2034 - 2035	0	0	541	78		541	1052	210	1262	721		0	0	0	0	0		0	0	643	721	2762	721
21	2035 - 2036	0	0	583	78		583	1237	247	1484	901		0	0	0	0	0		0	0	823	901	3663	901
22	2036 - 2037	0	0	630	78		630	1268	254	1522	892		0	0	0	0	0		0	0	814	892	4555	892
23	2037 - 2038	0	0	679	78		679	1491	298	1789	1110		0	0	0	0	0		0	0	1032	1110	5665	1110
24	2038 - 2039	0	0	733	78		733	1529	306	1835	1102		0	0	0	0	0		0	0	1024	1102	6767	1102
25	2039 - 2040	0	0	791	78		791	1812	362	2174	1383		0	0	0	0	0		0	0	1305	1383	8150	1383
26	2040 - 2041	0	0	854	100	725	1579	1857	371	2228	649		0	0	0	0	0		0	0	1274	649	8799	649
27	2041 - 2042	0	0	922	123	761	1683	2178	436	2614	931		0	0	0	0	0		0	0	1569	931	9730	931
28	2042 - 2043	0	0	995	123	0	995	2199	440	2639	1644		0	0	0	0	0		0	0	1521	1644	11374	1644
29	2043 - 2044	0	0	1074	123	0	1074	2566	513	3079	2005		0	0	0	0	0		0	0	1882	2005	13379	2005
30	2044 - 2045	0	0	1160	123	0	1160	2591	518	3109	1949		0	0	0	0	0		0	0	1826	1949	15328	1949
		1991	**598**	**13152**	**2044**	**1486**	**17227**	**27624**	**5387**	**33011**	**15.44%**	**664**				**1327**	**1345**	**18**		**1102**	**16713**	**15328**		**15.89%**
											15784													

Mumbai Metro (Dehisar to DN Nagar) Corridor		JICA ELIGIBIITY	1948	3156
CAPITAL COST-FIXED	4673	MB	12%	0.00%
CAPITAL COST - CURRENT	5925	JICA Loan	1.40%	100.00%
DOMESTIC FUNDING - BASE CASE		Front end Fee (one time)	0.20%	

JICA ELIGIBIITY	61.72%		Table 15.17
MB	0.00%		
JICA Loan	1.40%		
Front end Fee (one time)	1.40%		

	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	247					247			0	-247	356	109	109	0	0	0	6	6				
2	2016 - 2017	667					667			0	-667	748	81	190	0	0	0	0	6				
3	2017 - 2018	1386					1386			0	-1386	765	-621	-431	431	431	0	3	440				
4	2018 - 2019	1286					1286			0	-1286	527	-759	-1190	1190	759	0	11	1210				
5	2019 - 2020	1106		136	178		1242	212	21	233	-1009	373	-733	-1923	1923	733	0		1943	22	-103	75	75
6	2020 - 2021	595	0	146	178		741	228	-116	112	-629	0	-595	-2518	2518	595	0		2538	31	-243	-65	10
7	2021 - 2022	638	102	174	181		914	281	-83	198	-716		-638	-3156	3156	638	0		3176	40	-197	-118	-108
8	2022 - 2023	0	0	188	181		188	293	-45	248	60		0	0	0	0	0		3176	44	-165	16	-93
9	2023 - 2024	0	0	203	181		203	348	29	377	174		0	0	0	0	0		3176	44	-51	130	37
10	2024 - 2025	0	0	219	181		219	362	187	549	330		0	0	0	0	0		3176	44	105	286	322
11	2025 - 2026	0	0	236	181		236	435	222	657	421		0	0	0	0	218		2958	44	196	158	481
12	2026 - 2027	0	0	255	181		255	453	249	702	447		0	0	0	0	218		2740	41	225	187	668
13	2027 - 2028	0	0	275	181		275	546	289	835	560		0	0	0	0	218		2521	38	341	303	971
14	2028 - 2029	0	0	297	181		297	568	317	885	588		0	0	0	0	218		2303	35	372	335	1306
15	2029 - 2030	0	0	320	181		320	676	360	1036	716		0	0	0	0	218		2085	32	503	466	1771
16	2030 - 2031	0	0	346	181		346	704	467	1171	825		0	0	0	0	218		1867	29	615	578	2349
17	2031 - 2032	0	496	430	196		926	845	511	1356	430		0	0	0	0	218		1649	26	704	186	2535
18	2032 - 2033	0	0	464	196		464	866	532	1398	934		0	0	0	0	218		1430	23	715	693	3227
19	2033 - 2034	0	0	501	196		501	1027	581	1608	1107		0	0	0	0	218		1212	20	891	869	4096
20	2034 - 2035	0	0	541	196		541	1052	605	1657	1116		0	0	0	0	218		994	17	903	881	4977
21	2035 - 2036	0	0	583	196		583	1237	663	1900	1317		0	0	0	0	97		897	14	1107	1206	6183
22	2036 - 2037	0	0	630	196		630	1268	691	1959	1329		0	0	0	0	97		799	13	1120	1219	7402
23	2037 - 2038	0	0	679	196		679	1491	757	2248	1569		0	0	0	0	97		702	11	1362	1460	8862
24	2038 - 2039	0	0	733	196		733	1529	787	2316	1583		0	0	0	0	97		604	10	1377	1476	10338
25	2039 - 2040	0	0	791	196		791	1812	867	2679	1888		0	0	0	0	97		507	8	1684	1782	12120
26	2040 - 2041	0	0	854	218	725	1579	1857	902	2759	1180		0	0	0	0	97		410	7	1680	1076	13196
27	2041 - 2042	0	0	922	241	761	1683	2178	993	3171	1488		0	0	0	0	97		312	6	2002	1385	14580
28	2042 - 2043	0	0	995	241	0	995	2199	1026	3225	2230		0	0	0	0	97		215	4	1985	2128	16709
29	2043 - 2044	0	0	1074	241	0	1074	2566	1127	3693	2619		0	0	0	0	97		117	3	2375	2519	19227
30	2044 - 2045	0	0	1160	241	0	1160	2591	1163	3754	2594		0	0	0	0	97		20	2	2351	2495	21722
		5925	598	13152	5112	1486	21161	27624	13102	40726	8.65%	2769				3156	3156	20		612	21850	21722	
											19565												

Mumbai Metro (Dehisar to DN Nagar) Corridor | Table 15.18

CAPITAL COST-FIXED 4673

CAPITAL COST - CURRENT 5925 | MARKET BORROWING 12.00%

DOMESTIC FUNDING - BASE CASE

	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	247					247			0	-247	356	109	109	0	0	0	0	0				
2	2016 - 2017	667					667			0	-667	748	81	190	0	0	0	0	0				
3	2017 - 2018	1386					1386			0	-1386	765	-621	-431	431	431	0	26	457				
4	2018 - 2019	1286					1286			0	-1286	527	-759	-1190	1190	759	0	97	1313				
5	2019 - 2020	1106		136	181		1242	212	21	233	-1009	373	-733	-1923	1923	733	0		2046	202	-286	-105	-105
6	2020 - 2021	595	0	146	181		741	228	-116	112	-629	0	-595	-2518	2518	595	0		2641	281	-496	-315	-420
7	2021 - 2022	638	102	174	184		914	281	-83	198	-716		-638	-3156	3156	638	0		3279	355	-515	-433	-853
8	2022 - 2023	0	0	188	184		188	293	-45	248	60		0	0	0	0	0		3279	393	-517	-333	-1186
9	2023 - 2024	0	0	203	184		203	348	29	377	174		0	0	0	0	0		3279	393	-403	-219	-1406
10	2024 - 2025	0	0	219	184		219	362	187	549	330		0	0	0	0	0		3279	393	-247	-63	-1469
11	2025 - 2026	0	0	236	184		236	435	222	657	421		0	0	0	0	164		3115	393	-156	-136	-1606
12	2026 - 2027	0	0	255	184		255	453	249	702	447		0	0	0	0	164		2951	374	-111	-91	-1697
13	2027 - 2028	0	0	275	184		275	546	289	835	560		0	0	0	0	164		2787	354	22	42	-1655
14	2028 - 2029	0	0	297	184		297	568	317	885	588		0	0	0	0	164		2623	334	70	90	-1565
15	2029 - 2030	0	0	320	184		320	676	360	1036	716		0	0	0	0	164		2459	315	217	237	-1328
16	2030 - 2031	0	0	346	184		346	704	467	1171	825		0	0	0	0	164		2295	295	346	366	-962
17	2031 - 2032	0	496	430	199		926	845	511	1356	430		0	0	0	0	164		2131	275	452	-9	-971
18	2032 - 2033	0	0	464	199		464	866	532	1398	934		0	0	0	0	164		1967	256	479	514	-457
19	2033 - 2034	0	0	501	199		501	1027	581	1608	1107		0	0	0	0	164		1803	236	672	707	250
20	2034 - 2035	0	0	541	199		541	1052	605	1657	1116		0	0	0	0	164		1640	216	701	736	986
21	2035 - 2036	0	0	583	199		583	1237	663	1900	1317		0	0	0	0	164		1476	197	921	956	1942
22	2036 - 2037	0	0	630	199		630	1268	691	1959	1329		0	0	0	0	164		1312	177	953	988	2930
23	2037 - 2038	0	0	679	199		679	1491	757	2248	1569		0	0	0	0	164		1148	157	1213	1248	4178
24	2038 - 2039	0	0	733	199		733	1529	787	2316	1583		0	0	0	0	164		984	138	1246	1281	5459
25	2039 - 2040	0	0	791	199		791	1812	867	2679	1888		0	0	0	0	164		820	118	1571	1606	7065
26	2040 - 2041	0	0	854	221	725	1579	1857	902	2759	1180		0	0	0	0	164		656	98	1586	918	7983
27	2041 - 2042	0	0	922	244	761	1683	2178	993	3171	1488		0	0	0	0	164		492	79	1926	1245	9228
28	2042 - 2043	0	0	995	244	0	995	2199	1026	3225	2230		0	0	0	0	164		328	59	1927	2007	11235
29	2043 - 2044	0	0	1074	244	0	1074	2566	1127	3693	2619		0	0	0	0	164		164	39	2336	2416	13651
30	2044 - 2045	0	0	1160	244	0	1160	2591	1163	3754	2594		0	0	0	0	164		0	20	2330	2410	16061
		5925	**598**	**13152**	**5190**	**1486**	**21161**	**27624**	**13102**	**40726**	**8.65%**	**2769**				**3156**	**3279**	**123**		**6150**	**16234**	**16061**	
											19565												

	Mumbai Metro (Dehisar to DN Nagar) Corridor																							Table 15.19
	CAPITAL COST-FIXED			4673														12.00%						
	CAPITAL COST - CURRENT			2501																				
	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
1	2015 - 2016	42					42			0	-42	166	124	124	0	0	0	0	0					-166
2	2016 - 2017	170					170			0	-170	166	-4	120	0	0	0	0	0					-166
3	2017 - 2018	458					458			0	-458	166	-292	-172	172	172	0	10	182					-166
4	2018 - 2019	596					596			0	-596	166	-430	-602	602	430	0	46	658					-166
5	2019 - 2020	416		136	77		552	212	21	233	-319		-416	-1018	1018	416	0		1074	79	-59	18	18	18
6	2020 - 2021	319	0	146	77		465	228	23	251	-214		-319	-1337	1337	319	0		1393	129	-101	-24	-6	-24
7	2021 - 2022	500	102	174	80		776	281	-111	170	-606		-500	-1837	1837	500	0		1893	167	-251	-273	-279	-273
8	2022 - 2023	0	0	188	80		188	293	-82	211	23		0	0	0	0	189		1704	227	-284	-393	-672	-393
9	2023 - 2024	0	0	203	80		203	348	-39	309	106		0	0	0	0	189		1514	204	-178	-288	-960	-288
10	2024 - 2025	0	0	219	80		219	362	66	428	209		0	0	0	0	189		1325	182	-53	-162	-1122	-162
11	2025 - 2026	0	0	236	80		236	435	202	637	401		0	0	0	0	189		1136	159	162	53	-1070	53
12	2026 - 2027	0	0	255	80		255	453	226	679	424		0	0	0	0	189		947	136	208	98	-971	98
13	2027 - 2028	0	0	275	80		275	546	267	813	538		0	0	0	0	189		757	114	344	235	-736	235
14	2028 - 2029	0	0	297	80		297	568	294	862	565		0	0	0	0	189		568	91	394	285	-451	285
15	2029 - 2030	0	0	320	80		320	676	338	1014	694		0	0	0	0	189		379	68	546	437	-15	437
16	2030 - 2031	0	0	346	80		346	704	366	1070	724		0	0	0	0	189		189	45	599	489	475	489
17	2031 - 2032	0	496	430	95		926	845	495	1340	414		0	0	0	0	189		0	23	792	202	677	202
18	2032 - 2033	0	0	464	95		464	866	515	1381	917		0	0	0	0	0		0	0	822	917	1594	917
19	2033 - 2034	0	0	501	95		501	1027	564	1591	1090		0	0	0	0	0		0	0	995	1090	2684	1090
20	2034 - 2035	0	0	541	95		541	1052	586	1638	1097		0	0	0	0	0		0	0	1002	1097	3781	1097
21	2035 - 2036	0	0	583	95		583	1237	642	1879	1296		0	0	0	0	0		0	0	1201	1296	5077	1296
22	2036 - 2037	0	0	630	95		630	1268	670	1938	1308		0	0	0	0	0		0	0	1213	1308	6385	1308
23	2037 - 2038	0	0	679	95		679	1491	735	2226	1547		0	0	0	0	0		0	0	1452	1547	7932	1547
24	2038 - 2039	0	0	733	95		733	1529	765	2294	1561		0	0	0	0	0		0	0	1466	1561	9493	1561
25	2039 - 2040	0	0	791	95		791	1812	843	2655	1864		0	0	0	0	0		0	0	1769	1864	11357	1864
26	2040 - 2041	0	0	854	117	725	1579	1857	876	2733	1154		0	0	0	0	0		0	0	1762	1154	12511	1154
27	2041 - 2042	0	0	922	140	761	1683	2178	967	3145	1462		0	0	0	0	0		0	0	2083	1462	13973	1462
28	2042 - 2043	0	0	995	140	0	995	2199	997	3196	2201		0	0	0	0	0		0	0	2061	2201	16174	2201
29	2043 - 2044	0	0	1074	140	0	1074	2566	1099	3665	2591		0	0	0	0	0		0	0	2451	2591	18765	2591
30	2044 - 2045	0	0	1160	140	0	1160	2591	1132	3723	2563		0	0	0	0	0		0	0	2423	2563	21328	2563
		2501	**598**	**13152**	**2486**	**1486**	**17737**	**27624**	**12457**	**40081**	**15.31%**	**664**				**1837**	**1893**	**56**		**1624**	**22819**	**21328**		**15.94%**
											22344													

Chapter 15B

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

15.1 INTRODUCTION

The Mumbai Metro Rail Project (Dahisar (E) to DN Nagar) is proposed to be constructed at an estimated cost of Rs 5913.00 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	Dahisar (E) to D N Nagar	18.589	5263.00	5913.00	6280.00

The estimated cost at July-2015 price level includes an amount of Rs.7.24 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 consist of Custom Duty (CD), Excise Duty (ED), State Value Added Tax (VAT) and Octroi levied by the Brihanmumbai Municipal Corporation (BMC). Mumbai Metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective CD works out to 23.4155% (Basic CD (5%), Countervail Duty (CVD) + Additional Custom Duty (ACD)) on the imported portions, ED @ 12.50% and VAT @ 12.50% on indigenously manufactured items and Octroi @ 4% on supply items, which have been considered for working out the estimated taxes and duties. Service Tax on "Works Contract Services" on new construction pertaining to Metro and Mono Rail Projects is exempted from the Service Tax on date and therefore the same has been considered as Nil in the estimated cost. It has been assumed that Maharashtra State Government will exempt the local taxes or reimburse the same (Sate VAT, Octroi etc) and provide the land worth Rs. Rs. 665 crore on completion cost basis free of cost or shall provide Interest Free Subordinate Debt.

It is assumed that the construction work will start on 01.10.2015 and is expected to be completed on 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2019 for the corridor. The total completion costs duly escalated and shown in the table 15.2 have been taken as the initial investment. The cash flow of investments separately is placed in Table –15.2 as below.

Table 15.2 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at July -2015 Price Level	Completion Cost including land cost and central taxes
2015-16	255.00	260.00
2016-17	733.00	802.00
2017-18	1476.00	1737.00
2018-19	1327.00	1679.00
2019-20	1061.00	1443.00
2020-21	531.00	776.00
2021-22	530.00	833.00
Total	**5913.00**	**7530.00**

15.2.1.2 Although the construction is expected to get over by 31st March 2019, the cash flow spill over up to March 2022 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

15.2.1.3 The cost of Land of Rs. 665 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	18	305.00
2031-32	12	331.00
TOTAL	**30**	**636.00**

15.2.3 Operation & Maintenance (O&M) Costs

The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs
(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables
(iii) Energy costs

The requirement of staff has been assumed @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The prevailing rate of electricity in Mumbai is Rs. 8.46 per unit which has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 7.50% per annum. The O&M costs have been tabulated in Table 15.4.1as below.:

Table 15.4 Operation and Maintenance Costs

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2019	-	2020	41.03	27.88	87.51	156.42
2020	-	2021	44.72	29.97	94.07	168.77
2021	-	2022	48.75	32.22	115.15	196.12
2022	-	2023	53.14	34.64	123.79	211.56
2023	-	2024	57.92	37.24	133.07	228.23
2024	-	2025	63.13	40.03	143.05	246.21
2025	-	2026	68.81	43.03	153.78	265.62
2026	-	2027	75.00	46.26	165.31	286.58

YEAR			Staff	Maintenance Expenses	Energy	Total
2027	-	2028	81.75	49.73	177.71	309.20
2028	-	2029	89.11	53.46	191.04	333.61
2029	-	2030	97.13	57.47	205.37	359.97
2030	-	2031	105.87	61.78	220.77	388.42
2031	-	2032	115.40	66.41	299.63	481.45
2032	-	2033	125.79	71.39	322.11	519.29
2033	-	2034	137.11	76.75	346.27	560.12
2034	-	2035	149.45	82.50	372.24	604.19
2035	-	2036	162.90	88.69	400.15	651.75
2036	-	2037	177.56	95.34	430.16	703.07
2037	-	2038	193.54	102.49	462.43	758.46
2038	-	2039	210.96	110.18	497.11	818.25
2039	-	2040	229.95	118.44	534.39	882.79
2040	-	2041	250.64	127.33	574.47	952.44
2041	-	2042	273.20	136.88	617.56	1027.64
2042	-	2043	297.79	147.14	663.87	1108.81
2043	-	2044	324.59	158.18	713.66	1196.44
2044	-	2045	353.80	170.04	767.19	1291.04
2045	-	2046	385.65	182.80	824.73	1393.17

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 year wise as provided by MMRDA are as indicated in table 15.5 as below: -

Table 15.5 Projected Ridership

Financial Year	Trips per day (lakhs)
2019-20	5.98
2021-22	6.97
2031-32	9.02

b. The growth rate for traffic is assumed @8% Per Annum upto 2021-22, and @ 2.61% per annum upto 2031-32 thereafter NIL per annum.

15.3.2.2 Trip Distribution

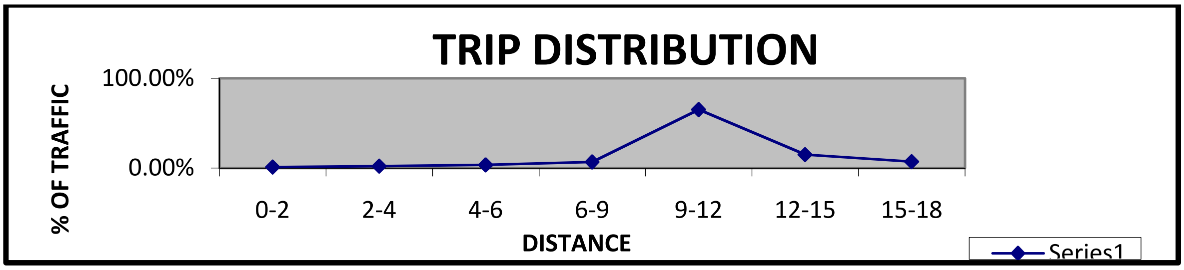
The trip distribution has been worked out by considering average lead of 10.74 KM which is shown in Table 15.6 below: -

Table 15.6 Trip Distribution

Distance in km	Percent distribution
0-2	1.00%
2-4	2.00%
4-6	3.35%
6-9	6.65%
9-12	65.00%
12-15	15.00%
15-18	7.00%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-15.1.

Figure 15.1 –Trip Distribution



Fare Structure

The fare structure for the FY 2019-20 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the existing fare structure has been escalated by using an escalation factor @15.00% once in every two years. The fare structure for the FY 2019-20 as per the proposed fare slabs is shown in the table 15.7 below:

Table 15.7 Fare Structure in 2019-20

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

The above fare structure has been taken as furnished by MMRDA since it has been approved by GOM. DMRC proposed that the under mentioned fare structure in a multiple of Rs. 10 be adopted in 2019-20 at the time of commissioning of this Line.

Table 15.8 Fare Structure in multiple of Rs. 10

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

The proposed Fare Structure will have convenience in making use of ticket vending machine and 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 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 10.91%. 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
2015	-	2016	260				260			0	-260
2016	-	2017	802				802			0	-802
2017	-	2018	1737				1737			0	-1737
2018	-	2019	1679				1679			0	-1679
2019	-	2020	1443		156		1599	446	45	491	-1108
2020	-	2021	776	0	169		945	482	48	530	-415
2021	-	2022	833	305	196		1334	595	60	655	-679
2022	-	2023	0	0	212		212	611	61	672	460
2023	-	2024	0	0	228		228	723	72	795	567
2024	-	2025	0	0	246		246	741	148	889	643
2025	-	2026	0	0	266		266	872	174	1046	780
2026	-	2027	0	0	287		287	894	179	1073	786
2027	-	2028	0	0	309		309	1054	211	1265	956
2028	-	2029	0	0	334		334	1081	216	1297	963
2029	-	2030	0	0	360		360	1279	256	1535	1175
2030	-	2031	0	0	388		388	1312	262	1574	1186
2031	-	2032	0	331	481		812	1561	312	1873	1061
2032	-	2033	0	0	519		519	1561	312	1873	1354
2033	-	2034	0	0	560		560	1802	360	2162	1602
2034	-	2035	0	0	604		604	1802	360	2162	1558
2035	-	2036	0	0	652		652	2053	411	2464	1812
2036	-	2037	0	0	703		703	2053	411	2464	1761
2037	-	2038	0	0	758		758	2358	472	2830	2072
2038	-	2039	0	0	818		818	2358	472	2830	2012
2039	-	2040	0	0	883		883	2725	545	3270	2387
2040	-	2041	0	0	952	725	1677	2725	545	3270	1593
2041	-	2042	0	0	1028	761	1789	3127	625	3752	1963
2042	-	2043	0	0	1109	0	1109	3127	625	3752	2643
2043	-	2044	0	0	1196	0	1196	3608	722	4330	3134
2044	-	2045	0	0	1291	0	1291	3608	722	4330	3039
Total			**7530**	**636**	**14705**	**1486**	**24357**	**44558**	**8626**	**53184**	**10.91%**

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**
10.10%	9.39%	11.83%	12.90%
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**
8.09%	9.58%	12.13%	13.25%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
10.55%		**11.25%**	

These sensitivities have been carried out independently for each factor.

15.5 FINANCING OPTIONS

Objectives of Funding: - The objective of funding metro rail systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
    - Low infrastructure maintenance costs
    - Longer life span
    - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai, Bengaluru and Mumbai Line-3 projects are funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

15.5.1 Alternative Models Of Financing

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

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

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

SPV Model: - The State Government has already formed a fully owned SPV in the name of Mumbai Metro Rail Corporation (MMRC), which is responsible for the implementation of all the metro rail corridors under the Mumbai Metro rail project. The issue of extending JICA loan for the project was discussed informally with JICA India Office. It was told that an informal understanding between GOI & GOJ has taken place. According to which JICA will extend only modified step loan for the new projects in India at an interest rate of 0.30% per annum. The tenure of the loan will be 40 years with 10 years moratorium period. JICA shall fund to the extent of 85% of the cost of project excluding cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. However, pending formal notification from the MOF, GOI, the existing terms applicable for JICA loan have been assumed except the quantum of project cost eligible for funding. The funding pattern under this model (SPV) is placed in table 15.11 as under: -

Table 15.11 Funding pattern under SPV model (with central taxes and land) (Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	949.00	13.82%
Equity By GOM	949.00	13.82%
SD for CT by GOM	424.00	6.18%
SD for CT by GOI	424.00	6.18%
1.40% Loan from JICA / 12% Market Borrowings	4119.00	60.00%
Total	6865.00	100.00%
SD for Land by GOM	665.00	
Total	7530.00	
Interest During Construction	27.00	
Grand Total	7557.00	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.538.00 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	1373.00	20.00%
VGF by GOM	587.00	8.55%
Equity by Concessionaire	1635.00	23.82%
Concessionaire's debt @12% PA	3270.00	47.63%
Total	6865.00	100.00%
Land Free by GOM	665.00	
Total	7530.00	
IDC	86.00	
Total	7616.00	

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.538.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

15.6. RECOMMENDATIONS

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	1373.00	1052.00
GOM	2038.00	2052.00
Total	**3411.00**	**3104.00**

In addition to the above, State Taxes (Sate VAT, Octroi etc) of Rs.538.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

The FIRR of the corridor with central taxes and land is 10.91%. The pre-tax Equity FIRR to the BOT operator worked out to 16% with total VGF of Rs.3104.00 crore.

Inspite that Project FIRR is high and cash outgo in BOT model is lesser than completely Government model, BOT model is not recommended for the number of uncertainties during implementation. This project should be implemented as completely government funded on the pattern of Bangalore Chennai and Delhi on the funding pattern as given in table 15.11

The detailed cash flow statements under various alternatives are enclosed at Table No. 15.14, 15.15, 15.16

The funding pattern assumed under SPV model & BOT model is depicted in the pie chart i.e., Figure 15.2.1 & 15.2.2 as under: -

Figure 15.2.1
Funding pattern under SPV Model

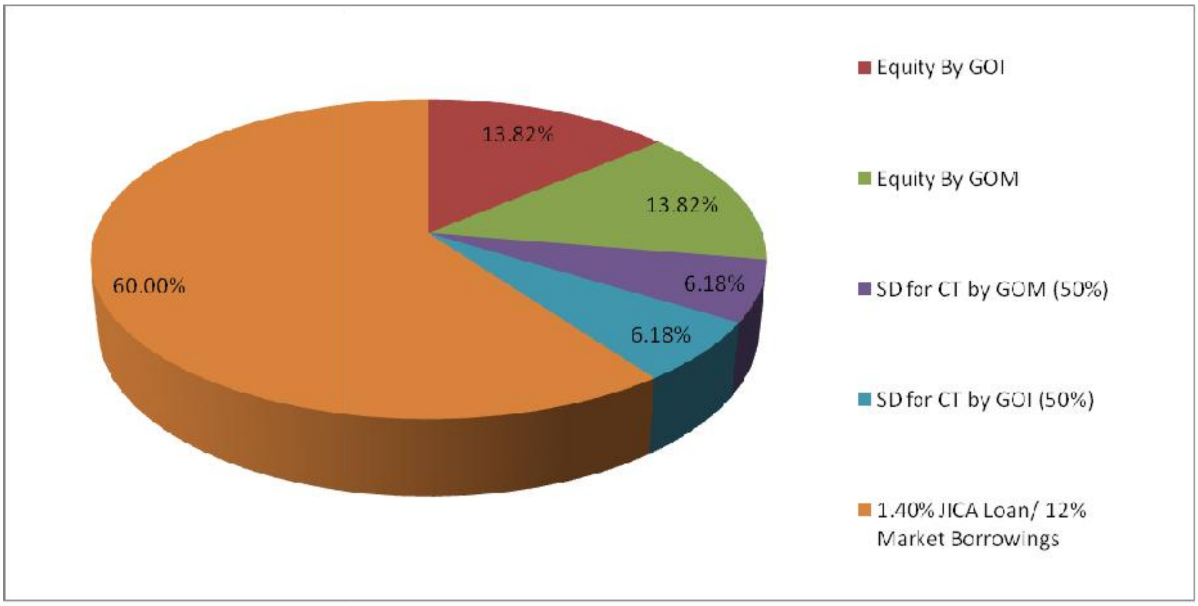
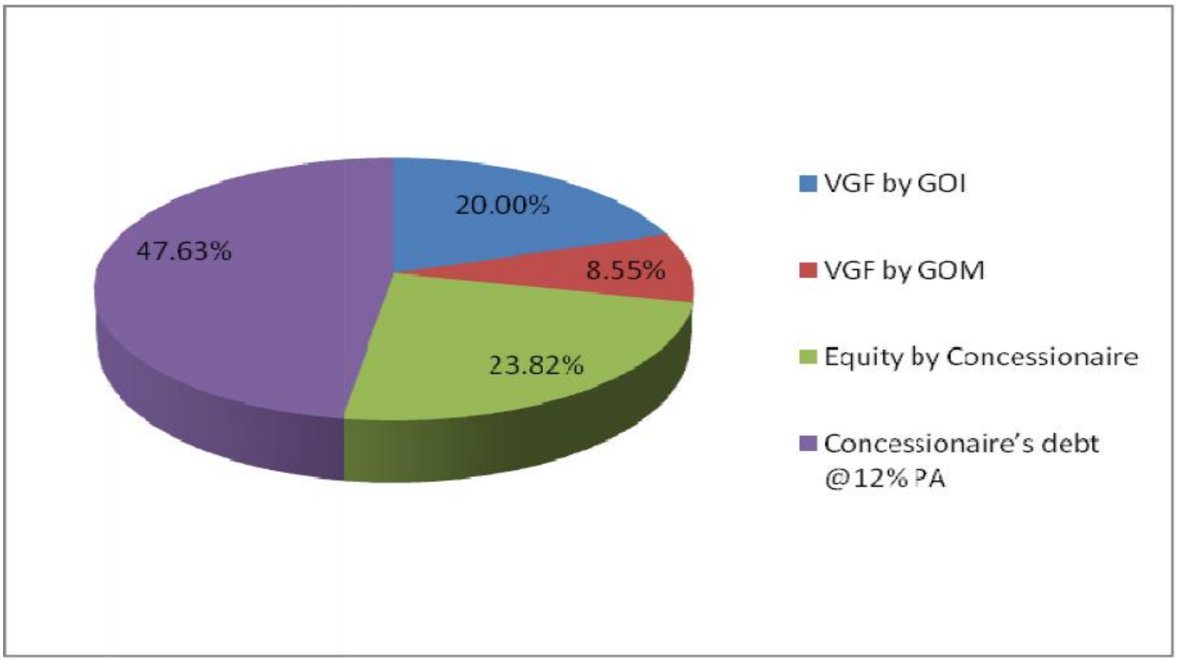


Figure 15.2.2
Funding pattern under BOT Model



	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
	Mumbai Metro (Dehisar to DN Nagar) Corridor														2171	JICA ELIGIBIITY		1948	4119	47.29%			**Table 15.14**
	CAPITAL COST-FIXED			5913												MB		12%	0.00%	0.00%			
	CAPITAL COST - CURRENT			7530												JICA Loan		1.40%	100.00%	1.40%			
	DOMESTIC FUNDING - BASE CASE															Front end Fee (one time)		0.20%		1.40%			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	260					260			0	-260	356	96	96	0	0	0	8	8				
2	2016 - 2017	802					802			0	-802	908	106	202	0	0	0	0	8				
3	2017 - 2018	1737					1737			0	-1737	925	-812	-610	610	610	0	4	622				
4	2018 - 2019	1679					1679			0	-1679	687	-992	-1602	1602	992	0	15	1629				
5	2019 - 2020	1443		156	227		1599	446	45	491	-1108	535	-908	-2510	2510	908	0		2537	29	79	306	306
6	2020 - 2021	776	0	169	227		945	482	48	530	-415	0	-776	-3286	3286	776	0		3313	41	93	320	626
7	2021 - 2022	833	305	196	236		1334	595	60	655	-679		-833	-4119	4119	833	0		4146	52	171	102	728
8	2022 - 2023	0	0	212	236		212	611	61	672	460		0	0	0	0	0		4146	58	166	402	1130
9	2023 - 2024	0	0	228	236		228	723	72	795	567		0	0	0	0	0		4146	58	273	509	1639
10	2024 - 2025	0	0	246	236		246	741	148	889	643		0	0	0	0	0		4146	58	349	585	2224
11	2025 - 2026	0	0	266	236		266	872	174	1046	780		0	0	0	0	315		3832	58	486	407	2631
12	2026 - 2027	0	0	287	236		287	894	179	1073	786		0	0	0	0	315		3517	54	496	418	3049
13	2027 - 2028	0	0	309	236		309	1054	211	1265	956		0	0	0	0	315		3203	49	671	592	3641
14	2028 - 2029	0	0	334	236		334	1081	216	1297	963		0	0	0	0	315		2888	45	682	604	4245
15	2029 - 2030	0	0	360	236		360	1279	256	1535	1175		0	0	0	0	315		2574	40	899	820	5065
16	2030 - 2031	0	0	388	236		388	1312	262	1574	1186		0	0	0	0	315		2259	36	914	835	5900
17	2031 - 2032	0	331	481	246		812	1561	312	1873	1061		0	0	0	0	315		1945	32	1114	715	6615
18	2032 - 2033	0	0	519	246		519	1561	312	1873	1354		0	0	0	0	315		1630	27	1081	1012	7627
19	2033 - 2034	0	0	560	246		560	1802	360	2162	1602		0	0	0	0	315		1316	23	1333	1265	8892
20	2034 - 2035	0	0	604	246		604	1802	360	2162	1558		0	0	0	0	315		1001	18	1294	1225	10117
21	2035 - 2036	0	0	652	246		652	2053	411	2464	1812		0	0	0	0	97		904	14	1552	1701	11818
22	2036 - 2037	0	0	703	246		703	2053	411	2464	1761		0	0	0	0	97		806	13	1502	1651	13469
23	2037 - 2038	0	0	758	246		758	2358	472	2830	2072		0	0	0	0	97		709	11	1815	1963	15432
24	2038 - 2039	0	0	818	246		818	2358	472	2830	2012		0	0	0	0	97		611	10	1756	1905	17337
25	2039 - 2040	0	0	883	246		883	2725	545	3270	2387		0	0	0	0	97		514	9	2132	2281	19618
26	2040 - 2041	0	0	952	268	725	1677	2725	545	3270	1593		0	0	0	0	97		417	7	2043	1488	21106
27	2041 - 2042	0	0	1028	291	761	1789	3127	625	3752	1963		0	0	0	0	97		319	6	2427	1860	22966
28	2042 - 2043	0	0	1109	291	0	1109	3127	625	3752	2643		0	0	0	0	97		222	4	2348	2541	25507
29	2043 - 2044	0	0	1196	291	0	1196	3608	722	4330	3134		0	0	0	0	97		124	3	2840	3033	28541
30	2044 - 2045	0	0	1291	291	0	1291	3608	722	4330	3039		0	0	0	0	97		27	2	2746	2940	31480
		7530	**636**	**14705**	**6460**	**1486**	**24357**	**44558**	**8626**	**53184**	**10.91%**	**3411**				**4119**	**4119**	**27**		**758**	**31261**	**31480**	
											28827												

Mumbai Metro (Dehisar to DN Nagar) Corridor — **Table 11.15**

CAPITAL COST-FIXED	5913		
CAPITAL COST - CURRENT	7530	MARKET BORROWING	12.00%
DOMESTIC FUNDING - BASE CASE			

	Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOM	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2015 - 2016	260					260			0	-260	356	96	96	0	0	0	0	0				
2	2016 - 2017	802					802			0	-802	908	106	202	0	0	0	0	0				
3	2017 - 2018	1737					1737			0	-1737	925	-812	-610	610	610	0	37	647				
4	2018 - 2019	1679					1679			0	-1679	687	-992	-1602	1602	992	0	133	1772				
5	2019 - 2020	1443		156	231		1599	446	45	491	-1108	535	-908	-2510	2510	908	0		2680	267	-163	68	68
6	2020 - 2021	776	0	169	231		945	482	48	530	-415	0	-776	-3286	3286	776	0		3456	368	-238	-7	61
7	2021 - 2022	833	305	196	240		1334	595	60	655	-679		-833	-4119	4119	833	0		4289	465	-246	-311	-250
8	2022 - 2023	0	0	212	240		212	611	61	672	460		0	0	0	0	0		4289	515	-295	-55	-305
9	2023 - 2024	0	0	228	240		228	723	72	795	567		0	0	0	0	0		4289	515	-188	52	-252
10	2024 - 2025	0	0	246	240		246	741	148	889	643		0	0	0	0	0		4289	515	-112	128	-124
11	2025 - 2026	0	0	266	240		266	872	174	1046	780		0	0	0	0	214		4075	515	25	51	-73
12	2026 - 2027	0	0	287	240		287	894	179	1073	786		0	0	0	0	214		3860	489	57	83	9
13	2027 - 2028	0	0	309	240		309	1054	211	1265	956		0	0	0	0	214		3646	463	253	278	288
14	2028 - 2029	0	0	334	240		334	1081	216	1297	963		0	0	0	0	214		3431	437	286	311	599
15	2029 - 2030	0	0	360	240		360	1279	256	1535	1175		0	0	0	0	214		3217	412	523	549	1148
16	2030 - 2031	0	0	388	240		388	1312	262	1574	1186		0	0	0	0	214		3002	386	560	586	1733
17	2031 - 2032	0	331	481	250		812	1561	312	1873	1061		0	0	0	0	214		2788	360	782	486	2219
18	2032 - 2033	0	0	519	250		519	1561	312	1873	1354		0	0	0	0	214		2573	335	769	805	3024
19	2033 - 2034	0	0	560	250		560	1802	360	2162	1602		0	0	0	0	214		2359	309	1043	1079	4103
20	2034 - 2035	0	0	604	250		604	1802	360	2162	1558		0	0	0	0	214		2145	283	1025	1060	5164
21	2035 - 2036	0	0	652	250		652	2053	411	2464	1812		0	0	0	0	214		1930	257	1305	1340	6504
22	2036 - 2037	0	0	703	250		703	2053	411	2464	1761		0	0	0	0	214		1716	232	1279	1315	7819
23	2037 - 2038	0	0	758	250		758	2358	472	2830	2072		0	0	0	0	214		1501	206	1616	1652	9471
24	2038 - 2039	0	0	818	250		818	2358	472	2830	2012		0	0	0	0	214		1287	180	1582	1617	11088
25	2039 - 2040	0	0	883	250		883	2725	545	3270	2387		0	0	0	0	214		1072	154	1983	2018	13106
26	2040 - 2041	0	0	952	272	725	1677	2725	545	3270	1593		0	0	0	0	214		858	129	1917	1250	14356
27	2041 - 2042	0	0	1028	295	761	1789	3127	625	3752	1963		0	0	0	0	214		643	103	2326	1646	16002
28	2042 - 2043	0	0	1109	295	0	1109	3127	625	3752	2643		0	0	0	0	214		429	77	2271	2351	18353
29	2043 - 2044	0	0	1196	295	0	1196	3608	722	4330	3134		0	0	0	0	214		214	51	2788	2868	21221
30	2044 - 2045	0	0	1291	295	0	1291	3608	722	4330	3039		0	0	0	0	214		0	26	2718	2799	24020
		7530	**636**	**14705**	**6564**	**1486**	**24357**	**44558**	**8626**	**53184**	**10.91%**	**3411**				**4119**	**4289**	**170**		**8048**	**23867**	**24020**	
											28827												

Funding Pattern:-SPV Model

	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
	Mumbai Metro (Dehisar to DN Nagar) Corridor																							**Table 15.16**
	CAPITAL COST-FIXED			5913														12.00%						
	CAPITAL COST - CURRENT			4905																				
	DOMESTIC FUNDING - BASE CASE																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	2015 - 2016	54					54			0	-54	409	355	355	0	0	0	0	0					-409
2	2016 - 2017	385					385			0	-385	409	24	379	0	0	0	0	0					-409
3	2017 - 2018	1009					1009			0	-1009	409	-600	-221	221	221	0	13	234					-409
4	2018 - 2019	1189					1189			0	-1189	408	-781	-1002	1002	781	0	73	1088					-408
5	2019 - 2020	953		156	150		1109	446	45	491	-618		-953	-1955	1955	953	0		2041	131	54	204	204	204
6	2020 - 2021	580	0	169	150		749	482	48	530	-219		-580	-2535	2535	580	0		2621	245	-34	116	321	116
7	2021 - 2022	735	305	196	159		1236	595	60	655	-581		-735	-3270	3270	735	0		3356	315	-15	-161	160	-161
8	2022 - 2023	0	0	212	159		212	611	61	672	460		0	0	0	0	336		3020	403	-102	-278	-118	-278
9	2023 - 2024	0	0	228	159		228	723	72	795	567		0	0	0	0	336		2685	362	46	-131	-249	-131
10	2024 - 2025	0	0	246	159		246	741	148	889	643		0	0	0	0	336		2349	322	162	-15	-264	-15
11	2025 - 2026	0	0	266	159		266	872	174	1046	780		0	0	0	0	336		2014	282	339	162	-102	162
12	2026 - 2027	0	0	287	159		287	894	179	1073	786		0	0	0	0	336		1678	242	385	209	107	209
13	2027 - 2028	0	0	309	159		309	1054	211	1265	956		0	0	0	0	336		1342	201	596	419	526	419
14	2028 - 2029	0	0	334	159		334	1081	216	1297	963		0	0	0	0	336		1007	161	643	466	992	466
15	2029 - 2030	0	0	360	159		360	1279	256	1535	1175		0	0	0	0	336		671	121	895	719	1711	719
16	2030 - 2031	0	0	388	159		388	1312	262	1574	1186		0	0	0	0	336		336	81	946	770	2481	770
17	2031 - 2032	0	331	481	169		812	1561	312	1873	1061		0	0	0	0	336		0	40	1183	685	3166	685
18	2032 - 2033	0	0	519	169		519	1561	312	1873	1354		0	0	0	0	0		0	0	1185	1354	4520	1354
19	2033 - 2034	0	0	560	169		560	1802	360	2162	1602		0	0	0	0	0		0	0	1433	1602	6122	1602
20	2034 - 2035	0	0	604	169		604	1802	360	2162	1558		0	0	0	0	0		0	0	1389	1558	7680	1558
21	2035 - 2036	0	0	652	169		652	2053	411	2464	1812		0	0	0	0	0		0	0	1643	1812	9492	1812
22	2036 - 2037	0	0	703	169		703	2053	411	2464	1761		0	0	0	0	0		0	0	1592	1761	11253	1761
23	2037 - 2038	0	0	758	169		758	2358	472	2830	2072		0	0	0	0	0		0	0	1903	2072	13325	2072
24	2038 - 2039	0	0	818	169		818	2358	472	2830	2012		0	0	0	0	0		0	0	1843	2012	15337	2012
25	2039 - 2040	0	0	883	169		883	2725	545	3270	2387		0	0	0	0	0		0	0	2218	2387	17724	2387
26	2040 - 2041	0	0	952	191	725	1677	2725	545	3270	1593		0	0	0	0	0		0	0	2127	1593	19317	1593
27	2041 - 2042	0	0	1028	214	761	1789	3127	625	3752	1963		0	0	0	0	0		0	0	2510	1963	21280	1963
28	2042 - 2043	0	0	1109	214	0	1109	3127	625	3752	2643		0	0	0	0	0		0	0	2429	2643	23923	2643
29	2043 - 2044	0	0	1196	214	0	1196	3608	722	4330	3134		0	0	0	0	0		0	0	2920	3134	27057	3134
30	2044 - 2045	0	0	1291	214	0	1291	3608	722	4330	3039		0	0	0	0	0		0	0	2825	3039	30096	3039
		4905	**636**	**14705**	**4458**	**1486**	**21732**	**44558**	**8626**	**53184**	**15.41%**	**1635**				**3270**	**3356**	**86**		**2905**	**31116**	**30096**		**16.00%**
											31452													

Chapter - 16 A

ECONOMIC APPRAISAL

16.0 Alignment Description and Issues

Traffic study was conducted for Dahisar(E) to Mandale Metro Corridor (Mumbai) and ridership was estimated. Revenue earning length of the entire section is 41.94 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 Mandale (24.38 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, Power supply, Signalling, Electronics and telecommunication equipments etc. This is distributed year wise as cost stream. Two options are considered namely **(1)** Consider first stage as isolated or stand alone system and discard the ridership after D.N. Nagar and **(2)** Consider first stage as a part of the full length to be constructed simultaneously and take full ridership. **Present Economic appraisal is for the stretch is for first stage (Dahisar(E) to D.N. Nagar) under option 1 in which ridership figures within the section are taken.** Presented below alignment description in table 16.0 for better understanding.

Table 16.0 Alignment Description

Dahisar(E) to Mandale Metro Corridor (Mumbai)			
0	DEAD END	(-) 413.941	
1	DAHISAR (E)	0.0	413.941
2	DAHISAR (W)	711.0	711.0
3	RUSHI SANKUL	2422.7	1711.7
4	I C COLONY	3383.1	960.4
5	LIC COLONY	4468.4	1085.3
6	DON BOSCO	5537.5	1069.1
7	KASTUR PARK	6465.9	928.4
8	EKATA NAGAR	7571.8	1105.9
9	KANDIVALI NAGAR	8200.3	628.5
10	CHARKOP	9535.5	1335.2
11	MALAD METRO	10846.0	1310.5
12	KASTURI PARK	12243.4	1397.4
13	BANGUR NAGAR	13183.1	939.7
14	OSHIWARA METRO	14455.5	1272.4
15	SAMARTHA NAGAR	15468.7	1013.2
16	SHASTRI NAGAR	16433.0	964.3
17	D N NAGAR	17578.6	1145.6
18	ESIC Nagar	18783.6	1205.0

Dahisar(E) to Mandale Metro Corridor (Mumbai)			
19	Prem Nagar	20099.6	1316.0
20	Indira Nagar	20770.6	671.0
21	Nanavati Hospital	21825.6	1055.0
22	Khira Nagar	23315.6	1490.0
23	Saraswat Nagar	24014.6	699.0
24	National College	24669.6	655.0
25	Bandra Metro	25307.6	638.0
26	MMRDA	26007.6	700.0
27	Income Tax Office	27079.6	1072.0
28	ILFS	28750.6	1671.0
29	MTNL Metro	30179.6	1429.0
30	S G Barve Marg	31545.6	1366.0
31	Kurla Railway	32226.6	681.0
32	Tilak Nagar	33559.6	1333.0
33	Kurla (E)	34512.6	953.0
34	EEH	35565.6	1053.0
35	R C Marg	36837.6	1272.0
36	Shivaji Chowk	38041.6	1204.0
37	B S N L Metro	39699.6	1658.0
38	Mankhurd	40804.6	1105.0
39	Mandale Metro	41963.6	1159.0

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	Derived
2	Maintenance Cost	Derived
3	Annual Time Cost Saved by Metro Passengers	100%
4	Annual Fuel Cost Saved by Metro Passengers	80%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	80%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	100%

9	Annual Fuel Cost Saved by Road Passengers	80%
10	Annual Infra Structure Maintenance Cost	100%

16.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in table 16.2.

Table 16.2: **Values adopted for some important variables**

	Values	Important variables
1	Rs. 0.51/min (2014 value)	Weighted value of Travel Time is derived 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	14.88 min	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	24.68 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	Fare	Total Journey Time (Min)	VOC (Rs.)	Time Cost (Rs.)
Bus	9.00	37.79	3.994	5.01
Train	7.00	30.32	0.285	6.72
Two Wh.	17.00	18.39	10.156	6.84
Four Wh.	80.00	18.39	35.137	44.86
Three Wh.	68.00	23.55	15.936	52.06
Private Bus & Others	9.00	40.07	4.301	4.70
Average Trip Length 6.33 km		Average Journey Time 21.65 min		

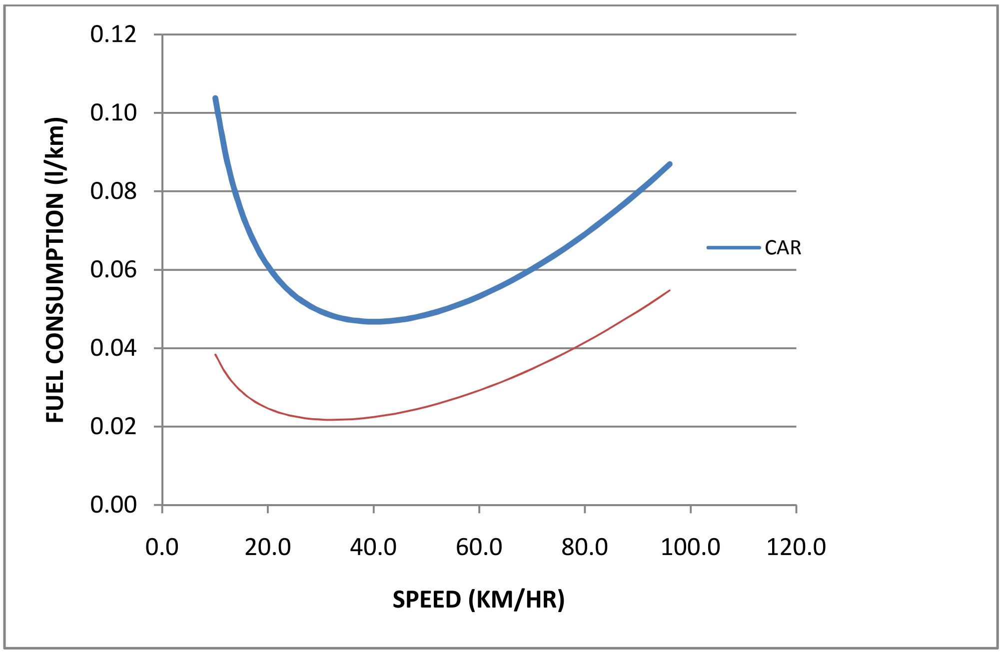
Table 16.5: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

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 table 16.7 and 16.8.

Table 16.7: Summary of the Ridership

Particulars	2016	2021	2031
Trips/day	279210	407830	609850
Average Trip length (km)	6.02	6.41	6.34
Passenger km	1680844	2614190	3866449
Passenger km/km	95611	148703	219935

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. All Benefit component values (economic) accrued between the years 2021-2045 are shown in figure 16.2 which shows that benefits are mainly coming from saving of travel time by metro and road passengers (50.34%), fuel saving cost (36.54%), vehicle maintenance cost (10.78%) and Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 2.34%.

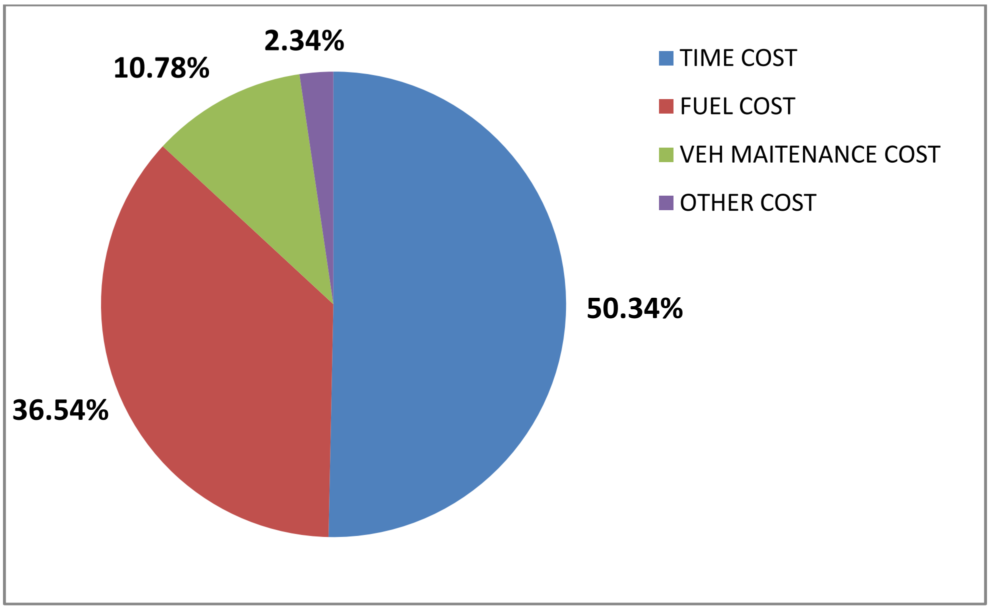


Figure 16.2 Percent of Benefits

Benefits are obtained directly from the projected passenger km saved for the horizon years (shown in table 16.6) and the values for other years are interpolated and extrapolated on the basis of projected traffic. Benefit Components Stream for proposed line is shown in table 16.8.

Table 16.9 Component wise Stream of Economic Benefit Value

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Maintenance Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2019	2020	231	120	37	6	2	5	1	5	406
2020	2021	272	144	44	7	2	7	1	5	482
2021	2022	321	173	53	7	3	8	1	6	572
2022	2023	378	207	64	7	3	10	1	7	678
2023	2024	446	249	76	8	4	11	1	8	804
2024	2025	504	283	86	9	5	13	2	8	910
2025	2026	570	321	98	11	5	15	2	9	1030
2026	2027	644	364	110	12	6	17	2	9	1166
2027	2028	728	413	125	14	7	19	3	10	1319
2028	2029	823	469	142	15	9	23	3	11	1494
2029	2030	930	531	160	17	10	27	4	11	1690
2030	2031	1051	603	181	20	12	31	5	12	1914
2031	2032	1188	837	252	27	14	47	7	16	2388
2032	2033	1343	959	288	31	16	54	8	17	2716
2033	2034	1518	1093	328	36	18	63	9	18	3083
2034	2035	1716	1256	376	41	22	73	11	19	3514
2035	2036	1940	1436	431	47	25	85	12	21	3998
2036	2037	2376	1789	535	58	32	107	16	24	4937
2037	2038	2662	2027	605	66	37	123	18	26	5564
2038	2039	2983	2298	684	74	43	140	20	27	6271
2039	2040	3342	2605	774	84	50	161	23	29	7068
2040	2041	3744	2952	876	95	58	184	27	31	7967
2041	2042	4194	3346	991	108	68	210	31	33	8981
2042	2043	4699	3793	1121	122	78	241	35	35	10124
2043	2044	5264	4299	1268	138	91	275	40	37	11413
2044	2045	5898	4872	1435	156	105	315	46	39	12867

16.4 METRO CONSTRUCTION COST

Total cost of metro construction (**Completion cost**) is derived after considering cost of all major component such as Relocation and Rehabilitation (RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. (**Recurring cost**) includes energy cost, maintenance cost, and operation cost. These costs are inclusive of central tax and yearly escalation cost applied on fixed cost. Analysis period is taken from 2015-16 to 2044-45 out of which 4 years (2015-2019) are marked as construction period. During the years 2021-22, additional capital will again be required for rolling stock and in 2040-41-42 major repairing and replacement cost is envisaged. Operation is expected to start in 2019-20 (4th Year).

To obtain economic cost, escalation factors (7.5%) are removed from the completion cost. Tax is removed from fixed cost which is 10.21%. 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 16.10.**

Table 16.10: Completion and Economic Cost stream

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
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
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

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2042	2043	0	995	0	127
2043	2044	0	1074	0	127
2044	2045	0	1160	0	128

16.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **table 16.11**. Project period is 2015-2045, On the basis of **completion** cost, EIRR is 17.19% B/C Ratio is 4.88 and NPV is 82193, which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **21.53%** and B/C ratio as **13.53** and with 12 % discount, EIRR is **8.51%** and B/C ratio is **2.67**. NPV without discount is Rs **95714** Cr. and with 12% discount rate, NPV is Rs. **6286** Cr.

Table 16.11: Economic Indicator Values (2044-45)

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.)	103354	10051	103354	10051
Benefit Cost Ratio	4.88	1.64	13.53	2.67
NPV(Cr.)	82193	3909	95714	6286
EIRR	17.19%	4.63%	21.53%	8.51%

16.6 SENSITIVITY ANALYSIS

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 16.12**. 2044-45 is taken for the year of comparison.

Table 16.12 Sensitivity of EIRR (Completion Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	17.19%	4.88	21161	4.63%	1.64	6142
-10%	0%	16.02%	4.40	21161	3.59%	1.47	6142
-20%	0%	14.77%	3.91	21161	2.47%	1.31	6142
0%	10%	16.13%	4.44	23277	3.69%	1.49	6756
0%	20%	15.20%	4.07	25393	2.85%	1.36	7371
-10%	10%	15.00%	4.00	23277	2.68%	1.34	6756
-20%	20%	12.88%	3.26	25393	0.79%	1.09	7371

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 12.88%.

Table 16.13 Sensitivity of EIRR (Economic Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	21.53%	13.53	7640	8.51%	2.67	3765
-10%	0%	20.32%	12.17	7640	7.43%	2.40	3765
-20%	0%	19.03%	10.82	7640	6.28%	2.14	3765
0%	10%	20.43%	12.30	8404	7.53%	2.43	4141
0%	20%	19.47%	11.27	9168	6.67%	2.22	4518
-10%	10%	19.27%	11.07	8404	6.49%	2.18	4141
-20%	20%	17.17%	9.02	9168	4.61%	1.78	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 17.17%.

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 16.14**(Reduction of Vehicle gas Emission). It is seen that reduction of CO2 will be 16828 tons in 2019 and particulate matters (PM) is reduced by 10 tons in 2019.

Table 16.14 Environmental Benefits Quantified

Tons/Year	2019	2020	2021	2022	2023
CO	234.16	210.22	234.06	246.48	259.56
HC	104.32	72.92	81.19	85.49	90.03
NOX	85.27	95.03	105.81	111.42	117.33
PM	10.09	9.23	10.27	10.82	11.39
SO2	0.71	0.72	0.80	0.84	0.89
CO2	16828	18737	20862	21969	23135
Total Emission Saved	17263	19125	21295	22424	23614

From **Table 16.14**, it may be seen that in 2021, due to shifting, metro passengers time saving will be 7.62 Cr. (10 million) hour, fuel saving by metro passengers will be 9.93 thousand tons. Amount of travel in terms of passenger km reduced due to shifting to Metro Rail is equivalent to reduction of 7939 vehicles from the road. About 4 fatal accidents and 27 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the area.

Table 16.14 Travel Benefits Quantified

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Time Saved by Metro Passengers in Cr. Hr.	6.33	6.95	7.62	8.01	8.42
Annual Fuel Saved by Metro Passengers in thousand Tons.	7.84	8.81	9.93	10.56	11.21
Daily vehicles reduced (off the road)	6404	7131	7939	8360	8804
CO2 reduced in thousand tons	16.83	18.74	20.86	21.97	23.13
Other gases reduced in thousand tons	0.43	0.39	0.43	0.46	0.48
Reduced No of Fatal Accidents in Year	2.92	3.36	3.85	4.19	4.55
Reduced No of Other Accidents in year	20.97	24.09	27.67	30.05	32.65
Annual Vehicle km Reduced in Cr. Km.	11.96	13.31	14.82	15.61	16.44

Chapter - 16 B

ECONOMIC APPRAISAL

16.0 Alignment Description and Issues

Traffic study was conducted for Dahisar (E) to Mandale Metro Corridor (Mumbai) and ridership was estimated. Revenue earning length of the entire section is 41.94 km which include 39 stations. Competent authority considered the report carefully and thought the section could be divided in to two section 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 Mandale (24.38 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, Power supply, Signalling, Electronics and telecommunication equipments etc. This is distributed year wise as cost stream. Two options are considered namely **(1)** Consider first stage as isolated or stand alone system and discard the ridership after D.N. Nagar and **(2)** Consider first stage as a part of the full length to be constructed simultaneously and take full ridership. **Present Economic appraisal is for the stretch is for first stage (Dahisar(E) to D.N. Nagar) under option 2 in which full ridership figures are taken.** Presented below alignment description in table 16.0.for better understanding.

Table 16.0 Alignment Description

Dahisar(E) to Mandale Metro Corridor (Mumbai)			
0	DEAD END	(-) 413.941	
1	DAHISAR (E)	0.0	413.941
2	DAHISAR (W)	711.0	711.0
3	RUSHI SANKUL	2422.7	1711.7
4	I C COLONY	3383.1	960.4
5	LIC COLONY	4468.4	1085.3
6	DON BOSCO	5537.5	1069.1
7	KASTUR PARK	6465.9	928.4
8	EKATA NAGAR	7571.8	1105.9
9	KANDIVALI NAGAR	8200.3	628.5
10	CHARKOP	9535.5	1335.2
11	MALAD METRO	10846.0	1310.5
12	KASTURI PARK	12243.4	1397.4
13	BANGUR NAGAR	13183.1	939.7
14	OSHIWARA METRO	14455.5	1272.4
15	SAMARTHA NAGAR	15468.7	1013.2
16	SHASTRI NAGAR	16433.0	964.3
17	D N NAGAR	17578.6	1145.6
18	ESIC Nagar	18783.6	1205.0

Dahisar(E) to Mandale Metro Corridor (Mumbai)			
19	Prem Nagar	20099.6	1316.0
20	Indira Nagar	20770.6	671.0
21	Nanavati Hospital	21825.6	1055.0
22	Khira Nagar	23315.6	1490.0
23	Saraswat Nagar	24014.6	699.0
24	National College	24669.6	655.0
25	Bandra Metro	25307.6	638.0
26	MMRDA	26007.6	700.0
27	Income Tax Office	27079.6	1072.0
28	ILFS	28750.6	1671.0
29	MTNL Metro	30179.6	1429.0
30	S G Barve Marg	31545.6	1366.0
31	Kurla Railway	32226.6	681.0
32	Tilak Nagar	33559.6	1333.0
33	Kurla (E)	34512.6	953.0
34	EEH	35565.6	1053.0
35	R C Marg	36837.6	1272.0
36	Shivaji Chowk	38041.6	1204.0
37	B S N L Metro	39699.6	1658.0
38	Mankhurd	40804.6	1105.0
39	Mandale Metro	41963.6	1159.0

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	Derived
2	Maintenance Cost	Derived
3	Annual Time Cost Saved by Metro Passengers	100%
4	Annual Fuel Cost Saved by Metro Passengers	80%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	80%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	100%
9	Annual Fuel Cost Saved by Road Passengers	80%
10	Annual Infra Structure Maintenance Cost	100%

16.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in table 16.2.

Table 16.2: **Values adopted for some important variables**

	Values	Important variables
1	Rs. 0.44/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)
3	Table 16.3	Vehicle Operating Cost per km (Derived from Life Cycle Cost of different passenger vehicles)
4	Table 16.4	Journey Time, VOC and Time Cost
4	Table 16.5	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton).
5	Table 16.6	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	19.84 min	Average Journey 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	25.51 kmph	Average Journey Speed (Speed and delay Survey)

Table 16.3: Vehicle Operating Cost (VOC) in Rs.

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	4.84	3.78	2.22	0.93	0.88	2.40	2.99
Capital Cost	4.81	4.27	1.87	0.29	0.19	1.20	2.57
Vehicle Maintenance Cost including overhead	10.61	8.85	4.50	1.34	1.18	3.96	6.12
Fuel Cost	9.38	5.02	3.11	1.07	1.07	3.09	4.75
VOC (with fuel)	19.99	13.87	7.61	2.41	2.25	7.05	10.87

As there is substantial number of trips by local train (EMU), VOC cost of train is derived from energy (electricity) consumed which is about Rs. 175.5 per train km carrying 3000 passenger and running @33 km per hour. Energy charges is taken as Rs. 8 per KWH.

Table 16.4 Journey Time, VOC and Time Cost

Mode	Fare	Total Journey Time (Min)	VOC (Rs.)	Time Cost (Rs.)
Bus	11.00	51.85	6.458	4.54
Train	7.00	37.52	0.599	6.40
Two Wh.	26.00	29.73	16.421	9.58
Four Wh.	123.00	29.73	56.810	66.19
Three Wh.	102.00	34.99	25.766	76.23
Private Bus & Others	11.00	55.54	6.954	4.05
Average Trip Length 10.24 km		Average Journey Time 33.40 min		

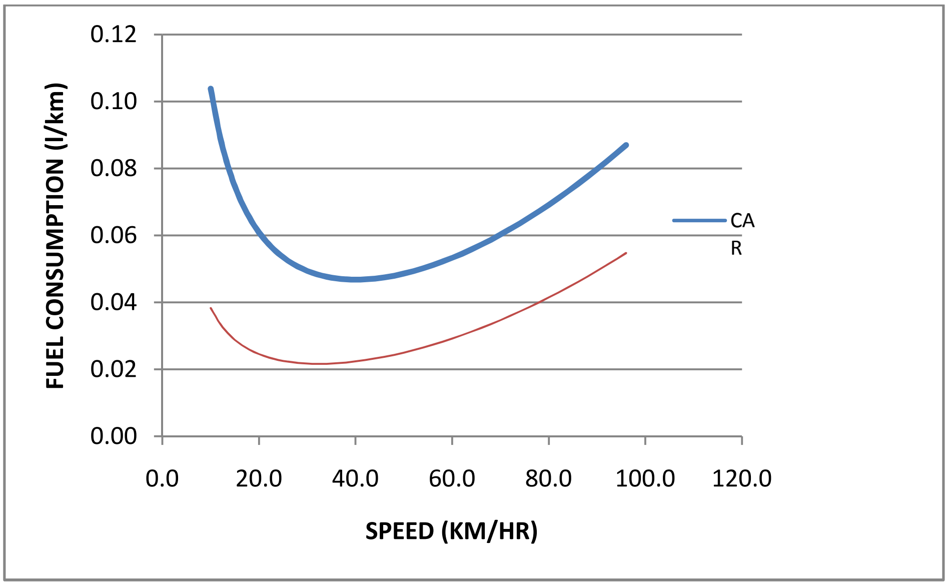
Table 16.5: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

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 table 16.7 and 16.8.

Table 16.7: Summary of the Ridership

Particulars	2016	2021	2031
Trips/day	448800	697040	902050
Average Trip length (km)	9.97	11.26	9.80
Passenger km	4474536	6607033	7848670
Passenger km/km	254524	375827	446455

Source: Traffic Study Report

In this area, public transport system is good (passenger local train 71.6%, Bus 19.58%). Personalised mode passenger (car, and two wheelers)-trips are 6.61% and IPT mode (Autos etc.) 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. All Benefit component values (economic) accrued between the years 2021-2045 are shown in figure 16.2 which shows that benefits are mainly coming from saving of travel time by metro and road passengers (35.38%), fuel/energy saving cost (47.13%), vehicle maintenance cost (13.9%) and Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 3.60%.

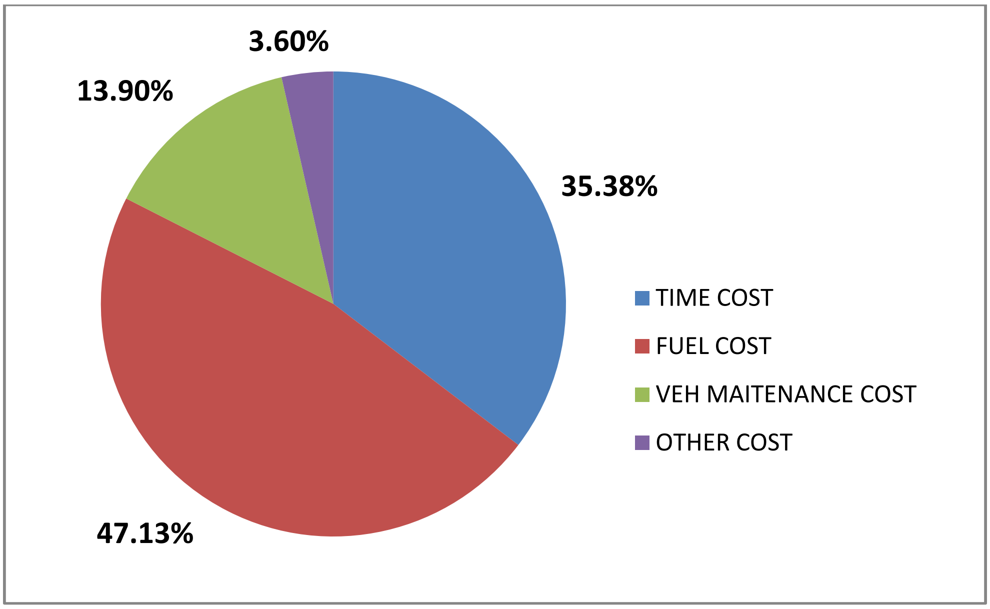


Figure 16.2 Percent of Benefits

Benefits are obtained directly from the projected passenger km saved for the horizon years (shown in table 16.6) and the values for other years are interpolated and extrapolated on the basis of projected traffic. Benefit Components Stream for proposed line is shown in table 16.8.

Table 16.9 Component wise Stream of Economic Benefit Value

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Maintenance Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2019	2020	439	340	105	16	5	13	1	14	933
2020	2021	521	420	130	20	6	17	2	16	1131
2021	2022	618	519	160	21	8	22	3	18	1369
2022	2023	732	641	197	21	11	28	4	21	1656
2023	2024	868	793	243	26	14	31	5	25	2006
2024	2025	967	886	270	29	17	36	6	26	2238
2025	2026	1078	990	301	33	20	41	6	27	2497
2026	2027	1201	1107	336	37	24	46	7	28	2786
2027	2028	1338	1235	374	41	28	53	8	30	3107
2028	2029	1490	1381	417	45	33	61	10	31	3469
2029	2030	1660	1540	465	51	40	70	11	33	3870
2030	2031	1850	1722	519	56	47	80	13	34	4322
2031	2032	2061	2567	773	84	55	131	20	48	5740
2032	2033	2296	2905	872	95	66	152	24	51	6459
2033	2034	2558	3272	983	107	78	174	27	54	7253
2034	2035	2850	3764	1127	123	93	203	32	58	8251
2035	2036	3175	4309	1292	140	112	237	37	63	9365
2036	2037	3725	5215	1559	169	143	289	45	71	11216
2037	2038	4113	5912	1764	192	170	331	52	75	12608
2038	2039	4541	6702	1996	217	202	380	60	80	14176
2039	2040	5014	7597	2258	245	240	435	68	85	15943
2040	2041	5536	8613	2555	278	286	498	78	90	17933
2041	2042	6112	9764	2891	314	340	571	90	96	20177
2042	2043	6748	11069	3271	356	404	654	103	102	22706
2043	2044	7451	12548	3702	402	481	749	118	108	25558
2044	2045	8226	14225	4188	455	573	858	135	115	28775

16.4 METRO CONSTRUCTION COST

Total cost of metro construction (**Completion cost**) is derived after considering cost of all major component such as Relocation and Rehabilitation (RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. (**Recurring cost**) includes energy cost, maintenance cost, and operation cost. These costs are inclusive of central tax and yearly escalation cost applied on fixed cost. Analysis period is taken from 2015-16 to 2044-45 out of which 4 years (2015-2019) are marked as construction period. During the years 2021-22, additional capital will again be required for rolling stock and in 2040-41-42 major repairing and replacement cost is envisaged. Operation is expected to start in 2019-20 (4th Year).

To obtain economic cost, escalation factors (7.5%) are removed from the completion cost. Tax is removed from fixed cost which is 10.21%. After that economic factors are applied. While estimating, design charges are kept as 5% and contingency charges are kept as 3%. These are not removed from fixed cost. Following this argument, economic cost is derived. Cost stream generated for both options are shown in **Table 16.10.**

Table 16.10: Completion and Economic Cost stream

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2015	2016	260	0	233	0
2016	2017	802	0	670	0
2017	2018	1737	0	1350	0
2018	2019	1679	0	1214	0
2019	2020	1443	156	970	105
2020	2021	776	169	485	106
2021	2022	1138	196	662	114
2022	2023	0	212	0	115
2023	2024	0	228	0	115
2024	2025	0	246	0	115
2025	2026	0	266	0	116
2026	2027	0	287	0	116
2027	2028	0	309	0	116
2028	2029	0	334	0	117
2029	2030	0	360	0	117
2030	2031	0	388	0	118
2031	2032	331	481	93	136
2032	2033	0	519	0	136
2033	2034	0	560	0	137
2034	2035	0	604	0	137
2035	2036	0	652	0	138
2036	2037	0	703	0	138
2037	2038	0	758	0	139
2038	2039	0	818	0	139
2039	2040	0	883	0	140
2040	2041	725	952	107	140
2041	2042	761	1028	104	141

		Completion Cost		Economic Cost	
Year	Year	Capital Cost	Recurring Cost	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs	Cr. Rs.	Cr. Rs
2042	2043	0	1109	0	141
2043	2044	0	1196	0	142
2044	2045	0	1291	0	142

16.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are given in **table 16.11**. Project period is 2015-2045, On the basis of **completion** cost, EIRR is **25.33%** B/C Ratio is **9.67** and NPV is **211188** (without discount), which shows that the project is economically viable. On the basis of **economic** cost, EIRR is found to be **30.58%** and B/C ratio as **25.59** and with 12 % discount, EIRR is **16.59%** and B/C ratio is **4.97**. NPV without discount is Rs **226340** Cr. and with 12% discount rate, NPV is Rs. **18634** Cr.

Table 16.11: Economic Indicator Values (2044-45)

ANDHERI-DAHISAR	(Completion Cost Basis)		(Economic Cost Basis)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	24357	7537	9205	4690
Cumulative benefit(Cr.)	235545	23324	235545	23324
Benefit Cost Ratio	9.67	3.09	25.59	4.97
NPV(Cr.)	211188	15787	226340	18634
EIRR	25.33%	11.90%	30.58%	16.59%

16.6 SENSITIVITY ANALYSIS

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 16.12 and table 16.13**. 2044-45 is taken for the year of comparison.

Table 16.12 Sensitivity of EIRR (Completion Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	25.33%	9.67	24357	11.90%	3.09	7537
-10%	0%	23.80%	8.70	24357	10.53%	2.79	7537
-20%	0%	22.18%	7.74	24357	9.09%	2.48	7537
0%	10%	23.94%	8.79	26793	10.66%	2.81	8291
0%	20%	22.73%	8.06	29228	9.58%	2.58	9045
-10%	10%	22.48%	7.91	26793	9.36%	2.53	8291
-20%	20%	19.86%	6.45	29228	7.01%	2.06	9045

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 19.86%.

Table 16.13 Sensitivity of EIRR (Economic Cost)

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	30.58%	25.59	9205	16.59%	4.97	4690
-10%	0%	28.83%	23.03	9205	15.03%	4.48	4690
-20%	0%	27.01%	20.47	9205	13.40%	3.98	4690
0%	10%	29.00%	23.26	10125	15.17%	4.52	5159
0%	20%	27.63%	21.32	11046	13.95%	4.14	5628
-10%	10%	27.35%	20.94	10125	13.70%	4.07	5159
-20%	20%	24.42%	17.06	11046	11.09%	3.32	5628

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 24.42%.

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 16.14** (Reduction of Vehicle gas Emission). It is seen that reduction of CO2 will be 50542 tons in 2019 and particulate matters (PM) is reduced by 30 tons in 2019.

Table 16.14 Environmental Benefits Quantified

Tons/Year	2019	2020	2021	2022	2023
CO	703.25	650.12	745.37	772.87	801.39
HC	313.30	225.50	258.54	268.08	277.97
NOX	256.08	293.88	336.94	349.37	362.26
PM	30.30	28.53	32.71	33.92	35.17
SO2	2.12	2.22	2.54	2.64	2.74
CO2	50542	57946	66436	68887	71429
Total Emission Saved	51847	59147	67812	70314	72909

From **Table 16.15**, it may be seen that in 2021, due to shifting, metro passengers time saving will be 17.04 Cr. (10 million) hour, fuel saving by metro passengers will be 31.62 thousand tons. Amount of travel in terms of passenger km reduced due to shifting to Metro Rail is equivalent to reduction of 25283 vehicles from the road. About 14 fatal accidents and 102 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the area.

Table 16.15 Travel Benefits Quantified

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Time Saved by Metro Passengers in Cr. Hr.	14.01	15.45	17.04	17.66	18.30
Annual Fuel Saved by Metro Passengers in thousand Tons.	23.56	27.26	31.62	33.11	34.62
Daily vehicles reduced (off the road)	19234	22052	25283	26215	27183
CO_2 reduced in thousand tons	50.54	57.95	66.44	68.89	71.43
Other gases reduced in thousand tons	1.31	1.20	1.38	1.43	1.48
Reduced No of Fatal Accidents in Year	9.56	11.64	14.17	15.59	17.16
Reduced No of Other Accidents in year	68.64	83.54	101.68	111.93	123.20
Annual Vehicle km Reduced in Cr. Km.	35.91	41.17	47.20	48.94	50.74

CHAPTER 17

IMPLEMENTATION

17.1 Introduction

The Dahisar (E) - D. N. Nagar Corridor is one of the corridors, with route length of 18.589 Kms.

- **Option -1, Considering the proposed corridor as isolated Stretch**

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 4673 crores exclusive of State taxes and Octroi of Rs 321 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 5925 crores excluding State taxes and Octroi of Rs 465 Crores.

- **Option -2, considering the entire corridor from Dahisar to Mandale**

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 5913 crores exclusive of State taxes and Octroi of Rs 368 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 7530 crores excluding State taxes and Octroi of Rs 538 Crores.

To make the project financially sustainable DMRC recommended that the all State taxes and duties fully waived for this project in which case Government of India will come forward to fund the central taxes and duties to the extent of 50% through grant by subordinate debt. The State Government will have to meet 50% of the Central taxes and duties as well. When Metro projects are taken up, total funding for the project to be kept in view and not merely the present estimated cost. For this purpose DMRC has calculated separately completion cost of this project with or without taxes assuming that the project would take 4 years for completion.

17.2 Possible models for financing a Metro project:–

1. A Build, Operate & Transfer (BOT)
2. A Private Public Partnership (PPP) and
3 Fully through Government funding i.e. Government mobilizing all the funds required for the project through equity, grants or loans borrowed by the Government.

Possibilities, implications of the 3 models mentioned above are discussed below :-

1. BOT model:

Under this model the project is handed to a Consortium for a specified period of time, selected through competitive bidding. The consortium will bring in all the funds required for the project, appoints consultants for design, planning and project implementation, execute the project fully and then operate and maintain the same during concession period. All the revenues from the project, fare box collections as well as non-fare box collections will go to the Consortium and in all the concession period the project is handed over to the Consortium. Here the Government responsibility is only to make available the required land and right of way and monitor the quality of services and safety standards. Building the system to the specified safety standards and obtaining the safety certificate from the competent authority will be the responsibility of the BOT operator. In this model the Government has no financial liability and all the risks are carried by the BOT operator. The Government may or may not stipulate the fares to be levied.

2. PPP model:

There are essentially two variants under this model.

Variant 1:- Here the Government funds the fixed infrastructure cost such as land and basic civil structures and private investor funds all the systems such as rolling stock, signalling, power supply, traction, track, fare collection system and E&M works including station architectural design. An example for this is Delhi Metro Airport line. Under this arrangement, the Government's investment will be about 40 to 45% of the total cost and the PPP Operator funds the remaining cost. The operator is selected again on competent bidding with viability gap funding who operates and maintains the system to the specified service safety levels. All the Revenues will accrue to the Operator in all the concession period till the project is handed over to the owner. Ridership for this is taken by the Operator fully or shared between the operator and the owner.

Variant 2:- Under this the Government acquires the required land and offers to the concessionaire free of cost. The private partner funds all the rest of the project, operates and maintains the system taking all the revenues and risks. His expected losses are made good through a viability Gap Funding (VGF), by the Government arrived at based on competitive bidding. At the end of concession period the system reverts to the owner. Under the PPP model, Sweeteners are sometime offered to the operator in the form of lands for commercial exploitation. Private management generally ensures better efficiency in the execution and operation of the system compared to a Government agency.

When the project is taken up on BOT or PPP model the total cost of the project generally gets hiked up by the Concessionaire adding the availing additional costs.

1. As bulk of the funds will be through borrowings. Interest during construction period will get added on to the projects costs.
2. The funds are available to a private party to which borrowing costs compared to the Government and additional funding cost will get factor to the cost of the project.
3. When a private party executes the project the refunds of the taxes and duties of the two Governments may not be possible. This alone will increase the cost of project by 18 to 20%.
4. Metro projects by themselves will not be financially viable. Commercial exploitation of surplus lands and identified Governments lands along the route has to be necessary to augment the Capex as well as revenue earnings. Making available normal land free to the Concessionaire for commercial exploitation will lead to public criticism and often end up in scandals.

Nowhere in the country a complete BOT or PPP model has so far found successful or attractive for the main reason that the fare levels have to be kept low and affordable to the common citizens.

3. Fully through Government funding:-

Here, the Government takes full responsibility for funding the project either from its own resources or through borrowings. For convenience and speedy execution a Special Purpose Vehicle is set up and given the mandate to execute the project. The Operation and maintenance of the system can be either directly by the SPV or they can engage an operator for the purpose. Usually a debt equity ratio of 2:1 is followed but there can be variations depending upon the tender's terms and the Government's ability to provide funds. The government's own investment will be in the form, of share holdings in the SPV and borrowings can be either from a Consortium of local banks or from infrastructure funding organizations such as IIFCL, IDBI, etc. or through an external bilateral loan from institutions such as ADB, World Bank, JICA etc. All the loans will need Governmental guarantee to reduce the borrowing cost. The Government can also assist the SPV with interest free subordinate loans. The SPV will have responsibility to service and pay back the loan and if SPV fails the responsibility will then devolve on the Government.

17.3 The recommended financial model for Dahisar (E) - D. N. Nagar Corridor

- **Option -1, Considering the proposed corridor as isolated Stretch**

The Dahisar (E) – D.N. Nagar Corridor is carved out of corridors recommended in Phase-I and Phase-II with route length of 18.589 Kms and completion cost of Rs 5925 Crores. World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for the Dahisar (E) – D. N. Nagar Corridor is 8.65 % (with PD from 10 Ha. area).

- **Option -2, considering the entire corridor from Dahisar to Mandale**

The Dahisar (E) – D.N. Nagar Corridor is carved out of corridors recommended in Phase-I and Phase-II with route length of 18.589 Kms and completion cost of Rs 7530 Crores. World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial rate of return for the Dahisar (E) – D. N. Nagar Corridor is 10.91 %.

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 Dahisar(E) – D.N. Nagar 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 organisation responsible for land acquisition and mobilisation of funds. The entire Metro project can be entrusted on turnkey basis and on deposit terms to an experienced organisation such as DMRC who has the experience and track record and competency of technical manpower. DMRC is implementing on similar basis Jaipur Metro for Rajasthan Government and Kochi Metro for Kerala Government and Greater Noida Metro project for the Greater Noida Authority. The same way the Dahisar(E) – D.N. Nagar 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 Dahisar(E) – D.N. Nagar Corridor Project

The Dahisar(E) – D.N. Nagar Corridor is one of the phase–III corridors, with route length of 18.589 Kms.

Package –1: Starting from chainage (-)413.94m and upto Kandivali village(Including) proposed metro station.

Package – 2: Starting just after Kandivali Station and upto dead end of D. N. Nagar.

Package - 3: Detailed design consultant for Dahisar - D. N. Nagar corridor including Depot.

Package - 4: Construction of boundary wall for depot, earth work filling and construction of workshop, inspection bay, stabling lines etc.

Package – 5 System Contracts: Supply and installation of traction power system (3^{rd} bay) including sub-station.

Package - 6: Supply and installation of signaling system (CBTC)

Package - 7: Supply and installation of AFC System.

Package - 8: Supply and commissioning of rolling stock.

Any other small package may be decided at the time of implementation of the Project.

17.7 Implementation Schedule

A suggested project implementation schedule for Project Implementation on Turnkey Basis (Deposit Terms) is given in Table 17.1

Table 17.1 Project Implementation on Turnkey basis (Deposit Terms)

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 MMRC Ltd. It is reliably learnt that for the Delhi Metro also such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro Rail Project.

17.9 Concession from Government

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return. With reasonable fare level, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level. Following are the taxes and duties, which have to be borne by a metro project:

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- Sales Tax on works contracts to be executed for the implementation of the project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

As in the case of Delhi Metro, the State Government should exempt/reimburse the Maharashtra Value Added Tax (VAT) to this Metro project. It should also exempt the following:

As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State

Government. Maharashtra State Government may pursue the Central government to extend the same benefit to MMRC.

In the case of Delhi Metro project, the Union Government has granted exemption from payment of Custom Duty and Excise Duty while the Delhi Government has agreed to give exemption from payment of Sales Tax and on works contracts. Delhi Metro Rail Corporation is also pursuing with the Government for exemption from tax on electricity being consumed by Delhi Metro for its operation and maintenance.

It is recommended that similar exemptions from taxes and duties be granted by the Central Government/Maharashtra Government for Mumbai Metro. In this connection it may be mentioned that the Central Government has been encouraging infrastructure projects in the country through fiscal and non-fiscal concessions. Cities have emerged as the engines of growth and mass transport systems today are one of the most important pre-requisites for the balanced growth of the city. The Government can demonstrate the importance it attaches to this sector by granting the above concessions which would not only help reduce the initial cost of the project so that Mumbai Metro remains commercially viable during its operation phase but also send strong signals to the effect that it is committed to a safer and pollution free city. Moreover, public transport is employment-friendly and favours social balance in a sustainable way since it allows access to jobs and services to all.

17.10 Legal Cover for Mumbai Metro

Implementation of proposed **Dahisar (E) - D. N. Nagar** Metro can now be done under “The Metro Railways (Amendment) Act 2009”. The copies of the Gazette notification and the amendment are put up enclosure to this chapter.

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असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

प्राधिकार से प्रकाशित

PUBLISHED BY AUTHORITY

सं. 1418] नई दिल्ली, सोमवार, सितम्बर 7, 2009/भाद्र 16, 1931

No. 1418] NEW DELHI, MONDAY, SEPTEMBER 7, 2009/BHADRA 16, 1931

शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे ।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

विमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

Printed by the Manager, Govt. of India Press, Ring Road, Mayapuri, New Delhi-110064 and Published by the Controller of Publications, Delhi-110054.

रजिस्ट्री सं॰ डी॰ एल॰—(एन)04/0007/2003—09 REGISTERED NO. DL—(N)04/0007/2003—09

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग II — खण्ड 1
PART II — Section 1
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं॰ 38] नई दिल्ली, बृहस्पतिवार, अगस्त 27, 2009/भाद्र 5, 1931
No. 38] NEW DELHI, THURSDAY, AUGUST 27, 2009 / BHADRA 5, 1931

इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/Bhadra 5, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[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

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009.

Short title and commencement

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (*3*), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area".

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

'(*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.

PRINTED BY THE GENERAL MANAGER, GOVT OF INDIA PRESS, MINTO ROAD, NEW DELHI AND PUBLISHED BY THE CONTROLLER OF PUBLICATIONS, DELHI, 2009

GMGIPMRND—3842GI(S5)—28-8-2009.

CHAPTER–18

CONCLUSIONS AND RECOMMENDATIONS

18.1 Mumbai is the Commercial Capital of India and it's fast growth especially in the suburbs is causing heavy stress on all infrastructure, especially the Transport. Being a linear city, the existing suburban rail services are very effective and the modal split in favour of public transport is 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 Dahisar (E) - D. N. Nagar Corridor with route length of 18.589 Kms 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.

Dahisar (E) – D.N. Nagar corridor of Mumbai Metro Project is proposed to start at Western Express Highway with its station named as Dahisar (East) and platform located above the already proposed Dahisar (East) metro station for Andheri (E) – Dahisar corridor. The alignment stretches from Dahisar (E) to D.N. Nagar via Dahisar (W), Rushi Sankul, I.C. Colony, Don Bosco, Charkop, Kasturi Park, Oshiwara and runs on link road. D.N. Nagar Metro Station on this corridor is proposed on the median of the road and will be integrated with D.N. Nagar Station line.

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.

- **Option -1, Considering the proposed corridor as isolated Stretch**

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 4673 crores exclusive of State taxes and Octroi of Rs 321 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 5925 crores excluding State taxes and Octroi of Rs 465 Crores.

- **Option -2, considering the entire corridor from Dahisar to Mandale**

Cost of the project at July 2015 price level with central taxes and duties only is Rs. 5913 crores exclusive of State taxes and Octroi of Rs 368 Crores. Completion cost with Central taxes and duties only and escalation at 7.5% p.a. is estimated to be Rs. 7530 crores excluding State taxes and Octroi of Rs 538 Crores.

18.2 A study is in progress to assess the Environmental and Social Impact of the proposed Metro corridor from Dahisar (E) to D.N. Nagar 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 of Dahisar (E) - D. N. Nagar Metro Project, it has been recommended that the project should be got executed through a SPV on DMRC funding pattern.

18.4 The fare structure has been prepared based on prevailing fare structure in different PT/IPT modes as indicated in the Finance Chapter. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 15% every two years.

18.5 As in the case of Delhi Metro, the State Government should exempt/reimburse the Maharashtra Value Added Tax (VAT) 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 Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR)

- **Option -1, Considering the proposed corridor as isolated Stretch**

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **6.41%** without Property Development and **8.65%** with revenue from additional property development on 10 hectares of land. The Economic Internal Rate of Return (EIRR) works out to **17.19%**

- **Option -2, considering the entire corridor from Dahisar to Mandale**

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **10.91%**. The Economic Internal Rate of Return (EIRR) works out to **25.33%**

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 Dahisar (E) - D. N. Nagar 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.