FINAL

DETAILED PROJECT REPORT FOR MUMBAI METRO LINE - 12 FROM KALYAN TO TALOJA

Client: Mumbai Metropolitan Region Development Authority (MMRDA)

Prepared By

दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.

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SALIENT FEATURES

1. GAUGE (NOMINAL): 1435 mm

2. ROUTE LENGTH: 20.756 km (Entirely Elevated)

3. NUMBER OF STATIONS: 17 (All Elevated)

4. TRAFFIC PROJECTION:

Year	Daily Ridership	Average Lead (km)	Maximum PHPDT
2021	1,10,579	11.06	5,761
2031 (without PD)	1,92,420	10.34	9,156
2031 (with PD)	2,62,320	10.34	12,407

5. TRAIN OPERATION:

Section	Year	Head-way (min)	Total No. of Rakes	Rake Consist	Total No. of Cars**	Max. PHPDT Demand	PHPDT Capacity Available
Kalyan to Taloja	2021	6.00	15	3-car	45	8322	8620 (11000*)
Kalyan to Taloja	2031	6.25	15	6-car	90	16342	16858 (21504*)

* @ 8 persons per square meter of standee area
** Total No. of cars shown above are the total cars calculated as per PHPDT data.

6.
i. Design Speed 90 kmph
ii. Maximum Operating Speed 80 kmph
iii. Schedule Speed 35 kmph

7. TRACTION POWER SUPPLY:
a. Traction system voltage 25 kV AC
b. Current Collection Over Head Catenary
c. Receiving Sub Stations One near Sagaon and another at Depot near Pisarve Depot Station

Power Demand Estimation (MVA)

Load	Year	
	2021	2031
Traction	5.68	10.50
Auxiliary	7.72	9.02
Total	**13.40**	**19.52**

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.	862
e.	Capacity of 6 coach unit with 6 standees / sqm.	1756
f.	Class of accommodation	One (Air conditioned)

9. MAINTENANCE FACILITIES:

Maintenance Depot has been proposed near Pisarve Depot Station. Total land area proposed for maintenance facilities is 20 Ha.

10. SIGNALLING, TELECOMMUNICATION AND TRAIN CONTROL:

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

11. FARE COLLECTION:

Automatic Fare collection system with TVM and Smart card etc.

12. STRUCTURE:

i. Viaduct: Precast twin ‘U’ girders on Single pier with bored cast-in-situ pile foundations upto radius 300m and flatter, for sharper curves and location of Points & Crossings I-Girder.

ii. Station structure with viaduct columns supporting the concourse girders by a cantilever arm.

13. COST:

i)	Estimated Cost with all Taxes & Duties including Land Cost (At March 2018 Price Level)	**Rs. 4738 Crore**
ii)	Completion Cost with all Taxes & Duties including Land & IDC (by March 2026 at 5% p.a. escalation)	**Rs. 5865 Crore**

14. INDICES:

i)	FIRR (with additional PD income from 40 ha land)	**: 6.00%**
ii)	EIRR	**: 14.51%**

EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Background

MMRDA has carried out Comprehensive Transportation Study (CTS) of Mumbai Metropolitan Region (MMR) in 2005-2008. As per the recommendations in the Comprehensive Transportation Study of MMR and considering the need of better public transport to cater the rapid growth of urbanization in Kalyan–Dombivli, Taloja/Navi Mumbai due to upcoming international airport being implemented by CIDCO, MMRDA has proposed to extend the Metro Line-5 (Thane – Bhiwandi – Kalyan) up to Taloja (Navi Mumbai Metro) which further connects to Navi Mumbai International Airport (NMIA). Accordingly, MMRDA has taken up the preparation of Detailed Project Report (DPR) through M/s DMRC for said metro corridor which is 20.756 km in length.

Vide email dated 01/03/2017 (Annexure 1), Chief, Transport and Communication Division informed to DMRC that MMRDA wants to extend Mumbai Metro Line 5: Thane to Kalyan uptoTaloja and requested DMRC to provide ToR for preparation of Detailed Project Report. Accordingly, DMRC sent ToR on 06/3/2017 vide email dated 06/03/2017, which was accepted by MMRDA on 22/03/2018. However, agreement for carrying out this study signed between MMDRA and DMRC on 02/08/2017.

Draft DPR for this corridor was submitted in January 2019. MMRDA sent their Observations/Comments on the same vide email dated 14.02.2019 and 26.03.2019. Now this Final DPR is prepared after incorporating the comments received from MMRDA.

0.1.2 Need of Kalyan-Taloja Metro Rail Corridor

Area along the corridor is not much habitated. Most of the length of the corridor is passing through agriculture and barren land. MRTS corridors are generally planned along the highly populated areas to fulfill the transportation need of the masses living in that area. However, this corridor is for Transit Oriented Development (TOD). This 8l/Corridor will actuate the development in this area and encourage people to move out from crowded parts of the city to this area. Purpose of this corridor is to decongest the Mumbai city and accelerate the development activities in the area covered by this corridor. The upcoming projects along the corridor are as under.

- Kalyan Growth Centre
- Navi Mumbai Airport Influence Notified Area (NAINA)
- Development by other Builders

0.2 TRAFFIC FORECAST

0.2.1 The daily ridership, peak hour station loads and peak hour section loads for the proposed Metro Corridor is given in **Table 0.1, 0.2 (a) & (b) and 0.3 (a) & (b)** for horizon year 2021, 2031 and 2041 respectively.

Table 0.1: Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2021

Boarding	Alighting	Volume (Kalyan-Taloja)	Stations	Volume (Taloja-Kalyan)	Boarding	Alighting
2986	0	2986	APMC Market Kalyan	0	0	895
975	131	3829	Ganesh Nagar	895	199	670
544	431	3942	Pisavali Gaon	1366	127	464
309	113	4138	Golavli	1703	19	267
42	46	4134	Dombivli MIDC	1951	139	11
494	386	4242	Sagaon	1822	422	154
127	139	4230	Sonarpada	1554	139	27
2226	979	5477	Manpada	1442	324	109
0	26	5451	Hedutane	1226	0	7
438	128	5761	Kolegaon	1234	163	72
35	330	5466	Nilje Gaon	1143	121	23
0	25	5441	Vadavli(Khu.)	1045	0	0
33	0	5474	Bale	1045	33	0
0	0	5474	Waklan	1012	0	0
0	132	5342	Turbhe	1012	0	61
0	0	5342	Pisarve Depot	1073	0	0
52	2847	2548	Pisarve	1073	496	39
0	2548	0	Taloja	616	616	0
8260	8260	**5761**	**PHPDT**	1951	2797	2798
			Daily Ridership	**110579**		

Table 0.2 (a): Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2031

Boarding	Alighting	Volume (Kalyan-Taloja)	Stations	Volume (Taloja-Kalyan)	Boarding	Alighting
7188	0	7188	APMC Market Kalyan	0	0	1291
1133	97	8224	Ganesh Nagar	1291	91	282
196	123	8296	Pisavali Gaon	1482	0	155
292	0	8588	Golavli	1637	4	15
175	252	8511	Dombivli MIDC	1648	0	125
840	194	9156	Sagaon	1774	411	127
156	161	9151	Sonarpada	1489	173	38
466	618	8999	Manpada	1354	170	425
0	367	8632	Hedutane	1608	202	52
716	220	9128	Kolegaon	1458	296	110
141	1254	8015	Nilje Gaon	1271	136	195
0	3885	4130	Vadavli(Khu.)	1330	0	0
2635	0	6765	Bale	1330	0	0
0	0	6765	Waklan	1330	53	0
152	14	6904	Turbhe	1278	53	1725
0	0	6904	Pisarve Depot	2949	0	380
69	1203	5769	Pisarve	3329	231	165
0	5769	0	Taloja	3263	3263	0
14158	14158	**9156**	**PHPDT**	3329	5084	5084
			Daily Ridership	**192420**		

Table 0.2 (b): Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2031
with 40 Ha Land Development for ML-12 (at Vadavli (Khu.), Bale & Pisarve Depot Stations)

Boarding	Alighting	Volume (Kalyan- Taloja)	Stations	Volume (Taloja- Kalyan)	Boarding	Alighting
9357	0	9357	APMC Market Kalyan	0	0	1901
1111	52	10416	Ganesh Nagar	1901	23	277
249	44	10622	Pisavali Gaon	2155	0	175
309	0	10931	Golavli	2330	3	49
604	228	11308	Dombivli MIDC	2376	0	340
872	162	12019	Sagaon	2717	348	162
220	103	12136	Sonarpada	2531	184	67
220	537	11819	Manpada	2415	164	113
494	286	12027	Hedutane	2364	30	392
593	212	12407	Kolegaon	2726	314	84
0	1169	11238	Nilje Gaon	2496	126	0
275	5800	5713	Vadavli (Khu.)	2370	264	1509
1762	573	7694	Bale	3614	305	236
1174	382	7694	Waklan	3499	254	157
78	23	7749	Turbhe	3448	16	1335
1353	1980	7122	Pisarve Depot	4768	1390	291
286	1044	6365	Pisarve	3669	473	184
0	6365	0	Taloja	3381	3381	0
18957	18960	**12407**	**PHPDT**	4768	7275	7272
			Daily Ridership	**262320**		

Table 0.3 (a): Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2041

Boarding	Alighting	Volume (Kalyan-Taloja)	Stations	Volume (Taloja- Kalyan)	Boarding	Alighting
8067	0	8067	APMC Market Kalyan	0	0	1449
1271	109	9229	Ganesh Nagar	1449	102	317
220	138	9310	Pisavali Gaon	1663	0	174
328	0	9638	Golavli	1837	5	17
196	283	9551	Dombivli MIDC	1850	0	141
942	218	10275	Sagaon	1990	461	142
175	180	10269	Sonarpada	1671	195	43
523	693	10099	Manpada	1519	191	477
0	412	9687	Hedutane	1805	227	58
804	247	10244	Kolegaon	1636	332	123
158	1407	8995	Nilje Gaon	1427	152	218
0	4360	4635	Vadavli (Khu.)	1493	0	0
2957	0	7592	Bale	1493	0	0
0	0	7592	Waklan	1493	59	0
171	15	7748	Turbhe	1434	60	1936
0	0	7748	Pisarve Depot	3310	0	427
77	1350	6475	Pisarve	3737	259	185
0	6475	0	Taloja	3662	3662	0
15888	15888	**10275**	**PHPDT**	3737	5705	5705
			Daily Ridership	**216930**		

Table 0.3 (b): Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2041
with 40 Ha Land Development for ML-12 (at Vadavli (Khu.), Bale & Pisarve Depot Stations)

Boarding	Alighting	Volume (Kalyan- Taloja)	Stations	Volume (Taloja- Kalyan)	Boarding	Alighting
10501	0	10501	APMC Market Kalyan	0	0	2134
1247	58	11690	Ganesh Nagar	2134	26	311
280	49	11921	Pisavali Gaon	2419	0	196
347	0	12267	Golavli	2615	4	55
678	255	12690	Dombivli MIDC	2666	0	382
979	181	13488	Sagaon	3049	390	182
247	115	13619	Sonarpada	2841	206	75
247	603	13264	Manpada	2710	184	126
554	321	13497	Hedutane	2652	33	440
665	238	13924	Kolegaon	3059	352	95
0	1312	12612	Nilje Gaon	2801	142	0
309	6509	6412	Vadavli(Khu.)	2660	297	1693
1977	643	8635	Bale	4056	342	265
1318	429	8635	Waklan	3927	285	176
88	26	8696	Turbhe	3869	18	1498
1519	2222	7993	Pisarve Depot	5350	1560	327
321	1171	7143	Pisarve	4118	530	207
0	7143	0	Taloja	3794	3794	0
21277	21275	**13924**	**PHPDT**	5350	8163	8162
			Daily Ridership	**294400**		

0.3 SYSTEM DESIGN

0.3.1 Permanent Way

0.3.1.1 Choice of Gauge

The issue of Broad Gauge vs. Standard Gauge for Metro in India has been debated widely and the decision has been in favour of Standard Gauge. Even Delhi Metro which started with Broad Gauge hasswitched over to Standard Gauge. It is advantageous for many reasons as indicated below:

- In general alignment has to follow the road alignment, which has sharp curves. Standard Gauge permits adoption of sharper curves.
- In Standard Gauge 1 in 7 and 1 in 9 turn-outs which occupy lesser length can be used while in Broad Gauge 1 in 8 ½ and 1 in 12 turnouts are required.
- For Standard Gauge, optimized state-of-the-art rolling stock designs are available ‘of-the-shelf’ which is not so in case of Broad Gauge.
- Standard gauge has been adopted for metros all over the world. Due to large market, constant up-gradation of technology takes place on a continued basis. This is not available Broad Gauge.
- For same capacity gross weight of a metro coach is lower for Standard Gauge than for Broad Gauge. Standard Gauge rolling stock thus results in recurring saving in energy consumption during operation.

- Once technology for Standard Gauge coach gets absorbed and manufacturing base for this setup in India, there will be considerable export potential for the coaches.

0.3.1.2 Track Structure

Two types of track structures are proposed for any Metro. The normal ballasted track is suitable for At-Grade (surface) portion of Main Lines and in Depot (except inside the Workshops, inspection lines and washing plant lines. The ballastless track is recommended on viaducts as the regular cleaning and replacement of ballast at such location will not be possible. Only in case of the depot, normal ballasted track is proposed for adoption. From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose even the turnouts will have to be incorporated in LWR/CWR. The track will be laid with 1 in 20 canted rails and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

0.3.2 Rail Section

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg/m) rail section. Since main lines will have sharp curves and steep gradients, the grade of rail on main lines should be 1080 Head Hardened as per IRS-T- 12-2009. As these rails are not manufactured in India at present, these are to be imported. For the Depot lines, the grade of rails should be 880, which can be easily manufactured indigenously.

0.3.3 Signalling and Train Control System

The Signalling and Train Control System shall provide the highest security level for means of an efficient Train Control, ensuring safety in train movements. It assists in optimization of rail infrastructure investment and running of efficient train services on the network.

The Proposed Corridor of Mumbai Metro Line 12 i.e. from Kalyan to Taloja section is planned to be operated at maximum safe speed of 90 Km/hr. The trains are to be maintained headway at every about 100 seconds. However, the signaling System shall be designed at minimum for 90 second headway in one direction.

0.3.3.1 Signalling System

It is expected to carry large number of passengers by maintaining shorter spacing between trains 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 people.

The requirements of the Mumbai Metro Line 12 Corridor planned to be achieved by adopting following basic principles of signaling System: -

- The Train Control and Monitoring shall be ensured from Centralized Traffic control System located at Operation Control Centre (OCC). OCC equipments shall be connected to station equipment room through optical fiber network.

- The CBTC (Communication based Train Control) based system shall be provided on main line & in depot (except workshop area) for train operation & primary mode of detection. Secondary detection shall be through Axle Counter.
- Computer Based Interlocking System shall be designed on failsafe philosophy. In case of failure of any equipment, the equipment shall fail on safe side or more restrictive state. In such case the Signalling System shall authorized movement of train in normal and degraded operations.
- Track side equipment shall be connected to Electronic Interlocking (to Station Equipment Room) by secure links to ensure safe movement of train.
- Provide high level of safety with trains running at shorter headways ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provide safety and enforce speed limit on the sections having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed 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 equipment by monitoring System status of trackside and train borne equipment and enabling preventive maintenance.
- Signalling & Train Control System on the line shall be designed to meet the required headway during peak hours.
- For monitoring inside train saloon, signaling system shall provide radio transmission media to transfer live streams to OCC controller on large video screen & MMI.
- Provision for installing integrated passenger gate at platform. The purpose of PG is to avoid any accident at platform, Integrated Passenger Gate acts as a barrier between the track and platform accessible to passengers. Signalling and Rolling Stock interfaces shall be provided for Passenger Gate System.

0.3.4 Telecommunication

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

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:

- Radio System
- Backbone network using Optical Fiber Cable (OFC)
- Ethernet & WAN Network.

- Station to Station dedicated communication
- Telephone System with Telephone Exchanges, Telephones and their Recording
- Centralized Recording System (CDRS)
- Centralized Clock System
- Closed Circuit Television (CCTV) System
- Passenger Information & Display System within the station & trains and from Central Control to each station, Integrated Passenger Announcement System
- Train Traffic Control, Maintenance Control, Emergency Control, Assistance to Train Traffic Control.
- Data Channels for Signalling, SCADA, Automatic Fare Collection
- Power Supply of Telecommunications, and
- Cables for Telecommunications etc.

0.3.5 Automatic Fare Collection

0.3.5.1 Metro 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, amendable for quick fare changes and require overall less manpower. In view of the above computer based automatic fare collection system is proposed**.** Seamless ticketing is now being thought of for Mumbai Metro Rail.

Automatic Fare Collection system is recommended to be adopted as this will enable the commuters to travel hassle 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.

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 AFC system shall be of Contactless Smart Token / Card type. For multiple journeys, the stored value smart card shall be utilized and for the single journey, the smart media shall be as utilized as contactless smart token and QR Code / bar code / NFC based ticketing. The equipment 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.

It is proposed, the smart NCMC (National Common Mobility card) standard model for implementation of AFC system in Mumbai Metro. The AFC system as per the guidelines issued by Govt of India shall enable seamless travel by different metros and other transport systems across the city besides retail shopping and purchases.

The AFC system shall support the EMV (Europay, MasterCard, and Visa) and RuPay based open loop ticketing following the NCMC standard model for interoperability with other operators by use of non-proprietary standard so that the interface is scalable to other networks (transit operator/ retail outlets/parking/Toll etc) in Mumbai. The AFC equipments shall support EMV, RuPay, QR, NFC (Near field communication) based ticketing, integration of clearing house, smart card host system of Financial Institutions and integration of mobile application with AFC system.

0.3.5.2 Gate

Retractable Flap Type Control Gate is proposed which offer high throughput, require less maintenance and are latest in modern systems internationally. All these gates will have a functionality of Auto Top on smart cards in case balance goes below the threshold value (as per choice / business rule). The type of control gate may be finalised at detailed design stage.

The gate should also capable to NFC enabled Mobile Tickets or any latest type of Ticket media at the time of procurement/installation. The AFC system shall provide access control solutions, offering both access control devised and hardware which can be tailored to accept any ticket media readily available in market (Barcode, QR code, NFC etc).

0.3.5.3 Ticket Vending Machine (TVM)

The TVM should provide the convenience for the passengers to procure ticket on their own, without the need to queue at the ticket sale counter.

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

0.3.5.4 Ticket Reader/Add Value Machines

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

0.3.5.5 Recharge Card Terminal Machine (RCTM)

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

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

In Mumbai, different mode of transport 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, Waterway, Parking, Toll etc so that these systems may also be integrated with common smart card based fare products. This will facilitate the passengers as they need not carry different cards for different applications.

0.3.6 Rolling Stock:

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

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

Table 0.4 - Size of the coach

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

**Maximum length of coach over couplers/buffers = 23 m*

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

Following train composition is recommended:
3-Car Train: DMC+TC+DMC
6-car Train: DMC+TC+MC+MC +TC+DMC

Table 0.5 shows the carrying capacity of Medium Rail Vehicles.

Table 0.5 Carrying Capacity of Medium Rail Vehicles

Particulars	Driving Motor car		Trailer car/Motor car		3 Car Train		6 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush	Normal	Crush
Seated	42	42	50	50	134	134	284	284
Standing	120	240	124	248	364	728	736	1472
Total	162	282	174	298	498	862	1020	1756

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

The recommended performance parameters are:

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

0.3.6.2 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.

0.4 CIVIL ENGINEERING

0.4.1 Geometric Design Norms:

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

Desirable minimum horizontal curve radius specified is 200 m (elevated section) but in extreme cases it can be reduced to 120 m (elevated section). Minimum curve radius at stations is specified as 1000 m.

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. Radii of vertical curves are 2500 m desirable and 1500 m minimum.

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

0.4.1.2 Gradients

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

Between stations, generally the grades may not be steeper than 2.0 %. However, where existing road gradients are steeper than 2% or for Switch Over Ramps gradient up to 4% (compensated) can be provided in short stretches on the main line.

0.4.1.3 Design Speed

The maximum operating speed will be 80 km/h. The scheduled speed has been taken as 35 kmph.

0.4.2 Alignment

- First station of this extension is named as Ganesh Nagar and last station is Taloja. Since this corridor is South-West extension of Mumbai Metro Line-5 (Thane-Bhiwandi-Kalyan), thus Ganesh Nagar is not a terminal station rather it is followed by APMC Market Kalyan Station.

- Chainage of first station is taken as 843.771 m for reference.

- Total length of this extension is 20.756 km. The entire corridor is proposed as elevated.

- Seventeen stations have been proposed on this corridor. Names of stations are Ganesh Nagar, Pisavali Gaon, Golavli, Dombivli MIDC, Sagaon, Sonarpada, Manpada, Hedutane, Kolegaon, Nilje Gaon, Vadavli (Khu.), Bale, Waklan, Turbhe, Pisarve Depot, Pisarve and Taloja. 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; few stations could not be located at one km distance apart. The maximum and minimum inter station distances are 1804.966 m and 848.002 m respectively. Depot for this corridor has been planned at Pisarve Village near Pisarve Depot Station.

- This is an extension of Metro line 5 (Thane-Bhiwandi-Kalyan) towards South-West direction. It connects Dombivli MIDC/ residential area, MMRDA’s proposed growth centres, proposed NAINA area and Taloja MIDC area through Panvel Municipal Corporation area. This proposed metro line extension has been integrated with Taloja Metro station which is under implementation by CIDCO.

0.4.3 Station Locations

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

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

0.4.4 Terminals

Since this is an extension of Metro line 5 (Thane-Bhiwandi-Kalyan). Thus this section has only one terminal station as mentioned below:

Taloja

This Station is proposed off the road (Dr. Ritesh Patil Road), about 0.6 km before CIDCO Metro Depot and is near Railway Line. Cross over is proposed at the front end of station.

Scissors Crossovers will be provided at the terminal station viz. Taloja.

0.4.5 Depot

It is proposed to provide depot near Pisarve Depot station, on the Private Agricultural Land. The total land for Depot will be 20 Ha.

0.4.6 Construction Methodology

0.4.6.1 Viaduct–Elevated Structure

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

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

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

0.4.7 Geo Technical Investigations

0.4.7.1 Foundation Recommendations

Weathered bedrock is encountered at depths typically ranging between 1.0 m to 8.0 m below ground level. Foundations for proposed structures should be supported on hard rock. Depths to weathered and hard rock are summarized in below. Foundations installed on this hard rock can be designed for a net allowable bearing capacity of 130 t/m2.

Table 0.6: Depth to Weathered Rock below GL

S.No.	Bore hole No.	Depth to weathered rock (m)	Depth to hard rock (m)	Allowable bearing capacity (t/m^2)
1	BH-01	5.10	14.50	130
2	BH-02	3.00	5.50	
3	BH-03	1.60	6.00	
4	BH-04	3.00	4.70	
5	BH-05	6.50	6.50	
6	BH-06	3.10	8.50	
7	BH-07	8.00	9.50	
8	BH-08	4.50	7.50	
9	BH-09	5.00	5.00	
10	BH-10	1.00	1.00	
11	BH-11	1.70	3.50	
12	BH-12	3.00	5.50	
13	BH-13	1.54	3.00	
14	BH-14	1.00	2.00	
15	BH-15	1.00	3.50	
16	BH-16	3.00	4.50	
17	BH-17	4.50	8.50	
18	BH-18	7.50	11.50	
19	BH-18A	3.00	4.50	
20	BH-19	3.00	3.00	
21	BH-20	2.10	5.50	
22	BH-21	4.50	8.00	

A modulus of subgrade reaction of 10833 t/m^3 can be utilized for design of Spread /raft foundation. Excavation sides should be sloped at a maximum of 1:1 or flatter. If adequate space is not available for side slope excavations bored cast in situ piles as recommended in 0.4.7.2 shall be utilized.

0.4.7.2 Bored Piles

As mentioned in the previous section, Bored cast in situ piles can be utilized for proposed corridor.

Depth of rock socketing, representative diameter of piles and their safe pile capacities provided in Table 0.7 below.

Table 0.7: Safe Capacity of Piles

BH No.	Pile Diameter, D (mm)	Pile Rock Socketing in weathered rock	Cut of Level (mm)	Safe Vertical Downward Capacity (tons)	Safe Lateral Capacity (tons)	Safe Uplift Capacity (tons)
BH-1	800	6D	1200	245	25	95
	1000		1500	380	36	150
BH-2	800	5D	1200	220	25	80
	1000		1500	345	36	125
BH-3	800		1200	220	25	80
	1000		1500	345	36	125
BH-4	800		1200	220	25	80
	1000		1500	345	36	125
BH-5	800	4D	1200	365	25	80
	1000		1500	570	36	125
BH-6	800		1200	195	3.6	65
	1000		1500	310	5.0	100
BH-7	800		1200	195	25	65
	1000		1500	310	36	100
BH-8	800		1200	195	25	65
	1000		1500	310	36	100
BH-9	800	2D	1200	330	24	57
	1000		1500	520	35	85
BH-11	800	3D	1200	175	25	49
	1000		1500	270	36	75
BH-12	800	4D	1200	195	25	65
	1000		1500	310	36	100
BH-13	800	2D	1200	150	25	30
	1000		1500	235	36	50
BH-15	800	3D	1200	175	25	49
	1000		1500	270	36	75
BH-16	800		1200	175	25	49
	1000		1500	270	36	75
BH-17	800	5D	1200	220	25	80
	1000		1500	345	36	125
BH-18	800		1200	220	18	80
	1000		1500	345	25	125
BH-18A	800	1D	1200	325	25	50
	1000		1500	480	36	65
BH-19	800		1200	350	25	65
	1000		1500	510	36	85
BH-20	800	4D	1200	195	18	65
	1000		1500	310	25	100
BH-21	800		1200	195	25	65
	1000		1500	310	36	100

Maximum total settlement of piles installed as described above will be less than 12mm. The range of depth of fixity for lateral loads will be 1.5D in weathered rock.

0.4.8 Utility Diversions

A number of utilities like sewer lines, water pipelines, gas pipelines, power and communication cables etc. are there along and across the alignment. Some of these will have to be diverted or bridged. Details are given in chapter 4 on Civil Engineering.

0.4.9 Land

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

Land Requirement for following Major Components

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

0.4.9.1 Summary of Land Requirements

Abstract of land requirements for different components of this proposed extension is given in **Table 0.8 and Table 0.9**.

Table 0.8 Summary of Permanent Land Requirement (All figures in Sq. m)

S.No.	Description	Pvt. (agri.)	Pvt.	Total
1	Stations	21600	10800	**32400**
2	Running Section	249506.2	0	**249506.2**
3	Depot	200000	0	**200000**
4	Staff Quarters	10000	0	**10000**
5	Office Complex and OCC	5000	0	**5000**
6	RSS	11200	0	**11200**
	Total	**497306.2**	**10800**	**508106.2**

Total Permanent Land = 50.811 ha
Permanent Land (Pvt. Agri) = 49.731 ha
Permanent Land (Pvt.) = 1.08 ha

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

S. No.	Description	Area in sq. m	
		Pvt. (Agri.)	Pvt.
1	Temporary Office/ Site Office	6000	2000
2	Segment Casting Yard	60000	20000
	Total	66000	22000

Total land required for temporary acquisition is **6.6 ha (Pvt. Agri) and 2.2 ha (Pvt.).**

0.4.10 Safety & Security Systems

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

0.4.10.1 Requirements

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

0.5 STATION PLANNING

The proposed Corridor of Mumbai Metro Project has 17 elevated stations covering an approximated distance of 21 km.

The locations of stations are defined so as to serve passenger requirements and to enable convenient integration with other modes of transport. Efforts have been made to propose station locations at a uniform inter-station distance wherever possible. Average inter-station distance is ~1 km, though it varies from 0.95 Km to 1.54 km due to land-use and topographic reasons. Minimum inter-station distance is between APMC-Kalyan and Ganesh Nagar which is 954.1 m. Maximum inter-station distance is Pisarve and Taloja which is 1.54 km.

0.5.1 Station Type

The stations are generally located on the road median and a few off roads. Total length of the station is ~140 m. All the stations are two-level stations. The concourse is planned along the whole length of the platform with staircases leading from either side of the road. The maximum width of the station at concourse is ~21 m.

Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. List of Station is given in **Table 0.10.**

Table 0.10 List of Stations

Station Name	Chainage (m)	Inter-station Distance (m)	Type of the station	Remarks
Ganesh Nagar	843.771	954.1	Elevated	Side Platform
Pisavali Gaon	2320.000	1476.2	Elevated	Side Platform
Golavli	3400.000	1080.0	Elevated	Side Platform
Dombivli MIDC	4567.083	1167.1	Elevated	Side Platform
Sagaon	5573.311	1006.2	Elevated	Side Platform
Sonarpada	6700.000	1126.7	Elevated	Side Platform
Manpada	7689.746	989.7	Elevated	Side Platform
Hedutane	8947.974	1258.2	Elevated	Side Platform
Kolegaon	9978.357	1030.4	Elevated	Side Platform
Nilje Gaon	11093.376	1115.0	Elevated	Side Platform
Vadavli(Khu.)	12553.400	1460.0	Elevated	Side Platform
Bale	13974.564	1421.2	Elevated	Side Platform
Waklan	15478.984	1504.4	Elevated	Side Platform
Turbhe	16326.986	848.002	Elevated	Side Platform
Pisarve Depot	17176.971	849.985	Elevated	Side Platform
Pisarve	18981.937	1804.966	Elevated	Side Platform
Taloja	20525.676	1543.7	Elevated	Side Platform

0.5.2 Salient features

Salient features of a typical Metro Station are as follows:

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

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

3. The platform level at elevated stations is determined by a critical clearance of 5.5m under the concourse above the road intersection, allowing 3.3m for the concourse height, about 0.8m for concourse floor and 1.8 m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the rail level in an elevated situation at least 13 meters above ground.

4. The concourse contains automatic fare collection system in a manner that divides the concourse in two distinct areas. The “Unpaid Area” is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the “Paid Area”, which includes access to the platforms.

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

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

7. Station entrances are located with particular reference to passenger catchment points and physical site constraints allowing for required right-of-way in order to provide a minimum of lane width under the station building on either side of the median.

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The functions of such areas are given below in Table 0.11

9. The DG set, Bore Well, Pump House and Underground Water Tanks would be located generally in one area on ground within the Entry / Exit structures.

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

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

- Provision of display of passenger information and advertising.

12. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions such as delayed train service, fire etc.

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

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

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

Table 0.11 Station Accommodation Requirements

For Elevated Stations	
1. Station Control Room	2. Cleaner's Room
3. Station Master's Office	4. Security Room
5. Information & Enquiries	6. First Aid Room
7. Ticket Office	8. Miscellaneous Operations Room
9. Ticket Hall Supervisor & Access Fare Collection (AFC gates)	10. Platform Supervisor's Booth
11. Cash and Ticket Room	12. Auxiliary Substation / DG Room
13. Staff Area	14. Fire Tank and Pump Room
15. Staff Toilets	16. Commercial Outlets and Kiosks
17. Station Store Room	18. UPS and Battery Room
19. Refuse Store	20. Signaling / Communication Room
21. ECS Plant Room	22. ECS Supply and Exhaust Shafts
23. Water softening Plant Room	24. Sump, Seepage & Pump Room

0.6 TRAIN OPERATION PLAN

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

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- Optimization of train's reliability for achieving best possible availability on line.
- A train consists of 3 coaches which will be augmented to 6 coaches in future.
- Multi-tasking of train operation and maintenance staff.

List of stations for the Mumbai Metro Line-12 (Kalyan to Taloja) is given below: -

Table 0.12 –Stations

S. No	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	Station Type	Remarks
0.	APMC - KALYAN	-110.313			
1.	Ganesh Nagar	843.771	954.084	Elevated	
2.	Pisavali Gaon	2295.898	1452.127	Elevated	
3.	Golavli	3400.000	1104.102	Elevated	
4.	Dombivli MIDC	4567.083	1167.083	Elevated	
5.	Sagaon	5573.311	1006.228	Elevated	
6.	Sonarpada	6700.000	1126.689	Elevated	
7.	Manpada	7689.746	989.746	Elevated	
8.	Hedutane	8947.974	1258.228	Elevated	
9.	Kolegaon	9978.357	1030.383	Elevated	
10.	Nilje Gaon	11093.376	1115.019	Elevated	
11.	Vadavli (Khu.)	12553.400	1460.024	Elevated	
12.	Bale	13974.564	1421.164	Elevated	
13.	Waklan	15478.984	1504.420	Elevated	
14.	Turbhe	16326.986	848.002	Elevated	
15.	Pisarve Depot	17176.971	849.985	Elevated	
16.	Pisarve	18981.937	1804.966	Elevated	
17.	Taloja	20492.296	1510.359	Elevated	
	Dead End	20746.066	253.770		

0.6.1 Salient Features

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

0.6.2 Train Formation

To meet the above projected traffic demand, the possibility of running trains with composition of 3 and 6 cars with different headway has been examined.

Composition

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

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

Driving Motor Car (DMC)	-282 (42 seated + 240 standing)
Trailer Car (TC)	-298 (50 seated + 248 standing)
Motor Car (MC)	-298 (50 seated + 248 standing)
3 Car Train	- 862 (134 seated + 728 standing)
6 Car Train	- 1756 (284 seated + 1472 standing)

0.6.3 Year-Wise Rake Requirement

Based on the projected PHPDT demand, Train operation plan with train carrying capacity @ 6 persons per square meter of standee area for the Mumbai Metro 'Line-12: Kalyan to Taloja' for the year 2021 and 2031 is given below:

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

Table 0.13: Capacity Provided for Mumbai Metro Line-12: Kalyan to Taloja

Sections	Year	Head-way (min)	Total No. of Rakes	Rake Consist	Total No. of Cars**	Max. PHPDT Demand	PHPDT Capacity Available
Kalyan to Taloja	2021	6.00	15	3-car	45	8322	8620 (11000*)
Kalyan to Taloja	2031	6.25	15	6-car	90	16342	16858 (21504*)

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

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

0.7 MAINTENANCE DEPOT

0.7.1 Depot- Cum- Workshop

It is proposed to establish one depot- cum- workshop near Taloja 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 equipment.

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 train 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 (preferably as close to depot as possible) to cater to the required stability facilities.
(v) In case of space constraint for depot two storeyed Stabling lines can also be planned.

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

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

0.7.2 Maintenance Philosophy

- Monitoring of the performance of all key Rolling Stock equipment by suitable advanced condition monitoring techniques available. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, "A" checks, "B" type checks, "IOH" and "POH".
- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Increase in the periodic maintenance intervals with predictive maintenance based on condition monitoring.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Periodic review of maintenance practices to update replacement cycle of critical components based on experience.
- Energy conservation is given due attention.

0.8 POWER SUPPLY

0.8.1 Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting, ventilation fan & air-conditioning etc) and workshops in depots & other maintenance infrastructure within premises of metro system. The power requirements of Kalyan to Taloja 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 parameters: -

(i) Specific energy consumption of rolling stock at Pantograph/ Current Collector – 50 kWh/1000 GTKM for 25 kV ac system as per MOUD guideline.

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

(iii) Depot auxiliary load - initially 2000 kW, which will increase to 2200 kW in the year 2031.

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

Table 0.14 Power Demand Estimation (MVA)

Corridor	Load	Year	
		2021	2031
Kalyan to Taloja (17 Elevated, 20.75 km)	Traction	5.68 MVA	10.50 MVA
	Auxiliary	7.72 MVA	9.02 MVA
	Total	**13.40 MVA**	**19.52 MVA**

0.8.2 Sources of Power Supply

The high voltage power supply network of Mumbai Metropolitan Region was studied in brief. The city has 220, 110 and 100 kV network to cater to various types of demand in vicinity of this section/ corridor.

The Mumbai Metro Corridors from Kalyan to Taloja has 20.75km length with 17 elevated stations. Keeping in view of requirement of power supply two Receiving Sub-stations are proposed to be set up at the following locations:

a) At depot near Pisarve Depot station
b) Near Sagaon.

Power supply for this corridor will be taken care by these two RSS. In the event of failure of one of the two RSS, the power supply will be extended from the other RSS and vice versa. This is an economical solution without compromising reliability. Therefore, to avail power supply for traction as well as auxiliary services, the brief details of grid sub-stations of M/s MSETCL from which power will be taken at 220, 110 & 100 kV voltage through cable feeder are hereunder:

Table 0.15 Sources of Power Supply

S. No.	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length b/w GSS & RSS
1.	Kalyan to Taloja	100kV Sonarpada Sub-Station	Near Sagaon	1.5km
2.		220kV MIDC Taloja Sub-Station	At depot near Pisarve Depot Station	4 km

DMRC has done a joint survey/ meeting with M/s MMRDA and M/s MSETCL on 11.10.2018 & 12.10.2018 for this section for feasibility of Power Supply. Accordingly, availability of power supply has been planned and tabulated above. Projected Power demand is calculated on each RSS and furnished below -

Table 0.16– Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand** – Emergency (MVA)	
		Year (2021)	Year (2031)	Year (2021)	Year (2031)
Kalyan to Taloja	RSS Near Sagaon				
	Traction	2.31	4.46	5.68	10.50
	Auxiliary	2.68	3.22	7.72	9.02
	Sub-total (A)	4.99	7.68	13.40	19.52
	RSS at depot near Pisarve Depot Station				
	Traction	3.37	6.04	5.68	10.50
	Auxiliary	5.04	5.80	7.72	9.02
	Sub-total (B)	8.41	11.84	13.40	19.52

**In case of failure of other source of power

0.8.3 Various options of Traction system

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

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

- 1500 V DC Overhead Catenary system.

In view of techno-economic considerations, 25 kV AC traction system is suggested for this corridor.

0.8.4 Standby Diesel Generator Set

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 160 kVA capacity at the elevated stations. Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

UPS Supply to also be considered for following emergency services:

- Emergency Lighting
- Fire Detection & Fire Alarm system.
- Station Control Room
- Control Supply
- Signaling & telecommunications
- Lift operation
- Fare collection system

0.8.5 Supervisory control and Data Acquisition (SCADA) system

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fiber provided for telecommunications will be used as communication carrier for SCADA system.

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.

0.8.6 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.

0.8.7 Electric Power Tariff

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 30-38% of total annual operating cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 34.53 million units in initial years 2021, which will be about 53.21 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 220 & 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 M/s MSETCL for FY 2018 – 19 demand charges Rs. 350/ kVA per month and energy charges Rs 7.00/ kWh. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at "No Profit No Loss" basis. Similar approach has been adopted for Delhi Metro.

0.9 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

0.9.1 Objective and Scope of the Study

The objective of the study is to facilitate the Mumbai Metropolitan Region Development Authority (MMRDA) evaluate the environmental impacts of its proposed activity. MMRDA proposes to apply for loan to seek financial support from multilateral funding agencies. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of Kalyan- Taloja Metro corridor at Mumbai. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles. The MoEF, Government of India, Notification of 14th September 2006 and its amendment dated 1st December 2009 enlist projects in Schedule that require environmental clearance. However, as per the said notification Railway/ Metro projects do not require environmental clearance from MoEF.

0.9.2 Approach and Methodology

The MMRDA has considered different alternative corridors. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are minimum private land acquisition, least disturbance to properties, minimum disturbance to ecology/biodiversity. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the alignment proposed by MMRDA. The impacts are assessed for various phases of project cycle namely:

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

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

The standard methodology for the data collection, impact assessment and formulation of management plans is adopted. The national acts, legislation and laws along with guidelines were consulted with a view to ensuring compliance with various requirements. Environmental baseline data for environmental attributes from primary and secondary sources were collected and compiled. The primary sources include site visits, visual inspection, field studies, monitoring and analysis.

0.9.3 Environmental Scoping

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

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

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

0.9.4 Environmental Impacts

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

- Land Environment
- Water Environment
- Air Environment
- Noise Environment
- Biological Environment
- Socio-Economic Environment

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

0.9.5 Environmental Management Plan

The Mumbai Metro Project will provide employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand. The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components. For optimal integration of EMP into the project, there should be investment links for:

- ➢ Funding,

- Management and training, and
- Monitoring.

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

0.9.6 Environmental Monitoring Plan

Environmental monitoring plan has been developed for construction as well as operation phase so as to maintain and regulate the project activities keeping environment safe.

0.10 MULTI MODAL TRAFFIC INTEGRATION

Mumbai Metro Line-12 from Kalyan to Taloja is extension of Mumbai Metro Line-5 (Thane-Bhiwandi-Kalyan) and length of this extension is 20.756 km. It is completely elevated. Total Seventeen elevated stations have been proposed in this extension.

It will be augmented through enhanced flexibility of criss-cross interchanges to other metro corridors and other modes of public transport. It will 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.

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.

0.10.1 Way Forward

There is a need for providing a transportation system which is seamlessly integrated across all modes and provides first mile as well as last mile connectivity. It is also necessary that various public transportation modes including Inter-mediate Public Transport (IPT) and feeder buses etc. work together in order to facilitate increase in ridership to the Metro/Metro system and provide ease of using Metro system by the public at large.

Therefore, there is a need for doing more scientific study exclusively for this. To achieve this goal, Metro Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. Detailed Study is required to be done in this influenced zone of a Metro station for following aspects mainly:

i) Availability and review of existing public and IPT facilities, in terms of motorized and non-motorised mode with main consideration of the streets/roads adjoining to the stations and also to examine adequacy of availability of pedestrians/cycle paths in the influenced zone.

ii) Analysis and identification of gaps between supply and demand in terms of feeder facilities and other requirements for better first and last mile connectivity.

iii) Proposal for introduction/enhancement of feeder buses and cycle/pedestrians tracks, bike sharing arrangement for each Metro station to be finalised.

iv) Proposal for better integration of Metro station with other mode of transport, such as relocation of existing bus stop, introduction of new bus stop, bus base etc.

v) Cost of the requirements namely road widening including roads for pedestrian/cycle paths, feeder buses based on the outcome of the study.

The detailed study and requirement for providing first mile as well as last mile connectivity to the Metro users will be carried out separately and the same should be in place before the commercial operation of the Metro services for the benefit of the users as well as for better ridership and the financial viability of the project.

0.11 FRIENDLY FEATURES FOR DIFFERENTLY ABLED

The objective of making this chapter is to create a user-friendly mass transport system in India which can ensure accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems (e.g. a leg in plaster) and the elderly persons.

The design standards for universal access to Public Transport Infrastructure including related facilities and services, information, etc. would benefit people using public transport.

The access standards given 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) "Harmonised Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disabled and Elderly Persons", 2016 (by MoUD), and international best practices / standards.

Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around Metro stations.

0.11.1 Contents

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

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

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

0.12 SECURITY MEASURES FOR A METRO RAIL SYSTEM

Metro Rail System is emerging as the most favoured mode of urban transportation system. The inherent characteristics of Metro Rail System make it an ideal target for terrorists and miscreants. Metro Rail System is typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic importance, being the life line of city high news value, fear & panic and human casualties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

0.12.1 Three Pillars of Security

Security means protection of physical,human and intellectual assets either from criminal interference, removal of destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. There are three important pillars of security as mentioned under:

(i) The human factor
(ii) Procedures
(iii) Technology

0.12.2 Phases of Security

There are three phases of security as under:

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

0.13 DISASTER MANAGEMENT MEASURE

0.13.1 Introduction

“Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation.” Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area”. As per World Health Organization (WHO):

“Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area.”

A disaster is a tragic event, be it natural or manmade, which brings sudden and immense agony to humanity and disrupts normal life. It causes large scale human suffering due to loss of life, loss of livelihood, damages to property and persons and also brings untold hardships. It may also cause destruction to infrastructure, buildings, communication channels essential services, etc.

0.13.2 Need for Disaster Management Measures

The effect of any disaster spread over in operational area of Metro Rail System is likely to be substantial as Mumbai Metro will be dealing with thousands of passengers daily. Disaster brings about sudden and immense misery to humanity and disrupts normal human life in its established social and economic patterns. It has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro Rail System. Therefore there is an urgent need to provide for an efficient disaster management plan.

0.13.3 Objectives

The main objectives of this Disaster Management Measures are as follows:

- Save life and alleviate suffering.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instill a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation.
- Lay down the actions required to be taken by staff in the event of a disaster in VMRT in order to ensure handling of crisis situation in coordinated manner.
- To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

0.13.4 Provisions at Metro Stations/Other Installations

To prevent emergency situations and to handle effectively in case ‘one arises’ there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

(A) Fire Detection and Suppression System
(B) Smoke Management
(C) Environmental Control System (ECS)
(D) Track-Way Exhaust System (TES)
(E) Station Power Supply System
(F) DG Sets & UPS
(G) Lighting System
(H) Station Area Lights
(I) Seepage System

(J) Water Supply and Drainage System
(K) Sewage System
(L) Any Other System Deemed Necessary

The above list is suggestive not exhaustive actual provisioning has to be done based on site conditions and other external and internal factors.

0.14 COST ESTIMATE

Project Cost estimates for Mumbai Metro Line No. 12 from Kalyan to Taloja has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction etc. at March 2018 price level.

The overall Capital Cost of Mumbai Metro Line-12 from Kalyan to Taloja at March 2018 price level works out to **Rs. 4132 Crores** excluding applicable Taxes & Duties of **Rs. 606 crores** as tabulated hereunder.

Table 0.17 –Summary of Cost Estimate

Sr. No.	Name of the section	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Kalyan to Taloja	4132	606	4738

Table 0.18 - Capital Cost Estimate

Total length = 20.756 km (Completely Elevated)

Total Station =17 (All Elevated)

March 2018 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Private -Agricultural Land	ha	5.00	49.731	248.66
b	Private	ha	20.00	1.080	21.60
1.2	Temporary Land (@5% pa for 4 years)	Ha.			
a	Private -Agricultural Land		1.00	6.6	6.60
b	Private		4.00	2.2	8.80
1.3	**R & R incl. Hutments etc.**	R. Km.	4.12	7.4	30.49
	Subtotal (1)				**316.14**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	35.00	20.756	726.46
2.2	Depot entry connection	R. Km.	35.00	0.500	17.50
2.3	Additional Cost for Special Spans	LS			20.00
	Subtotal (2)				**763.96**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	27.00	14	378.00
b	Type (A) way side- EM works including lifts and escalators	Each	9.05	14	126.70

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
c	Type (B) Way side with signalling-civil works	Each	29.00	2	58.00
d	Type (B) Way side with signalling-EM works including lifts and escalators	Each	9.05	2	18.10
e	Type (C), Terminal station -civil works	Each	31.00	1	31.00
f	Type (c), Terminal station -EM works including lifts and escalators	Each	9.05	1	9.05
3.2	Half height Platform Screen Doors (PSD)	Each	2.79	34	94.86
3.3	OCC bldg.				
a	Civil works	LS			60.00
b	EM works etc	LS			40.00
	Subtotal (3)				**815.71**
4.0	**Depot**	LS			
4.1	Depot				
a	Civil works	LS			250.00
b	EM works	LS			25.00
c	M&P for Rolling stock	LS			50.00
d	Depot 25 kV AC Traction (OHE)	LS			25.00
	Subtotal (4)				**350.00**
5.0	**P-Way**				
5.1	Ballast less track for Elevated section	R. Km.	9.79	21.256	208.10
5.2	Ballasted track for Depot	R. Km.	5.38	5.00	26.90
	Subtotal (5)				**235.00**
6.0	**Traction & power supply incl. OHE , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated Section 25 kV AC Traction (OHE) with ASS & Cabling	R.Km.	7.19	21.256	152.83
6.2	RSS (GIS)	Each	61.27	2.00	122.54
	Subtotal (6)				**275.37**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	12.50	21.256	265.70
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	6.28	17	106.76
	Subtotal (7)				**372.46**
8.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works	R. Km.	5.14	21.256	109.26
b	EM works	R. Km.	4.00	21.256	85.02
	Subtotal (8)				**194.28**
9.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.00	45	405.00
	Subtotal (9)				**405.00**
10.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.08	21.256	1.70
b	EM works etc	R.Km.	0.33	21.256	7.01
	Subtotal (10)				**8.71**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.99	21.256	42.30
b	EM works etc	R.Km.	0.50	21.256	10.63
	Sub Total (11)				**52.93**
12.0	**Capital expenditure on Multimodal Traffic**				

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
	Integration				
a	Capital expenditure on Multimodal Integration	Each	2.65	17	45.05
	Sub Total (12)				**45.05**
13.0	**Total of all items except Land**				**3548.96**
14.0	**General Charges incl. Design charges @ 5 % on all items except land#**				**177.45**
15.0	**Total of all items including G. Charges except land**				**3726.40**
16.0	**Contingencies @ 3 %**				**111.79**
17.0	**Gross Total**				**3838.20**
	Cost without land			**=**	**3838**
	Cost with land including contingencies on land			**=**	**4132**

#In accordance with MoUD's letter F.No.K-14011/58/2013-MRTS-I(Vol.I)

Table 0.19 - Details of Taxes and Duties

Basic Customs duty =	5.1500
CGST Customs Duty=	9.4635
SGST Customs Duty=	9.4635
Total Customs Duty=	**24.0770**
General IGST=	12
General CGST =	6
General SGST =	6

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total Taxes & Duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated	763.96		91.68	**91.68**
2	**Station Buildings**				
	a) Elevated station - civil works	467.00		56.04	**56.04**
	b) Elevated station-EM works	153.85	7.41	14.77	**22.18**
	c) OCC bldg-civil works	60.00		7.20	**7.20**
	d) OCC bldg-EM works	40.00	1.93	5.76	**7.69**
3	**Depot**				
	Civil works	250.00	18.06	21.00	**39.06**
	EM, M&P works and OHE	100.00	4.82	14.40	**19.22**
4	**P-Way**	235.00	45.26	8.46	**53.72**
5	**Traction & power supply**				
	Traction and power supply	275.37	26.52	29.74	**56.26**
6	**S and T Works**				
	S & T	265.70	51.18	9.57	**60.74**
	AFC	106.76	19.28	4.80	**24.08**
	PSD	94.86	18.27	3.41	**21.69**
7	**R & R hutments**	30.49		3.66	**3.66**
8	**Misc.**				

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total Taxes & Duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
	Civil works	187.04	0.00	22.45	**22.45**
	EM works	113.93	0.00	20.51	**20.51**
9	**Rolling stock**	405.00	58.78	5.99	**64.77**
10	**Rent on Temporary Land**	15.40		2.77	**2.77**
11	**General Charges**	177.45		31.94	**31.94**
	Total	**3741.80**	**251.50**	**354.15**	**605.65**
	Total taxes & Duties				**606**
Rate of Taxes & Duties on Total cost without taxes & duties					**16.19%**
Total Central GST & Basic Customs duty					329.72
Total State GST					275.93
Total Taxes & Duties					**605.65**

0.15 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

The Mumbai Metro Rail Project i.e. Line 12 from Kalyan to Taloja (Extension of Line 5 metro project) is proposed to be constructed at an estimated cost of Rs. 4738.00 Crore with all taxes and land cost. The route length of the proposed metro rail system and estimated cost at March 2018 price level without and with all taxes are placed in table 0.20 as under:

Table 0.20 Cost Details

Sr. No.	Name of Corridor	Distance (km)	Estimated cost without taxes (Rs/Crore)	Estimated cost with all taxes & land cost (Rs/Crore)
1	Line 12 from Kalyan to Taloja	20.756	4132.00	4738.00

The estimated cost at March 2018 price level includes an amount of Rs.8.71 Crore as one-time charges of security personal towards cost of weapons, barricades, and handheld and door detector machine. However, the recurring cost towards salary and allowances of security personal have not taken in to account in the FIRR calculation since providing required security at metro stations shall be the responsibility of state police.

It is assumed that the construction work will start on 01.11.2019 and is expected to be completed on 31.10.2024 with Revenue Opening Date (ROD) as 01.11.2024 for the above corridor. The total completion costs duly escalated and shown in the table 0.21 have been taken as the initial investment. The cash flow of investments separately is placed in Table–0.21 as below.

Table 0.21 Year –wise Investment

Figures in Rs. Crore

Financial Year	Estimated Cost including cost of land and all taxes & duties at March 2018 Price Level	Completion Cost including cost of land cost and all taxes & duties
2019-20	523.00	549.00
2020-21	1406.00	1550.00

Financial Year	Estimated Cost including cost of land and all taxes & duties at March 2018 Price Level	Completion Cost including cost of land cost and all taxes & duties
2021-22	1406.00	1627.00
2022-23	962.00	1170.00
2023-24	441.00	563.00
Total	**4738.00**	**5459.00**

The cost of Land of Rs. 368 crore included in the above completion cost will be provided free of cost by the Maharashtra Government.

Fare Structure

The fare structure for the FY 2024-25 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the fare structure has been escalated by using @14.00% once in every two years. The fare structure for the FY 2024-25 as per the proposed fare slabs is shown in the table 0.22 below:

Table 0.22 Fare Structure in 2024-25

Sr. No.	Distance	Proposed Fare
1	0-2	11
2	2-4	13
3	4-6	16
4	6-9	20
5	9-12	22
6	12-15	24
7	15-18	26
8	>18	30

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

Year 2024-25	
SLAB	**FARE (Rs)**
0-3 km	10.00
3-12 km	20.00
12-18 km	30.00
18 km and more	40.00

The **Financial Internal Rate of Return (FIRR)** for 30 years business model including construction period without PD income and with PD income is **(-) 1.39% and 6.00%** respectively.

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 Central and State Government Control Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC)/Chennai Metro Rail Corporation (CMRL) etc.
(ii) Design, Built, Fund, Operate & Transfer (DBFOT), and
(iii) Public Private Partnership

SPV Model: - MOUD vide letter no. F.No. K-14011/03/2017-UT-V-Part(1) dated 6th July 2017 has proposed for sharing of overall Goods and Service Tax (GST) in the ratio of 1:2. The funding pattern under this model (SPV) with sharing of overall taxes and duties, post GST in the ratio of 1:2 is placed in table 0.23:

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

(Rs./Crore)

Particulars	Amount with Taxes & Duties	% of contribution
Equity By GOI	837.00	15.43%
Equity By GOM	837.00	15.43%
SD for Overall Taxes by GOM (2/3)	248.00	4.57%
SD for Overall Taxes by GOI (1/3)	496.00	9.15%
1.40% Loan from Multilateral/Overseas Development Agencies or 12% Domestic Market Borrowings	3005.00	55.42%
Total	**5423.00**	**100.00%**
SD for Land by GOM	368.00	
Total	**5791.00**	
PTA for Interest During Construction @1.40% by GOM	74.00	
Grand Total	**5865.00**	

Design, Built, Fund, Operate & Transfer (DBFOT) 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 Equity internal rate of return (EIRR) in the range of 16% to 18% or a comfort of guaranteed ridership. The funding pattern assumed under this model excluding the cost of land is placed in table 0.24 as under: -

Table 0.24 Funding pattern under DBFOT – (16% EIRR)
(With additional PD Income)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1085.00	20.00%
VGF by GOM	3135.00	57.82%
Equity by Concessionaire	141.00	2.60%
Concessionaire's debt @12% PA	1062.00	19.58%
Sub-Total	**5423.00**	**100.00%**

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
Land Free by GOM	368.00	
Sub-Total	**5791.00**	
IDC	166.00	
Grand Total	**5957.00**	

0.15.1 Recommendations

The FIRR for the corridors with all taxes and without additional PD income and with additional PD income works out to (-) 1.39% and 6% respectively. However, FIRR is not the only criteria to take up the metro project.

As per Metro Rail Policy 2017, issued by the Ministry of Housing and Urban Affairs, (MOH&UA), GOI, apart from financial viability, the economic and social viability of the project is also required to be assessed. The Economic Internal Rate of Return (EIRR) for any metro rail project proposal should be 14% and above for consideration of its approval. Accordingly, the metro corridor as discussed above are recommended for implementation provided the required EIRR works out to 14% or above.

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

Table 0.25 **(Rs. in crore)**

Particulars	SPV Model	DBFOT Model with PD
GOI	1085.00	1085.00
GOM	1701.00	3503.00
Total	**2786.00**	**4588.00**

Considering the difference in the contribution of funds under SPV owned by GOI & GOM vis-a-vis BOT model, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern given in Table 0.23. However, the state government may also explore the other sources of revenue from Transit Oriented Development and Value Capture Financing, which will be made available to metro authorities to meet out the O&M Expenses and servicing the debt properly.

0.16 ECONOMIC APPRAISAL

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

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

0.16.2 Economic Performance Indicators

After generating the cost and benefit stream table, values of economic indicators are derived and are given in table 0.26. Project period is 2019-2048. On the basis of **completion** cost, EIRR is **14.51%,** B/C Ratio is 3.3 and NPV is 37434 Cr, which shows that the project is economically viable. With 12 % discount, EIRR (completion cost) is **2.24%** and B/C ratio is 1.2. NPV is Rs 1264 Cr.

Table 0.26: Economic Indicator Values

Kalyan-Taloja	(Completion Cost Basis)	
ECONOMIC INDICATORS	**WITHOUT DISCOUNT**	**WITH DISCOUNT (12%)**
Cumulative cost (Cr.)	16408	5445
Cumulative benefit(Cr.)	53842	6708
Benefit Cost Ratio	3.3	1.2
NPV(Cr.)	37434	1264
EIRR	14.51%	2.24%

0.17 IMPLEMENTATION PLAN

World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial internal rate of return for this corridor with all taxes and without additional PD income and with additional PD income works out to **(-) 1.39% and 6.00% respectively.**

The only Metro which has been implemented on BOT model so far is the Rapid Metro in Gurgaon. Financially this Metro has been a total failure since the revenues are not able to meet even the interest payment on the loans raised. It is therefore recommended that the project is implemented fully as a Government initiative. By this route the project can be completed at the shortest time and at the lowest cost. This is important because then only ticket can be priced low, affordable to the common citizens and make the system truly a popular public transport.

0.17.1 Implementation Schedule

A suggested project implementation schedule for Project Implementationis given in Table 0.27.

Table 0.27 Project Implementation Schedule

S. No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D+0.5 month
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D+1 month
4.	Sanction of Project by GOI	D+2 months
5.	Selection of GC	D+12 months
6.	Tendering	D+24 months
7.	Implementation of the project	D+57 months

S. No.	Item of Work	Completion Date
8.	Testing and Commissioning	D+59 months
9.	CMRS Sanction	D+60 months
10.	ROD	D+60 months

0.17.2 Institutional Arrangements

The State Govt. of Maharashtra will have to approve the implementation of the project by Mumbai Metropolitan Region Development Authority (MMRDA).

0.17.3 Legal Cover for Mumbai Metro

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

0.18 CONCLUSIONS

0.18.1 Area along this corridor is not much habitated. Most of the length of the corridor is passing through agriculture and barren land. MRTS corridors are generally planned along the highly populated areas to fulfill the transportation need of the masses living in that area. However, as brought out in the meetings by MMRDA, they intend to develop the area along this corridor at a very fast rate to provide houses for all. They have also planned developmental sites namely Kalyan Growth Centre and NAINA along this corridor. 40 Ha of land has also been identified for Property Development. Purpose of this corridor is to decongest the Mumbai city and accelerate the development activities in the area covered by this corridor. Hence, this corridor is only a development corridor and will need special efforts if Government decides to implement it.

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

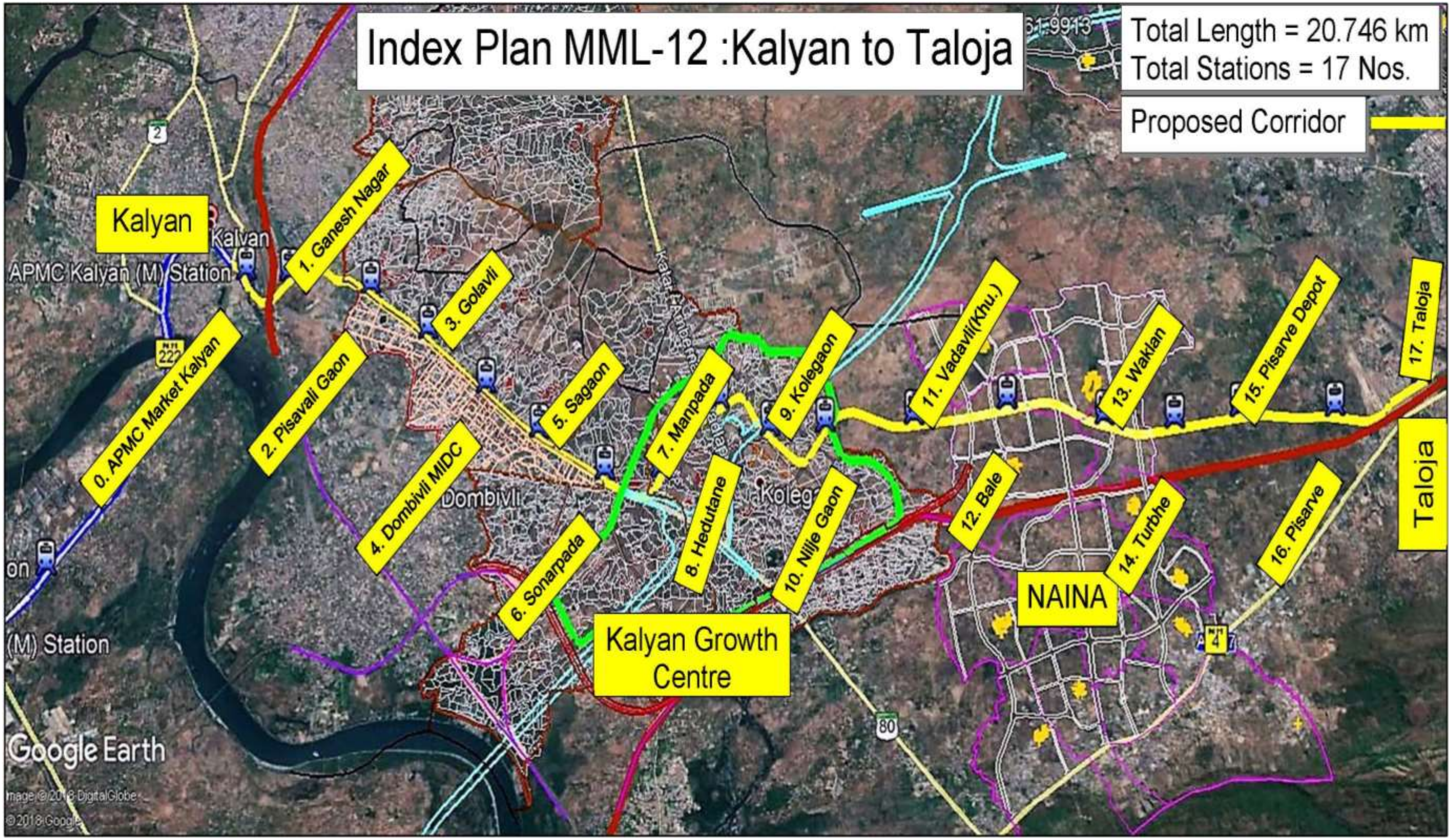
0.18.3 Project Cost

Estimated Cost of the project at March 2018 price level is 4738 Crore with land and all the taxes, duties. Completion cost with 5% p.a. escalation is estimated to be Rs.5791 Crores including land and all the taxes, duties, but excluding IDC. IDC will be additional Rs. 74 Crores.

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

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

The Financial Internal Rate of Return (FIRR) for the project has been assessed as **6.00% (With additional PD income from 40 Ha land)**. The Economic Internal Rate of Return (EIRR) works out to **14.51%.**



Index Plan MML-12 :Kalyan to Taloja
Total Length = 20.746 km
Total Stations = 17 Nos.
Proposed Corridor
Kalyan
APMC Kalyan (M) Station
0. APMC Market Kalyan
1. Ganesh Nagar
2. Pisavali Gaon
3. Golavli
4. Dombivli MIDC
5. Sagaon
6. Sonarpada
7. Manpada
8. Hedutane
9. Kolegaon
10. Nilje Gaon
11. Vadavli(Khu.)
12. Bale
13. Waklan
14. Turbhe
15. Pisarve Depot
16. Pisarve
17. Taloja
Taloja
Dombivli
Kalyan Growth Centre
NAINA
(M) Station
Google Earth

CHAPTER – 01

INTRODUCTION

1.1 BACKGROUND

MMRDA has carried out Comprehensive Transportation Study (CTS) of Mumbai Metropolitan Region (MMR) in 2005-2008. As per the recommendations in the Comprehensive Transportation Study of MMR and considering the need of better public transport to cater the rapid growth of urbanization in Kalyan–Dombivli, Taloja/Navi Mumbai due to upcoming international airport being implemented by CIDCO, MMRDA has proposed to extend the Metro Line-5 (Thane – Bhiwandi – Kalyan) up to Taloja (Navi Mumbai Metro) which further connects to Navi Mumbai International Airport (NMIA). Accordingly, MMRDA has taken up the preparation of Detailed Project Report (DPR) through M/s DMRC for said metro corridor which is 20.756 km in length.

Vide email dated 01/03/2017 (Annexure 1), Chief, Transport and Communication Division informed to DMRC that MMRDA wants to extend Mumbai Metro Line 5: Thane to Kalyan upto Taloja and requested DMRC to provide ToR for preparation of Detailed Project Report. Accordingly, DMRC sent ToR on 06/3/2017 vide email dated 06/03/2017, which was accepted by MMRDA on 22/03/2018. However, agreement for carrying out this study signed between MMDRA and DMRC on 02/08/2017.

Draft DPR for this corridor was submitted in January 2019. MMRDA sent their Observations/Comments on the same vide email dated 14.02.2019 and 26.03.2019. Now this Final DPR is prepared after incorporating the comments received from MMRDA.

1.2 NEED OF KALYAN-TALOJA METRO RAIL CORRIDOR

Area along the corridor is not much habitated. Most of the length of the corridor is passing through agriculture and barren land. MRTS corridors are generally planned along the highly populated areas to fulfill the transportation need of the masses living in that area. However, this corridor is for Transit Oriented Development (TOD). This Corridor will actuate the development in this area and encourage people to move out from crowded parts of the city to this area. Purpose of this corridor is to decongest the Mumbai city and accelerate the development activities in the area covered by this corridor. The upcoming projects along the corridor are as under.

- Kalyan Growth Centre
- Navi Mumbai Airport Influence Notified Area (NAINA)
- Development by other Builders

Kalyan Growth Centre

The Govt. of Maharashtra by its Notification dated 9th Aug., 2006 (published in Govt. Gazette on 7th Dec., 2006) appointed MMRDA as 'Special Planning Authority' for 27 villages from Kalyan and Ambarnath Talukas of Thane District. MMRDA after completing all statutory procedure stipulated under the Maharashtra Regional and Town Planning Act (M.R and T.P.) 1966, submitted the Draft Development Plan to the Government for sanction on 14th Dec. 2012 u/s of 30 (1) of the Act. The Government by its Notification no.TPS-1212/1697/CR No.101/13/UD-12, dt.11th March, 2015 (published in Maharashtra Govt. Gazette on 13th March, 2015) has partly sanctioned the Development Plan for this Notified Area in accordance with section 31 of M.R and T.P. Act, 1966. Thereafter, the Govt. by its Notification no. TPS-1216/CR No.240/16/UD-12, dt. 9th May, 2017 & subsequent corrigendum dtd.13th June, 2017 and Notification dtd.3rd June, 2017 has sanctioned Excluded Part (EP) of Development Plan for the said Notified Area (Except EP-24 & EP 125).

The Draft Regional plan of MMR has identified four no. of growth Centres within the Mumbai Metropolitan Region (MMR). The Growth centres are envisaged as integrated complexes with opportunities for office sector employment, research and development, educational and recreational facilities and the necessary housing and infrastructure. These Growth centre are proposed at locations that are served by Rail as well as Road networks.

The Growth Centre at Kalyan Taluka is one of the four Proposed Growth Centres identified as per the Draft Regional Plan of MMR. Accordingly, as per the list of Govt's important projects & the minutes of Hon. Chief Minister's War Room Meeting which includes the said proposed Growth Centre at Kalyan, MMRDA identified an area of approx. 1,089 Hectare to be developed as Growth Centre on the lines of Bandra-Kurla Complex (BKC) in Mumbai. This Growth Center envisages to create employment opportunities, better infrastructure in this area and connectivity with suburbs of Thane, Kalyan and Dombivli.

MMRDA in its 138th Authority Meeting held on 26/08/2015 vide Resolution No. 1340 has granted In-principle Approval to develop growth Centre in Kalyan Taluka (area approx. 1089 Ha.) through implementation of Town Planning Schemes (TPS).

The Government of Maharashtra by its Notification No. TPS.1215/941/CR-42/15/UD-12, dt. 30th April 2016, has retained the appointment of the Mumbai Metropolitan Region Development Authority as a Special Planning Authority for an area (admeasuring approx. 1089 Ha) from the Villages Bhopar (Pt), Sandap, Usarghar (Pt), Gharivali (Pt), Mangaon (Pt), Hedutane (Pt), Kole, Katai (Pt), Nilaje (Pt) and Ghesar (Pt) of the said Notified Area.

MMRDA has prepared the Draft Development Plan under section 23 of MR & TP Act in the Maharashtra Government Gazette by notice dated 7th February 2008. Draft Development Plan for 27 villages of Kalyan & Ambarnath Tehsils of Thane District has already been approved by GoM.

Table – 1.1

No.	Tehsil Name	Village Name	Total Village Area		% of Total Notified Area
			Sq.km	Ha	
1	Kalyan	Ghesar	1.67	167.32	3.45
2		Hedutane	4.03	402.77	8.32
3		Nandivali turfe Ambarnath	0.64	63.94	1.32
4		Davadi	2.63	262.57	5.42
5		Pisavali	1.08	108.44	2.24
6		Golivali	1.6	160.18	3.31
7		Sonarpada	1.49	148.73	3.07
8		Mangaon	1.41	140.58	2.9
9		Kole	1.65	164.79	3.4
10		Nilaje	2.82	282.38	5.83
11		Katai	1.07	107.24	2.21
12		Usarghar	1.9	189.75	3.92
13		Gharivali	0.81	81.41	1.68
14		Sandap	0.51	51.3	1.06
15 & 16		Bhopar (Deslapada)	4.47	447.3	9.24
17		Nandivali – Panchanand	1.51	150.75	3.11
18		Asade	1.56	155.74	3.22
19	Ambarnath	Sagaon	1.17	117.48	2.43
20		Chinchapada	1.04	103.58	2.14
21		Adivali – Dhokali	1.79	179.4	3.7
22		Umbroli	1.91	190.96	3.94
23		Bhal	2.12	212.01	4.38
24		Dwarli	1.02	102.01	2.11
25		Manere	2.36	235.56	4.86
26		Vasar	4.54	453.82	9.37
27		Ashele	1.63	163.38	3.37
Total of Notified Area for 27 villages			**48.43**	**4843.4**	**100**

Source: Draft Development Plan for Notified Area of 27 Villages of Kalyan and Ambarnath Tehsils of Thane District, Maharashtra 2008 - 2028

The approximate total population of these 27 villages as per the records from KDMC is 125000. The KDMC had prepared in 1996, Development Plan for Kalyan Municipal Corporation limits, which included this area. The Government of Maharashtra has not sanctioned the proposals of Draft Development Plan submitted by the KDMC for the area of these 27 villages. As per letter dt.11th January 2007 from the Urban Development Department, Government of Maharashtra, the Proposals/Regulations in the sanctioned Regional Plan for Mumbai Metropolitan Region (1996 – 2011) are applicable for the proposed development in the area of these 27 villages till the Development Plan is prepared. As per the provisions of sanctioned Regional Plan, the area of these 27 villages consists of land use of Urbanisable Zones, U-1 and U-2, and also the Industrial and G-1 (Green Zone) Zones.

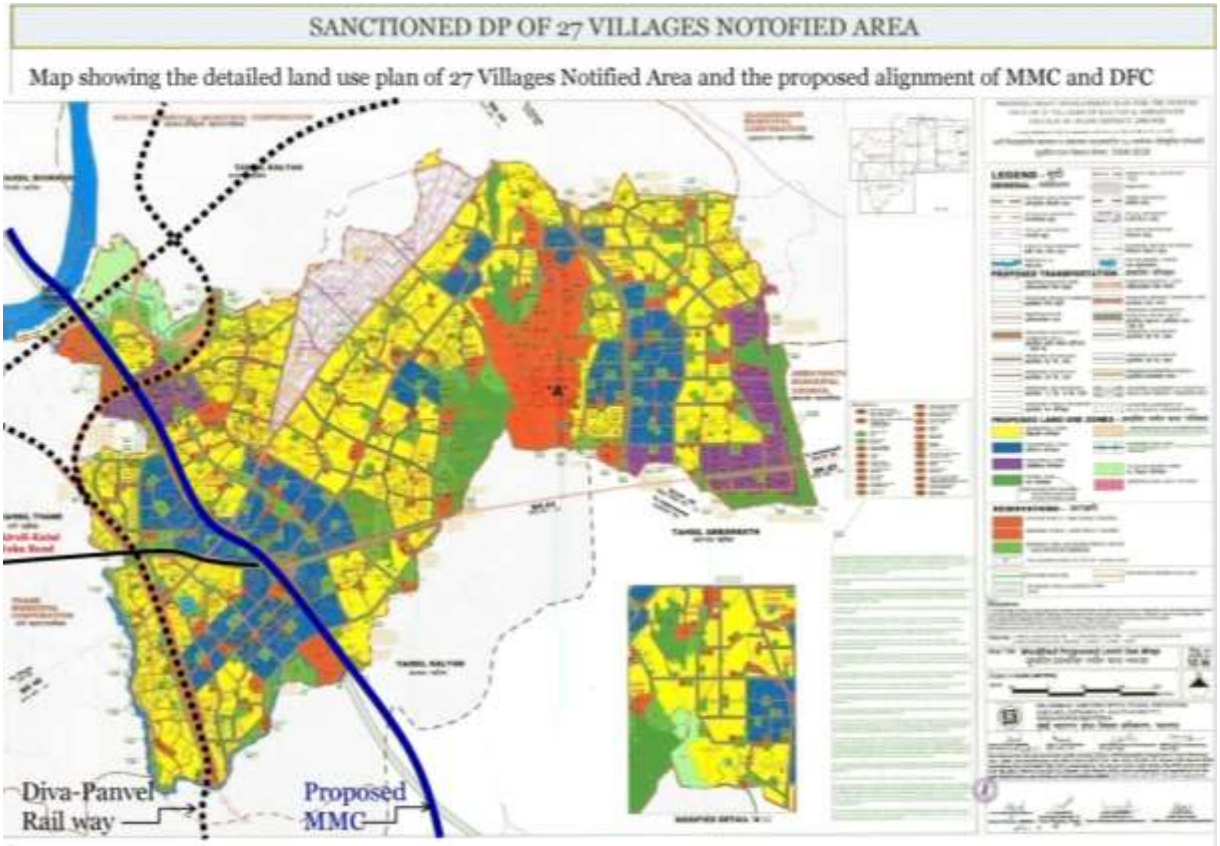


Figure - 1.1: Sanctioned DP of Kalyan Growth Centre

Navi Mumbai Airport Influence Notified Area (NAINA)

The Govt. of Maharashtra after consulting the Mumbai Metropolitan Region Development Authority (MMRDA), State Town Planning & Valuation Dept. has considered it appropriate to appoint a Planning Authority for a planned and orderly development within a radial distance of about 25km from the proposed International Airport site Navi Mumbai. Accordingly, the Urban Development Dept. (UDD), Govt of Maharashtra (GOM), vide the Notification No. TPS-1712/475/CR-98/12/UD-12 dated 10th January 2013, under the Clause (b) of subsection (1) of Section 40 of the Maharashtra Regional & Town Planning Act, 1966, has appointed CIDCO as the Special Planning Authority (SPA) for the area so identified as Navi Mumbai Airport Influence Notified Area (NAINA).

CIDCO prepared the development proposals and Development Control Regulations for NAINA and submitted it to the Govt. for sanction after following the due procedure prescribed in the MRTP Act, 1966.

The NAINA has 270 villages in six talukas of Thane, Uran, Karjat, Pen, Khalapur and Panvel of the Thane and Raigad Districts. Some villages fall partly in Matheran Eco Sensitive Zone (MESZ). Details of taluka wise villages included in the NAINA project, is given here below:

Table – 1.2

S No.	Name of District	Name of Tahsil	No. Of Villages			Remark
			Complete	Part	Total	
1	Raigad	Uran	5	0	**5**	
2		Panvel	74	37	**111**	37 villages partly within MESZ
3		Karjat	3	3	**6**	3 villages by Karjat-Khopoli Rail line
4		Khalapur	41	15	**56**	10 Villages partly within MESZ & 5 Villages by Karjat-Khopoli Rail line
5		Pen	78	0	**78**	
6	Thane	Thane	14	0	**14**	
Total			**215**	**55**	**270**	

Source: htpp://cidco.maharashtra.gov.in/pdf/SPA/NAINA_website_new.pdf.

MSEZ = Matheran Eco-Sensitive Zone
Boundary of Matheran Eco-Sensitive Zone boundary is as per Notification of MoEF, dated 4th February, 2003.

Total area is estimated to be around **550 to 600** sq.km.

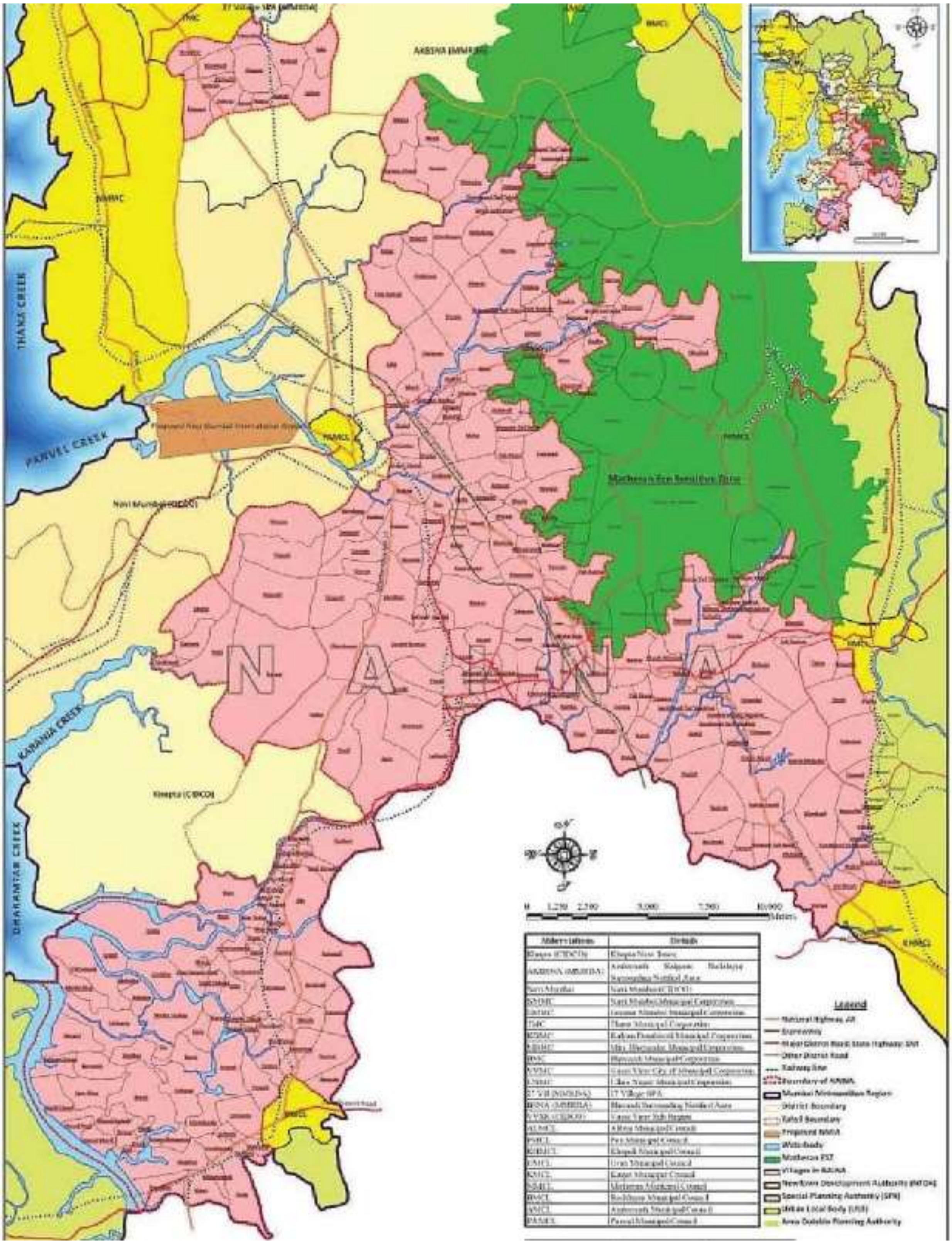


Figure - 1.2: Navi Mumbai Airport Influence Notified Area (NAINA)

Other Development by Builders

In addition to Kalyan Growth Centre and NAINA there are several other projects in pipeline as listed here under. All the projects are in various phases of execution / approval. It is also expected that over 20,000 Ha of land owned by agriculturist in the area will also come under development over the time.

Table - 1.3

Key developments	Estimated Floating Population (work/ retail etc.)	Estimated Residential Population	Area in hectares	Comments
MMRDA's Business Hub	750,000	70,000	1,000	Assuming 80% of area is developed by 2043 and of that, 10% is residential.
Taloja MIDC	103,282	36,300	875	
Runwal My City Development		42,000	60	
Palava Integrated Township development (650 acres)	45,500	182,000	260	
Integrated Industrial Area (IIA) proposed on Taloja Road	13,000			
Premier Automobiles Land (~150 acres)	8,400	33,600	60	Assuming 80% residential
PAL-Peugot Land (~180 acres)	10,500	42,000	75	Assuming 80% residential
Proposed Integrated Township by Lodha (~1200 acres)	87,500	350,000	500	
Megacity development in 27 villages of KDMC	6,000	75,000		
Sub-Total of large developments known currently (A)	1,024,182	830,900		
Add estimated demand from small and medium scale development (100% of A for residential and 50% for visiting) (B)	512,091	830,900		
Add existing population	20,000	150,000		
Total Estimated Population by 2043 (25 years) (A+B = C)	**1,556,273**	**1,811,800**		

1.3 STUDY OBJECTIVES

The objective of the assignment is to prepare Detailed Project Report (DPR) for the proposed metro corridor from Kalyan to Taloja.

1.4 SCOPE OF WORK

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

ii. Preparation of alternative routes on Google/available standard maps in consultation with MMRDA.

iii. Multi modal Traffic integration, Station Area Traffic Dispersal Plans, planning for feeder bus services, public bike sharing and pedestrianisation in the influence area of stations and also with the proposed infrastructure in and around the area.

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

v. Field Surveys for identification of major above-ground utilities along the proposed Metro route requiring diversion/relocation. Details of underground utilities shall be supplied by State Govt. through the concerned utility agencies.

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

vii. Identification of depots & preparation of it's general layout plans, covering all facilities.

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

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

x. Geo-technical investigations along the identified corridors.

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

xii. Conceptual Plan for the rolling stock maintenance depots.

xiii. Creation of disable friendly features to ensure accessibility to persons with disabilities.

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

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

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

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

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

xix. Study on the Fare Structure.

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

xxi. Financial and Economic analysis for the project.

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

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

1.5 STRUCTURE OF REPORT

The report is structured in under mentioned 18 chapters:

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

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

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

iv. Chapter four presents civil engineering along with geometric designing parameters including horizontal & vertical alignment of the proposed corridor.

v. Chapter five consists of Station Planning.

vi. Chapter six presents the Train Operation Plan.

vii. Chapter seven discusses the maintenance facilities /depot.

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

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

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

xi. Chapter eleven consists of friendly features for differently abled.

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

xiii. Chapter thirteen is on Disaster Management Measures.

xiv. Cost estimate is in chapter fourteen.

xv. Chapter fifteen presents the funding options, fare structure and financial viability.

xvi. Chapter sixteen is on economic appraisal.

xvii. Chapter seventeen is on implementation strategies.

xviii. Chapter eighteen consists of conclusions and recommendations.

Annexure - 1

Gmail R G Sharma <rgs0511@gmail.com>

Preparation of DPR for Extension of Line - 5 Metro from Kalyan to Taloja

3 messages

K Vijayalakshmi <chieftc@mailmmrda.maharashtra.gov.in> Wed, Mar 1, 2017 at 2:52 PM
To: som sharma <sdscvo1984@yahoo.com>, R G Sharma <rgs0511@gmail.com>
Cc: K Vijayalakshmi <chieftc@mailmmrda.maharashtra.gov.in>, Manoj Dandare <manoj.dandare@mailmmrda.maharashtra.gov.in>, Chandrakant Bansode <chandrakant.bansode@mailmmrda.maharashtra.gov.in>, Mugdha Kulkarni <mugdha.kulkarni@mailmmrda.maharashtra.gov.in>

Dear Sir,

This is to inform that Hon'ble Metropolitan Commissioner, MMRDA directed to extend the Metro line-5 i.e.Thane-Bhiwandi-Kalyan Metro corridor up to Taloja (Navi Mumbai Area) and to take up the Detailed Project Report through DMRC. The Scope/TORs of the consultancy Services will be same as agreed upon for the previous DPRs. The approximate length of the corridor is 25 km.

In this context, you are requested to submit your financial offer for the Kalyan-Taloja DPR study.

Regards,

K. Vijaya Lakshmi
Chief, Transport & Communications Division
Mumbai Metropolitan Region Development Authority,
Bandra-Kurla Complex, Bandra (East)
Mumbai-400 051, India
Email Id: chieftc@mailmmrda.maharashtra.gov.in
Telephone No: 022-2659 7512

R G Sharma <rgs0511@gmail.com> Thu, Mar 2, 2017 at 11:36 AM
To: K Vijayalakshmi <chieftc@mailmmrda.maharashtra.gov.in>, Manoj Dandare <manoj.dandare@mailmmrda.maharashtra.gov.in>, Chandrakant Bansode <chandrakant.bansode@mailmmrda.maharashtra.gov.in>, Mugdha Kulkarni <mugdha.kulkarni@mailmmrda.maharashtra.gov.in>
Cc: som sharma <sdscvo1984@yahoo.com>, ajaykr_gupta111@yahoo.com

Thanks for offer for preparation of DPR for extension Metro line-5 i.e Thane-Bhiwandi-Kalyan Metro corridor up to Taloja (Navi Mumbai Area). In this regard it may please be clarified that traffic projections will be provided by the **MMRDA** as these were provided in case of earlier DPRs.

--
regards

R G Sharma
+919717497431

Chandrakant Bansode <chandrakant.bansode@mailmmrda.maharashtra.gov.in> Thu, Mar 2, 2017 at 6:05 PM
To: R G Sharma <rgs0511@gmail.com>
Cc: K Vijayalakshmi <chieftc@mailmmrda.maharashtra.gov.in>, Manoj Dandare <manoj.dandare@mailmmrda.maharashtra.gov.in>, Mugdha Kulkarni <mugdha.kulkarni@mailmmrda.maharashtra.gov.in>

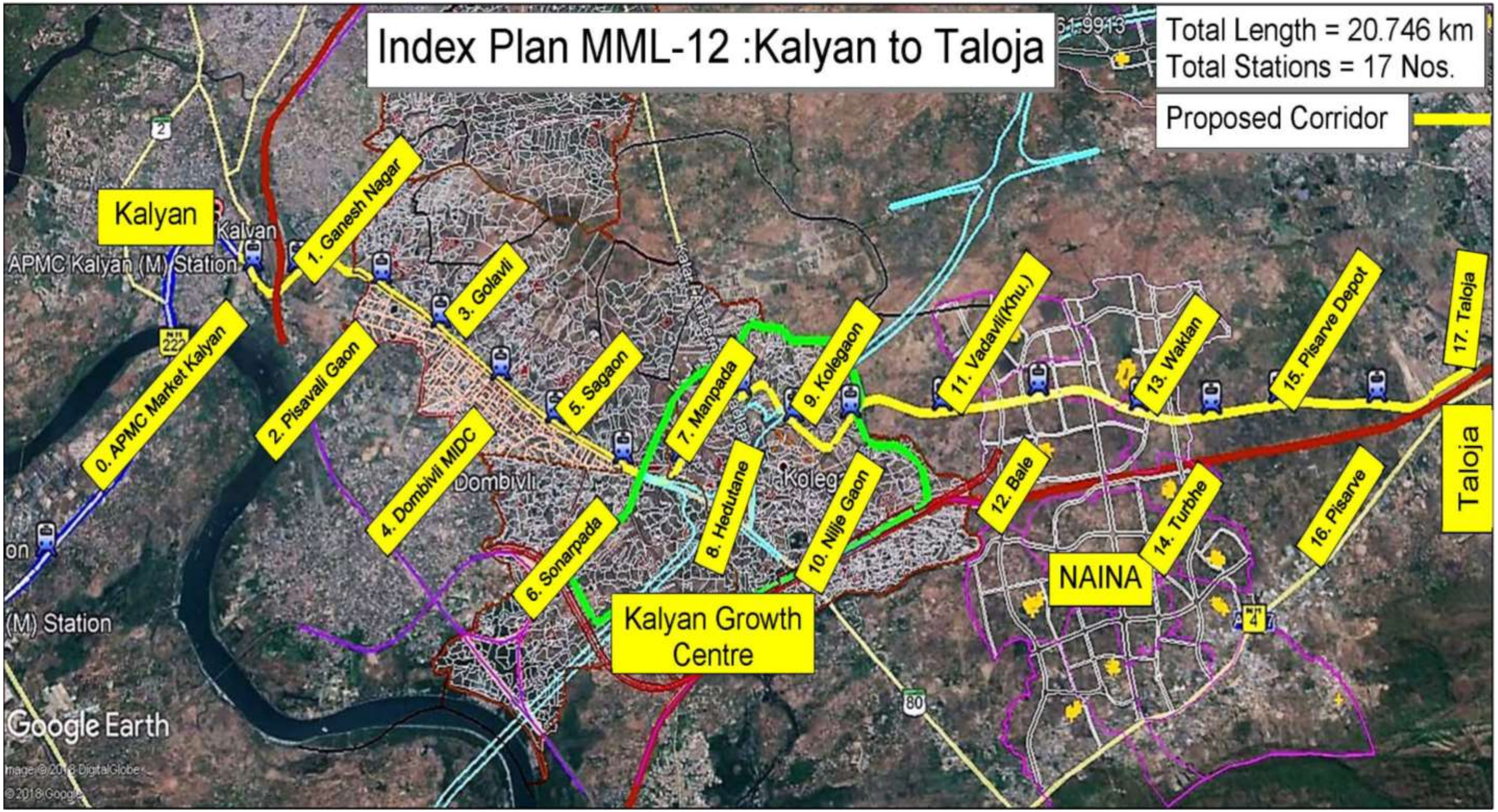
Dear Sir,

It is to inform you that Traffic projections for Taloja-Kalyan Metro corridor will be provided by the MMRDA. In this context, you are requested to submit your financial offer for the Kalyan-Taloja DPR study.

With Regards
(Chandrakant E. Bansode)
Transportation Planner,
T & C Division
MMRDA, Mumbai
Phone No 022-[illegible]

Figure - 1.3

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


Index Plan MML-12 :Kalyan to Taloja
Total Length = 20.746 km
Total Stations = 17 Nos.
Proposed Corridor
Kalyan
APMC Kalyan (M) Station
0. APMC Market Kalyan
1. Ganesh Nagar
2. Pisavali Gaon
3. Golavli
4. Dombivli MIDC
5. Sagaon
6. Sonarpada
7. Manpada
8. Hedutane
9. Kolegaon
10. Nilje Gaon
11. Vadavli(Khu.)
12. Bale
13. Waklan
14. Turbhe
15. Pisarve Depot
16. Pisarve
17. Taloja
Taloja
Dombivli
Kalyan Growth Centre
NAINA
Google Earth

CHAPTER - 2

TRAFFIC DEMAND FORECAST

2.1 PLANNING PARAMETERS

Planning parameters i.e. population and employment distribution across the MMR for the horizon year transport network assessment analysis are the prime inputs for travel demand assessment (purpose wise and mode wise). Post completion of CTS for MMR study (2005-08), MMRDA, CIDCO and other stakeholders have carried out number of project preparatory works towards implementation of regional transport infrastructure in MMR (Technical Assistance study, MTHL, Virar-Alibaug Multi-Modal Corridor) initiated by MMRDA, Regional and Local Transport Connectivity Study initiated by CIDCO, DPR studies initiated by MMRDA and CIDCO, etc.). During these studies, cluster wise planning parameters have been modified with time (called as Modified P3E3 scenario) and the details are presented in Table 2.1.

It is pertinent to mention here that, realization of envisaged growth (population and employment) and implementation of planned traffic & transportation infrastructure is not happened or taken more time than anticipated. Considering these aspects, it would be prudent to consider appropriate planning parameters for assessment of passenger loadings and ridership assessment for metro corridors, especially for metro corridors planned in greenfield areas. In this context, MMRDA reassessed the cluster wise population and employment for the horizon year with the following assumptions and the details are presented in Table 2.1.

2.2 ASSUMPTIONS AND CONSIDERATIONS:

1) Average Growth Rate of planning parameters as per past trend from 2011 Census and RP was considered as the CTS forecasted trend may not be achievable in green field of Kalyan-Taloja Corridor;
2) Work Force participation ratio as per CTS was 0.45, with which the revised employment for 2031 is 13.19 million by 2031;
3) Growth in Greater Mumbai is kept similar to that forecasted in CTS, as it seems to be achievable considering the ongoing metro and suburban rail improvements;
4) As per CTS annual population growth for Navi Mumbai was 4% till 2031 (CAGR), which is reconsidered as about 1.2% (CAGR) based on past trend; and
5) As per CTS annual growth for Kalyan-Dombivali was 7.1% till 2031 (CAGR), which is reconsidered as about 1.92% (CAGR) based on past trend.

Accordingly, the growth rate was revised for other clusters and incorporated into model to reassess the ridership and passenger loadings for ML-12.

Table 2.1: Planning Parameters considered for Reassessment of Ridership of ML-12 (in millions)

Cluster	2011 Census*	Modified P3 for 2031 (CTS)	Trend Based P3 for 2031	Modified E3 for 2031 (CTS)	Trend Based E3 for 2031
Island City	3.15	4.08	4.08	2.8	2.4
Western Suburbs	5.60	7.14	7.14	3.1	2.7
Eastern Suburbs	3.73	4.76	4.76	1.4	1.2
Total MCGM	12.48	15.99	15.98	7.4	6.3
Thane	1.92	2.84	2.06	1.3	1.1
Navi Mumbai/CIDCO	1.92	4.26	2.44	1.7	1.5
Mira Bhayander	0.81	1.36	1.01	1.5	1.3
Kalyan Dombivali	2.38	4.73	3.48	0.9	0.8
Bhiwandi	0.80	1.31	1.10	0.2	0.1
Vasai-Virar	1.22	2.2	2.27	1.3	1.1
Pen-SEZ	0.16	0.76	0.39	0.5	0.5
Rural Alibagh-Karjat-Khopoli	0.52	0.56	0.58	0.5	0.4
Total (MMR)	22.21	34.01	29.32	15.30	13.19

2.3 MODEL DEVELOPMENT

It is pertinent to mention here that; four stage travel demand modelling approach had been adopted in the CTS for MMR study carried out during 2005-08. Travel demand models were calibrated and further validated using the secondary and primary database collected as part of the study. The travel demand model and process adopted is described below:

Four stage travel demand modelling approach has been adopted in the study. Six purposes (Home Based Work Office, Home Based Work Industry, Home Based Work Others, Home Based Education, Home Based Others and Non-Home Based) and seven modes (Sub-urban train, metro, bus, auto, taxi, car and two-wheeler) have been considered to appreciate travel patterns and to undertake travel demand analysis. EMME (Equilibre Multimodal, Multimodal Equilibrium) software has been used for travel demand modelling and network analysis.

Major inputs to the model include:

a) Baseline Database (from Primary and secondary data sources);
b) Traffic Analysis Zoning (TAZ) System;
c) Base Year and Horizon year proposed transport network;
d) Initial assessment of internal travel demand and validation of travel demand matrices.
e) Planning parameters for each TAZ;
f) Calibration and validation of travel demand models
g) EMME software suit for further application.

The following logic was followed in defining primary or access mode for the mode choice:

TableError! No text of specified style in document. **2.2 - Primary and Access Mode**

Primary mode	In combination with Access modes
Rail	NMT (Walk and/or Cycle)
Rail	IPT
Rail	Bus
Rail	IPT + Bus
Rail	Private vehicle (as driver)
Rail	Private vehicle (as passenger) – drop off
Bus	NMT (Walk)
Bus	IPT
Bus	Private vehicle (as passenger) – drop off
Car 'All the Way'	--
Two Wheeler "All the Way'	-
Walk ''All the Way'	-
IPT (Taxis, or Auto rickshaws) 'All the way'	-

Travel Demand Modelling: EMME gives the overall network equilibrium assignment and the presentation of comprehensive results (most in a graphical and interactive way). This output can be used in traffic simulation models for the establishment of signal setting and evaluation of network performance. Applications of outputs include performance estimates of Bus lanes and truck traffic, location analysis of existing and future public transport and roadway facilities, and computation of least-cost paths according to any desired cost function. The following procedure was adopted or fur stage transport modelling:

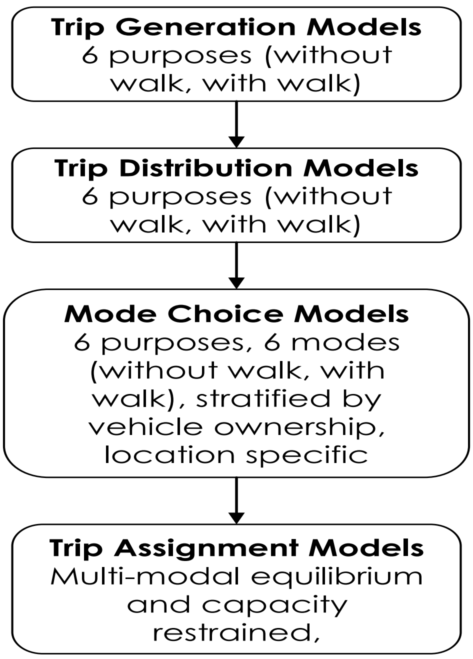


Figure 2.1 - Four Stage Travel Demand Modelling Process

2.3.1 Public Transport Assignment

For this aspect of the model, a detailed public transport network and its parameters has been considered. This is to ensure that the different existing and future public transport choices and costs of these choices are properly reflected in the modeling process.

The public transport network is defined as a set of individual routes each having their own service level characteristics –travel time, comfort, headway and fares.

Base Year public transportation network has been considered as:

a) Rail (utilizing data from MRVC, Western Railways and Central Railways);
b) Bus (BEST, TMT, KDMT, NMMT, MBMT and MSRTC); and

Their correct representation through a set of nodes and links as input to model is essential for reliable estimation of flows. Keeping its importance in view these networks have been thoroughly checked, to ensure that they satisfactorily represent the networks in place at the time of data collection and also the travel behaviour of their users. Transit (rail) network is identified based on primary and secondary surveys for the study purpose. The surveyed network is referred in terms of links. These links are constituted by a pair of nodes. In case of rail network, station becomes the node. The segment between two stations constitutes a link. The parameters of transit station are assigned to each station as a station attribute.

Road Network Assumptions

Base Year road transportation network has been considered separately:

Road (MMRDA, MCGM, MSRDC, Municipalities, Traffic Police and our own road inventory surveys).A network length of around 2,300 km is identified for the study for the base year 2006 and further proposed road network for different Horizon Years (2021&2031).

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

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

Public Transport Network Assumptions

Out of the total envisaged mass transit network in MMR, the assumed operational network in the transport model is set out in **Table 2.3**.

Table 2.3 - Metro Network Assumed

Line No.	Corridor Name	Length (km)
1.	Versova-Andheri-Ghatkopar	11.4
2A.	Dahisar-D.N.Nagar	18.6
2B.	D.N.Nagar-Mandale	23.6
3.	Colaba-SEEPZ	33.5
4.	Wadala-Kasarvadavli	32.3
4A.	Kasarvadavli-Gaimukh	2.7
4B.	Gaimukh-Shivaji Chowk	11.2
5.	Thane-Bhiwandi-Kalyan	23.5
6.	Swami Samarth Nagar-Vikhroli	14.5
7.	Dahisar(East)-Andheri(East)	16.5
8.	Airport Connectivity (CSIA-NMIA)	35.0
9.	Dahisar-Mira Bhayandar & Andheri-CSIA (Ext. Of line 7)	13.5
10.	Wadala-Vidhan Bhavan/CSTM (Ext. Of line 4)	14.0
12	Kalyan-Dombivli-Taloja (Ext. Of line 5)	25.0
13	Ghodbunder Road – Virar	24.00
	Total length	299.3

2.4 RIDERSHIP ON PROPOSED METRO CORRIDOR

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

- P3E3 land use scenario is considered. This scenario allocates growth to proposed growth centre's in Kalyan and Taloja and also Navi Mumbai International Airport.
- Future road and rail/ metro network as detailed in the previous section.
- This Corridor will actuate the development based on TOD concept in the vicinity area and will encourage people to move out from crowded parts of the city. Purpose of this corridor is to decongest the city and ignite the development activities in new undeveloped area. The upcoming projects along the corridor are as under.
- Interchanges with other mass transit corridors have been considered;
  - ML-5 (Thane-Bhiwandi-Kalyan)
  - Belapur-Taloja Metro Corridor (by CIDCO)
  - Suburban Corridors (Vasai-Dombivali & Diva-Panvel)
- Metro Fare is considered as 1.5 times the ordinary bus fare.
- Speed of the metro is taken as 35 kmph.
- Peak Hour Frequency of metro service is considered as 3.5 minutes for 2031.

The daily ridership, peak hour station loads and peak hour section loads for the proposed Metro Corridor are given in Table 2.4, 2.7 and 2.10 for horizon year 2021, 2031 and 2041 respectively.

The stations with no boarding and alighting are to be proposed as technical hault / future station requirement for the corridor.

Table 2.4 - Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2021

Boarding	Alighting	Volume (Kalyan-Taloja)	Stations	Volume (Taloja-Kalyan)	Boarding	Alighting
2986	0	2986	APMC Market Kalyan	0	0	895
975	131	3829	Ganesh Nagar	895	199	670
544	431	3942	Pisavali Gaon	1366	127	464
309	113	4138	Golavli	1703	19	267
42	46	4134	Dombivli MIDC	1951	139	11
494	386	4242	Sagaon	1822	422	154
127	139	4230	Sonarpada	1554	139	27
2226	979	5477	Manpada	1442	324	109
0	26	5451	Hedutane	1226	0	7
438	128	5761	Kolegaon	1234	163	72
35	330	5466	Nilje Gaon	1143	121	23
0	25	5441	Vadavli (Khu.)	1045	0	0
33	0	5474	Bale	1045	33	0
0	0	5474	Waklan	1012	0	0
0	132	5342	Turbhe	1012	0	61
0	0	5342	Pisarve Depot	1073	0	0
52	2847	2548	Pisarve	1073	496	39
0	2548	0	Taloja	616	616	0
8260	8260	**5761**	**PHPDT**	1951	2797	2798
			Daily Ridership	**110579**		

Table 2.5 - Trip Length Distribution for ML-12 (Kalyan-Taloja) for 2021

Dist.	% trips	No. of trips
<=2	8.16	905
<=4	8.22	912
<=6	11.19	1242
<=9	13.25	1470
>9	59.18	6566
	100	11094

Average Trip Length for 2021 = 11.06 km

Table 2.6 - Peak Hour Boarding/Alighting Matrix for ML-12 (Kalyan-Taloja) for 2021

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
APMC Market Kalyan	0	132	212	48	34	206	46	490	0	31	72	18	0	0	27	0	1116	563
Ganesh Nagar	199	0	220	33	12	124	28	262	0	21	17	8	0	0	13	0	112	128
Pisavali Gaon	5	122	0	33	0	32	39	71	0	26	21	0	0	0	22	0	139	163
Golavli	1	17	0	0	0	25	21	40	0	20	14	0	0	0	17	0	73	99
Dombivli MIDC	30	64	22	23	0	0	0	0	0	0	2	0	0	0	0	0	19	21
Sagaon	106	136	81	101	0	0	6	92	22	24	24	0	0	0	22	0	147	159
Sonarpada	33	46	23	35	0	4	0	28	0	6	8	0	0	0	1	0	39	46
Manpada	95	121	23	36	0	45	6	0	4	0	142	0	0	0	7	0	1024	1056
Hedutane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kolegaon	29	53	18	26	0	31	7	0	0	0	30	0	0	0	24	0	162	224
Nilje Gaon	24	10	40	5	1	8	2	24	1	6	0	0	0	0	0	0	12	23
Vadavli (Khu.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bale	5	9	3	4	0	5	1	3	0	3	0	0	0	0	0	0	12	21
Waklan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbhe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisarve Depot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisarve	98	39	209	17	3	24	5	42	5	22	10	0	0	0	24	0	0	52
Taloja	273	55	48	21	6	37	6	41	1	41	14	0	0	0	37	0	39	0

Table 2.7(a) - Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2031

Boarding	Alighting	Volume (Kalyan-Taloja)	Stations	Volume (Taloja-Kalyan)	Boarding	Alighting
7188	0	7188	APMC Market Kalyan	0	0	1291
1133	97	8224	Ganesh Nagar	1291	91	282
196	123	8296	Pisavali Gaon	1482	0	155
292	0	8588	Golavli	1637	4	15
175	252	8511	Dombivli MIDC	1648	0	125
840	194	9156	Sagaon	1774	411	127
156	161	9151	Sonarpada	1489	173	38
466	618	8999	Manpada	1354	170	425
0	367	8632	Hedutane	1608	202	52
716	220	9128	Kolegaon	1458	296	110
141	1254	8015	Nilje Gaon	1271	136	195
0	3885	4130	Vadavli (Khu.)	1330	0	0
2635	0	6765	Bale	1330	0	0
0	0	6765	Waklan	1330	53	0
152	14	6904	Turbhe	1278	53	1725
0	0	6904	Pisarve Depot	2949	0	380
69	1203	5769	Pisarve	3329	231	165
0	5769	0	Taloja	3263	3263	0
14158	14158	**9156**	**PHPDT**	3329	5084	5084
			Daily Ridership	**192420**		

Table 2.7(b) - Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2031
with 40 Ha Land Development for ML-12 (at Vadavli (Khu.), Bale & Pisarve Depot Stations)

Boarding	Alighting	Volume (Kalyan- Taloja)	Stations	Volume (Taloja- Kalyan)	Boarding	Alighting
9357	0	9357	APMC Market Kalyan	0	0	1901
1111	52	10416	Ganesh Nagar	1901	23	277
249	44	10622	Pisavali Gaon	2155	0	175
309	0	10931	Golavli	2330	3	49
604	228	11308	Dombivli MIDC	2376	0	340
872	162	12019	Sagaon	2717	348	162
220	103	12136	Sonarpada	2531	184	67
220	537	11819	Manpada	2415	164	113
494	286	12027	Hedutane	2364	30	392
593	212	12407	Kolegaon	2726	314	84
0	1169	11238	Nilje Gaon	2496	126	0
275	5800	5713	Vadavli (Khu.)	2370	264	1509
1762	573	7694	Bale	3614	305	236
1174	382	7694	Waklan	3499	254	157
78	23	7749	Turbhe	3448	16	1335
1353	1980	7122	Pisarve Depot	4768	1390	291
286	1044	6365	Pisarve	3669	473	184
0	6365	0	Taloja	3381	3381	0
18957	18960	**12407**	**PHPDT**	4768	7275	7272
			Daily Ridership	**262320**		

Table 2.8 - Trip Length Distribution for ML-12 (Kalyan-Taloja) for 2031

Dist.	% trips	No. of trips
<=2	4.12	793
<=4	14.86	2860
<=6	8.91	1714
<=9	20.96	4033
>9	51.15	9841
	100	19241

Average Trip Length for 2031 = 10.34 km

Table 2.9 - Peak Hour Boarding/Alighting Matrix for ML-12 (Kalyan-Taloja) for 2031

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
APMC Market Kalyan	0	97	115	0	122	158	119	441	160	146	827	2968	0	0	0	0	490	1545
Ganesh Nagar	91	0	9	0	122	24	22	56	53	32	68	186	0	0	0	0	46	514
Pisavali Gaon	0	0	0	0	4	0	1	22	2	0	14	67	0	0	0	0	10	76
Golavli	2	0	2	0	5	11	5	12	13	9	25	65	0	0	0	0	15	131
Dombivli MIDC	0	0	0	0	0	0	0	0	0	0	65	96	0	0	0	0	0	14
Sagaon	323	77	8	3	0	0	13	68	77	27	74	179	0	0	0	0	25	377
Sonarpada	98	46	10	0	14	5	0	20	16	4	20	59	0	0	0	0	6	32
Manpada	121	11	11	4	6	14	2	0	46	2	81	74	0	0	8	0	10	246
Hedutane	0	0	0	0	0	9	22	170	0	0	0	0	0	0	0	0	0	0
Kolegaon	160	44	41	0	17	24	5	5	0	0	80	192	0	0	0	0	49	395
Nilje Gaon	52	6	5	2	19	6	3	30	6	7	0	0	0	0	6	0	19	116
Vadavli (Khu.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	510	2124
Waklan	35	4	4	0	1	3	1	2	0	4	0	0	0	0	0	0	0	0
Turbhe	28	4	3	1	3	2	0	4	2	3	4	0	0	0	0	0	22	130
Pisarve Depot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisarve	105	10	11	0	3	4	1	7	0	13	5	0	0	0	60	12	0	69
Taloja	275	80	59	6	62	59	4	207	44	83	186	0	0	0	1665	368	165	0

Based on the above estimate from CTS travel demand models, the ridership for the horizon years 2041 are assessed (considering growth rates worked out population forecasted in Draft RP and CTS for MMR updation study) and details are presented in the table 2. Based on the section wise passenger loadings and daily ridership, the following inferences are made:

a) PHPD assessed for Kalyan -Taloja metro corridor for the horizon year 2031 is about 9,200 which is less than 10,000 PHPD i.e. threshold value considered for metro corridor.

b) PHPD assessed for the horizon year 2041 is 10,300 which is more than 10,000 PHPD.

Table 2.10 (a) - Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2041

Boarding	Alighting	Volume (Kalyan-Taloja)	Stations	Volume (Taloja- Kalyan)	Boarding	Alighting
8067	0	8067	APMC Market Kalyan	0	0	1449
1271	109	9229	Ganesh Nagar	1449	102	317
220	138	9310	Pisavali Gaon	1663	0	174
328	0	9638	Golavli	1837	5	17
196	283	9551	Dombivli MIDC	1850	0	141
942	218	10275	Sagaon	1990	461	142
175	180	10269	Sonarpada	1671	195	43
523	693	10099	Manpada	1519	191	477
0	412	9687	Hedutane	1805	227	58
804	247	10244	Kolegaon	1636	332	123
158	1407	8995	Nilje Gaon	1427	152	218
0	4360	4635	Vadavli (Khu.)	1493	0	0
2957	0	7592	Bale	1493	0	0
0	0	7592	Waklan	1493	59	0
171	15	7748	Turbhe	1434	60	1936
0	0	7748	Pisarve Depot	3310	0	427
77	1350	6475	Pisarve	3737	259	185
0	6475	0	Taloja	3662	3662	0
15888	15888	**10275**	**PHPDT**	3737	5705	5705
			Daily Ridership	**216930**		

Table 2.10(b) - Peak Hour Ridership for ML-12 (Kalyan-Taloja) for 2041

with 40 Ha Land Development for ML-12(at Vadavli (Khu.), Bale & Pisarve Depot Stations)

Boarding	Alighting	Volume (Kalyan- Taloja)	Stations	Volume (Taloja-Kalyan)	Boarding	Alighting
10501	0	10501	APMC Market Kalyan	0	0	2134
1247	58	11690	Ganesh Nagar	2134	26	311
280	49	11921	Pisavali Gaon	2419	0	196
347	0	12267	Golavli	2615	4	55
678	255	12690	Dombivli MIDC	2666	0	382
979	181	13488	Sagaon	3049	390	182
247	115	13619	Sonarpada	2841	206	75
247	603	13264	Manpada	2710	184	126
554	321	13497	Hedutane	2652	33	440
665	238	13924	Kolegaon	3059	352	95
0	1312	12612	Nilje Gaon	2801	142	0
309	6509	6412	Vadavli (Khu.)	2660	297	1693
1977	643	8635	Bale	4056	342	265
1318	429	8635	Waklan	3927	285	176
88	26	8696	Turbhe	3869	18	1498
1519	2222	7993	Pisarve Depot	5350	1560	327
321	1171	7143	Pisarve	4118	530	207
0	7143	0	Taloja	3794	3794	0
21277	21275	**13924**	**PHPDT**	5350	8163	8162
			Daily Ridership	**294400**		

CHAPTER – 3

SYSTEM DESIGN

3.0 INTRODUCTION

Mumbai Metro Line-12 from Kalyan to Taloja is an extension of Mumbai Metro Line-5. Length of this section is 20.756 km which is entirely elevated. Total Seventeen elevated stations have been proposed on this section. Depot for this section is proposed near Pisarve Depot Station.

3.1 PERMANENT WAY

3.1.1 Choice of Gauge

The issue of Broad Gauge vs. Standard Gauge for Metro in India has been debated widely and the decision has been in favor of Standard Gauge. Even Delhi Metro which started with Broad Gauge has switched over to Standard Gauge. It is advantageous for many reasons as indicated below:

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

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

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

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

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

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

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

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

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

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

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

3.1.2 Track Structure

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

General

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

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

Rail Section

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg/m) rail section. Since main lines will have sharp curves and steep gradients, the grade of rail on main lines should be 1080 Head Hardened as per IRS-T- 12-2009. 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 Main Lines

On the viaducts, it is proposed to adopt plinth type ballastless track structure with RCC derailment guards integrated with the plinths (shown in Fig.**3.1**). It is proposed to adopt suitable Fastenings System with a base-plate to base-plate spacing of ~65cm, on viaducts complying of performance criteria laid down by Railway Board vide letter Circular No. 2009/Proj/InAs/9/2, dated 02.05.2010.

In the underground section similar track structure with base plate spacing ~70cm is proposed on slab after first stage concrete.

Ballastless Track in Depot

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

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

Turnouts

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

i) On main lines, 1 in 9 type turnout with a lead radius of 300 meter and permissible speed on divergent track as 40 km/h (shown in **Fig. 3.2**).

ii) On Depot lines, 1 in 7 type turnout with a lead radius of 190 meter and permissible speed on divergent track as 25 km/h (shown in **Fig. 3.3**).

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

- The proposed specifications for turnouts are given below: -

i) The turnouts should have fan-shaped layout throughout the turnout so as to have same sleepers/base-plates and slide chairs for both LH and RH turnouts.
ii) The switches and crossings should be interchangeable between ballasted and ballastless turnouts (if required).

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

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

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

Buffer Stops

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

3.1.3 Rail Structure Interaction

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

Welding

Flash Butt Welding Technique is to be used for welding of rails. Alumino-Thermic Welding is to be done only for those joints which cannot be welded by Flash Butt Welding Technique, such as joints at de-stressing 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.

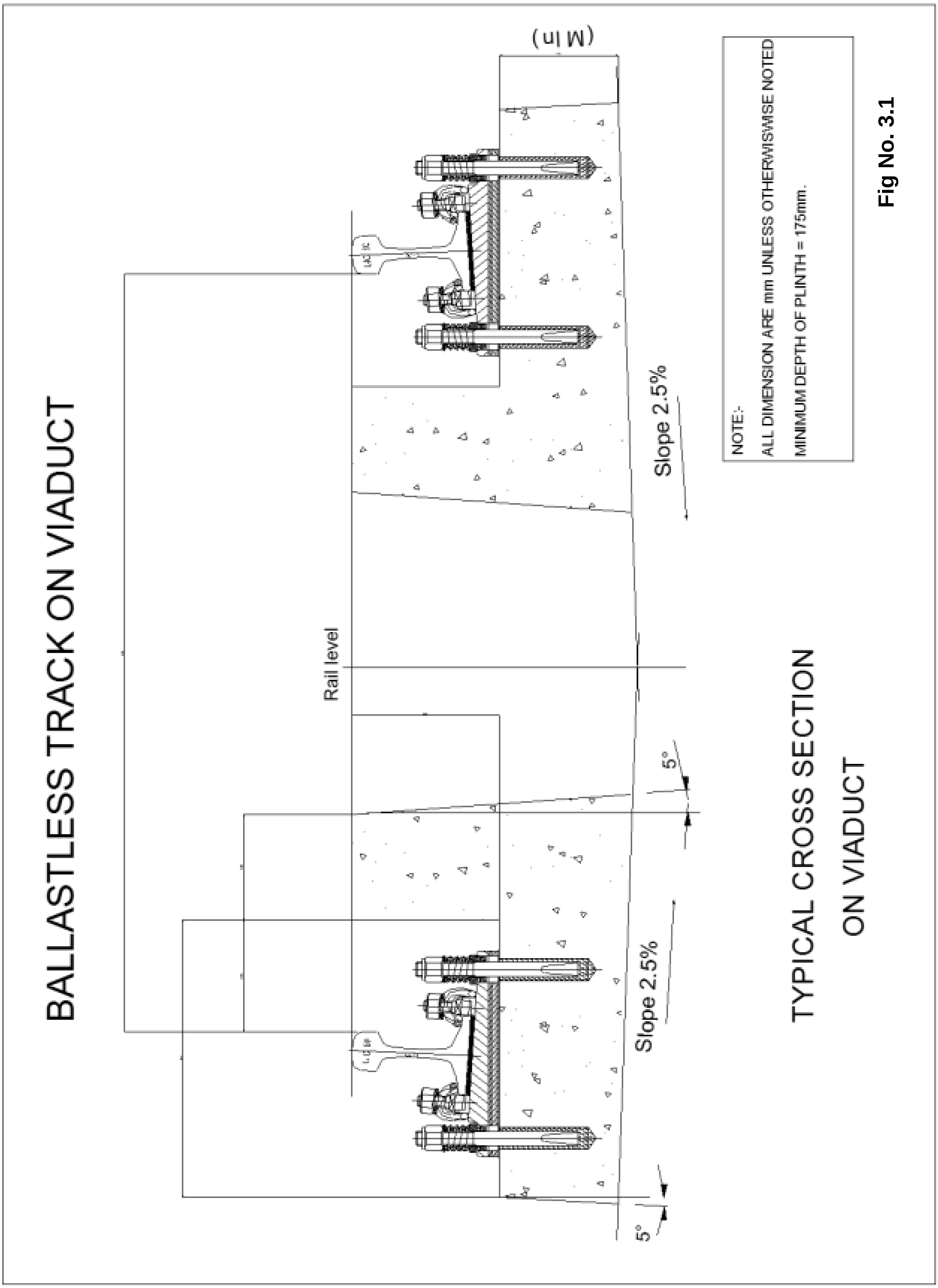
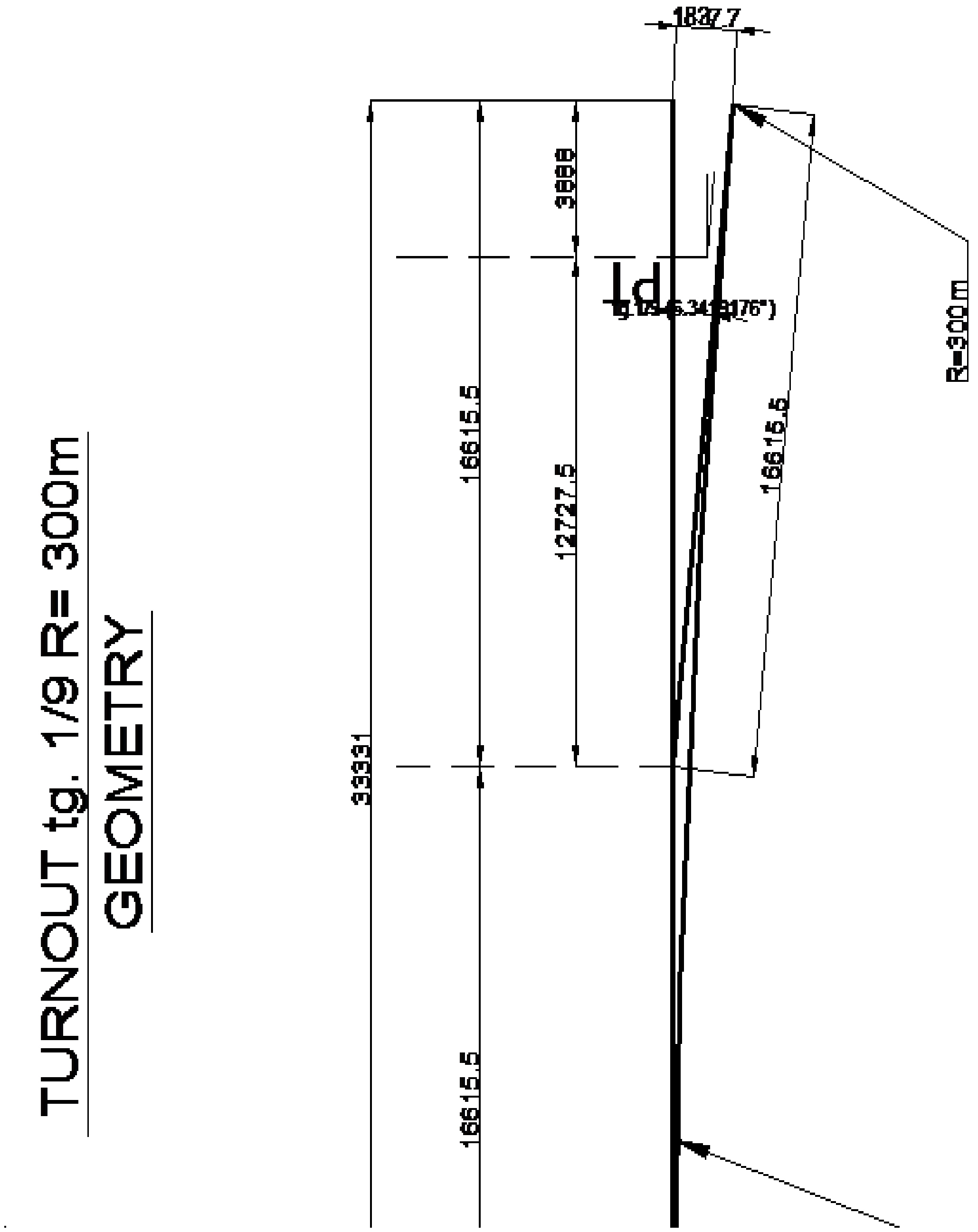

BALLASTLESS TRACK ON VIADUCT
(M In)
Rail level
Slope 2.5%
Slope 2.5%
5°
5°
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWSE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.
TYPICAL CROSS SECTION
ON VIADUCT

Fig No. 3.1

Fig No. 3.2


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

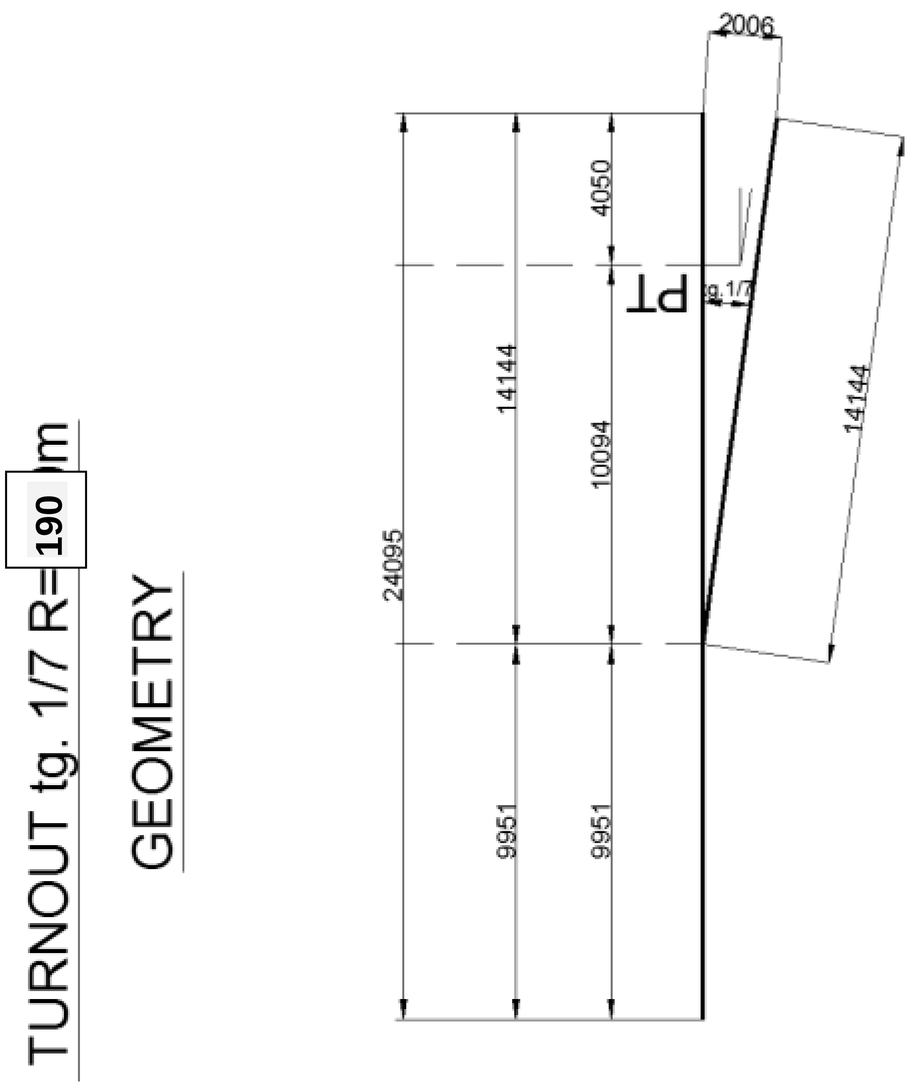

TURNOUT tg. 1/7 R=190m
GEOMETRY
2006
4050
14144
10094
24095
9951
9951
14144
PT
tg.1/7

Fig No. 3.3

DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500

AXLE SCHEME

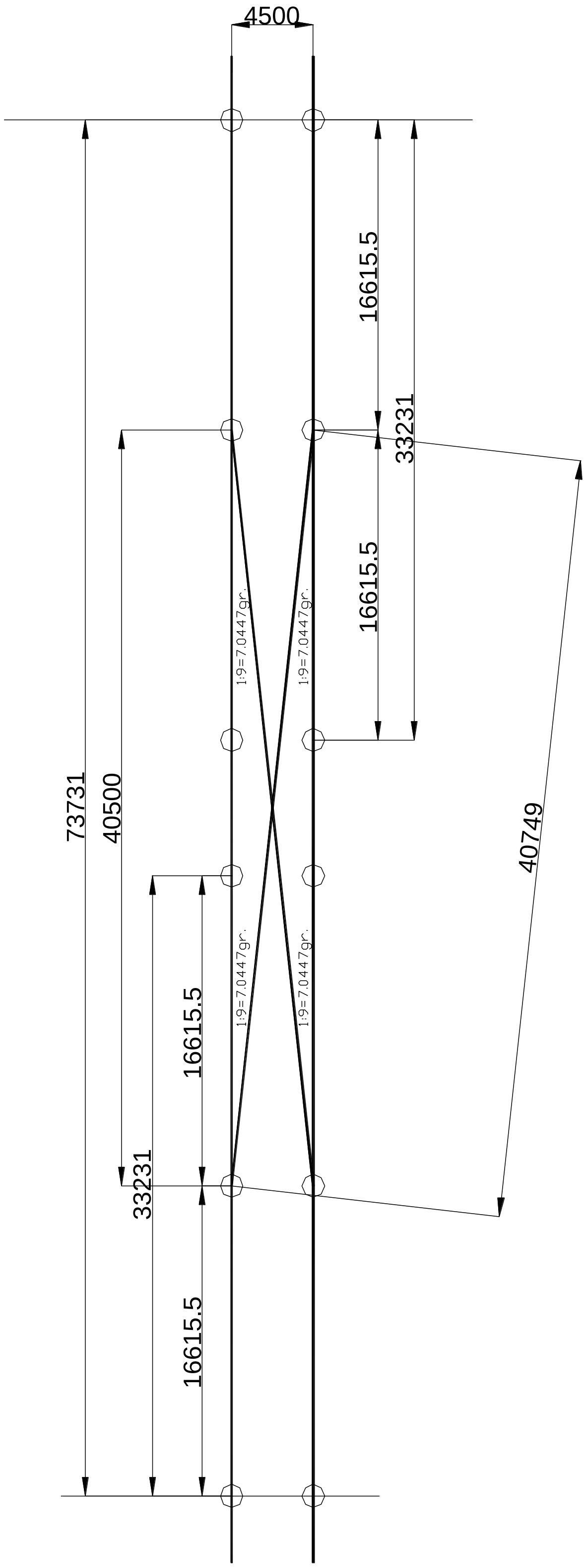


Fig No. 3.4

3.2 TRACTION SYSTEM

3.2.1 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:-

3.2.2 Merits and Demerits of various traction systems

a) 25 kV AC with OCS (Flexible/rigid):- Merits

- **Reduced cost** – Unlike dc traction this system, does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in cost. Cost of 25 kV AC traction systems is about 15% less as compared to 750V DC 3rd rail traction system for the estimated level of traffic.
- **Energy regeneration & line losses-** Energy regeneration is more than 30% in 25 kV AC traction system as compared to 18% in 750V DC 3rd rail traction system. In 25 kV AC traction system line losses are 12% less as compared to 750V DC 3rd rail traction system.
- **Cost of rolling stock-** The cost of rolling stock & maintenance cost of traction system are comparable.
- **Capacity** – In future, the system can cater to traffic needs even in excess of 75000 PHPDT, which, however, is restricted on account of other constraints.
- **Easy of capacity enhancement** – Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation.
- **Higher efficiency of operation** – The efficiency of regeneration is substantially more than DC systems and line losses are very less of the order of 5%. 100% recovery of regenerated energy is possible in the case of 25 kV AC traction compared to a figure of 75% in the case of 1500 V DC systems and 60% in the case of 750 V DC systems.
- **Less Fire hazards**-AC system poses lesser fire hazards as current levels are much lower than DC system.
- **Stray current** - There are no problem of stray currents and hence nearby metallic structures are not affected by corrosion. However, there are problems of EMC / EMI which can be controlled by using return conductor & screened cables in signaling applications & fiber optic cable in telecommunication system without using booster transformer as per recent developments. This also helps in avoiding use of booster transformer which causes 2%-line loss and excessive voltage drops besides involving maintenance & reliability issues.

- Traction equipments in 25 kV AC system are standardized & mostly indigenously available. In DC traction system it is mostly imported.
- Though in underground section higher side tunnel diameter is required.

b) 750-850 V DC third rail traction system:-Demerits

- **High operating currents and High voltage drops necessitating reduction in spacing of sub-station-** This leads to larger voltage drops along the Third Rail distribution system, which necessitates closer spacing of sub- stations at an interval of almost every 2 Km, leading to higher costs of construction.
- **Low levels of regeneration-** The regeneration is 18%, because 60% of re-generated energy in a 750 V dc system is possible to be retrieved.
- **Safety hazards with use of high voltage at ground level-** Due to existence of the “live” third rail at ground level, this system can be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.
- **Line losses-** Line losses are more due to higher current. Transmission line losses on 750 V DC traction system are around 21% as against 5% of 25 kV AC traction system.
- **Phenomenon of stray current-** In a third rail system, where the running rails are used as a return path, a part of the return current leaks into track structure. This current is called stray current. It is necessary to manage the stray current to ensure minimal corrosion effect and consequent damages to metallic components in the track structure as well as metallic reinforcement and metal pipes of building of metro and public areas adjacent to the Metro alignment.
- **Higher Consumption of Specific Energy:** As per MOUD guideline specific energy consumption in 750 V dc system is 60 kWh/GTKM and in 25 KV ac system is 50 kWh/GTKM. The specific energy consumption in 750 V dc system is higher as compared to 25 kV ac system. Hence operating cost will increase in 750 V dc system.

c) 1500 V dc system with Overhead Catenary System:-Demerits

- Higher maintenance requirement and costs as compared to 750V DC third rail system.
- Theoretical traffic capacity with 1500 V traction system is less as compared to 25 kV AC system.
- Line losses are more due to higher current as compared to 25 kV AC. It may be in the range of 10 to 12% as against 5% of 25 kV AC system.

d) 2x25 kV ac single phase Traction System

The following are the benefit of 2x25 kV ac traction system used for this corridor are:

- The electromagnetic interference in of 2x25 kV systems is very less and hence no BT/RC system is required which has its own maintenance and reliability issues. However, additional space for autotransformer shall be required.

- The line loss in of 2x25 kV system is almost half as compared to 25 kV conventional system.
- In the event of 2 x 25 kV traction systems being adopted no of neutral section shall reduce.
- Load balancing will be better on all the three phase using Scott connected transformer.
- Since the OHE current is much lower in the of 2x25 kV systems; hence the OHE voltage profile will be better than conventional system. In fact the voltage drop at the terminal end for the similar load will be almost half in of 2x25 kV system.
- Harmonics: since the fault currents are much higher in of 2x25 kV & 220/132 kV side, there are less harmonics on the system. Fifth harmonics on the system are in the range of 1% of less as compared to around 3% or higher, in case of conventional system. Due to fewer harmonic, the reliability of the Traction installation equipment and of electric rolling stock in expected to be better.
- Substation spacing: The inter-spacing between sub-station is almost double in of 2x25 kV system as compared to conventional system. Therefore the number of substation almost reduces to half in the 2x25 kV AT system (with proper planning) as compared to the conventional system. This brings in substantial saving of costly space of around 2000 sq. m. in Mumbai metro area, besides saving due to use of lesser high voltage cable.
- 2x25 kV system is highly suitable for high dense load, as the voltage fed to the system at 25 kV as system due to better voltages and thus improved efficiency of the rolling stock.
- Arcing problems are encountered at BT overlap in 25 kV system and there have been melting cases of contact wire at the BT overlap location when bridging by stationary pantograph. No such problem will be encountered in 2x25 kV system.
- With the use of 2x25 kV system return conductor shall be replaced be feeder wire and the design shall be finalized accordingly.

In view of above techno-economic considerations, 25 kV AC traction system is suggested for this corridor.

3.3 SIGNALLING AND TRAIN CONTROL SYSTEM

3.3.1 Introduction

The Signalling and Train Control System shall provide the highest security level for means of an efficient Train Control, ensuring safety in train movements. It assists in optimization of rail infrastructure investment and running of efficient train services on the network.

This provides the main design features of the signaling and train control for the operation of Mumbai Metro Line 12 i.e. from Kalyan to Taloja section of Mumbai Metro taking into account the proven and advance system being used worldwide.

The Proposed Corridor of Mumbai Metro Line 12 i.e. from Kalyan to Taloja section is planned to be operated at maximum safe speed of 90 Km/hr. The trains are to be maintained headway at every about 100 seconds. However, the signaling System shall be designed at minimum for 90 second headway in one direction.

3.3.2 Signalling

The Signalling shall provide the highest security level to ensure that the operational activities are developed following strict safety requirements. At the same time, it shall meet the requirements for efficient train operations and high quality of service.

The proposed signalling system design for this metro line will cater the following:

- Continuous Automatic Train Control System (CATC)
- Automatic Train Protection (ATP) System
- Automatic Train Operation (ATO)System
- Unattended Train Operation (UTO) System
- Communication based Automatic Train Control (ATC) System
- On board Equipment
- Cab Signalling
- Interlocking device (Computer based Interlocking)
- Track side Radio equipment
- Track Vacancy Detection System
- Electric Point Machine
- Track side Signals
- Centralized Traffic Control System
- OCC & BCC equipments
- Fall-Back Block Working System
- Power Supply of signalling
- Cable for signalling
- Integrated Platform Gate (PG)
- Display of CCTV images from Train to OCC
- Onboard Radio Antennas, Large Video Screen, MMIs etc

3.3.3 Overview of Signalling System

It is expected to carry large number of passengers by maintaining shorter spacing between trains 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 people.

The requirements of the Mumbai Metro Line 12 Corridor planned to be achieved by adopting following basic principles of signaling System: -

- The Train Control and Monitoring shall be ensured from Centralized Traffic control System located at Operation Control Centre (OCC). OCC equipments shall be connected to station equipment room through optical fiber network.

- The CBTC (Communication based Train Control) based system shall be provided on main line & in depot (except workshop area) for train operation & primary mode of detection. Secondary detection shall be through Axle Counter.
- Computer Based Interlocking System shall be designed on failsafe philosophy. In case of failure of any equipment, the equipment shall fail on safe side or more restrictive state. In such case the Signalling System shall authorized movement of train in normal and degraded operations.
- Track side equipment shall be connected to Electronic Interlocking (to Station Equipment Room) by secure links to ensure safe movement of train.
- Provide high level of safety with trains running at shorter headways ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provide safety and enforce speed limit on the sections having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed 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 equipment by monitoring System status of trackside and train borne equipment and enabling preventive maintenance.
- Signalling & Train Control System on the line shall be designed to meet the required headway during peak hours.
- For monitoring inside train saloon, signaling system shall provide radio transmission media to transfer live streams to OCC controller on large video screen & MMI.
- Provision for installing integrated passenger gate at platform. The purpose of PG is to avoid any accident at platform, Integrated Passenger Gate acts as a barrier between the track and platform accessible to passengers. Signalling and Rolling Stock interfaces shall be provided for Passenger Gate System.

3.3.4 System Description And Specifications

The 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 UTO (Unattended Train Operation), ATO (Automatic Train Operation), ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

Wireless communication system shall be used for communication between the wayside and train borne CBTC system. Radio for CBTC shall work in License free ISM band.

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

3.3.5 Continuous Automatic Train Control

Continuous Automatic Train Control based on CBTC will consist of - UTO, ATO, ATP, and ATS sub-systems. The Train- borne Automatic Train Control System will consist of Unattended Train Operation (UTO), Automatic Train Operation (ATO) and Automatic Train Protection (ATP).

This vital system maintains the safety of the train operations on the principle of moving block including separation of trains enforcement of speed restrictions and safe operation through interlocking.

3.3.6 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. ATP mode shall be the normal mode of operation in event of failure of ATO-UTO Mode. In this mode, the train control and signaling system shall

- Provide Cab Signalling.
- Determine continuously and protect the train in excess of Maximum Safety speed (MSS) & Limit of Movement Authority (LOMA).
- 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.
- Enable opening of train doors as per stopping platform when train is docked.

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

3.3.7 Automatic Train Operation (ATO)

This system shall 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. ATO Mode shall be normal mode of operation in the event of failure of UTO Mode. In ATO mode the train control and signalling system shall carry out the following function:

- Accelerate and decelerate the train by applying traction power, coasting, and applying and removing brakes.
- Automatically control speed, acceleration, preventing unnecessary braking and stopping.
- Automatic operation of train between stations and stop the train at stations.
- Provide all indications necessary to operate the train.
- Determine continuously the Maximum Safe Speed (MSS) and Limit of Movement Authority (LOMA) with ATP function.
- Train doors open indication on the correct side when the train is docked if permitted by the ATP door release.
- Prevent the train from starting if train doors are not detected closed.

3.3.8 Unattended Train Operation (UTO)

In this mode, the train shall operate full driverless (without any crew member onboard), it shall operate under the supervision and control of ATP function. This shall be operated unmanned or with attendant under fully automated conform to Grade of Automation 3 (GOA3) / Grade of Automation 4 (GOA4) as defined in IEC 62290-12006.

The train shall be automatically driven by UTO sub-system under monitoring & full control of OCC operator. On receipt of OCC operator's start-up command, ATS shall send wake up command to onboard ATC. Initialisation of UTO operation after system start-up or recovery after a system failure shall be without any manual intervention in the train or OCC operator's command. However, OCC operator can be able to stop/hold any operation in the train in case of emergency, if required.

In this mode doors will be opened as well as closed automatically including Platform Screen Door. This mode shall be available everywhere on the line and the depot except for the workshop lines.

UTO mode shall be the normal mode of operation. Transit between UTO & ATO/ATP/RM/ROS modes must be possible continuously and anywhere on the running line and in the yards.

3.3.9 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 direct line 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:

- Train movement control (Automatic Route setting, train dispatch, inter station stop, platform/system hold & release dwell time, skip-stop, auto crew/RS management etc.).
- 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.
- Event & fault logging.
- System distinguishes between a train ready signal in ATP and a train ready signal in ATP / ATO mode.

3.3.10 Automatic Train Reversal / Turn Back (ATB)

To minimize the turn back time at terminal and intermediate station, Automatic Turn Back mode (Cycle mode/Sequence mode) is introduced to automatically operate more than one route one after the other in a sequential manner.

ATB function is a part of ATO/UTO mode function. At the terminal station or intermediate station, the train shall be operated automatically by the onboard ATC to the turn back track and back to the terminal station without driver.

3.3.11 Restricted Mode (RM)/ Run of Site Mode (ROS)

This mode shall be available only when On Board ATC in operation. If the On-Board ATC does not receive ATP information, train shall be manually driven by driver using ATP (CBTC on board) with constant speed supervision. If train speed is exceeded to 25 Km/h, On Board ATC shall apply the emergency break. The On Board ATC give cab signal as soon as the train get ATP information or train reach a track position where normal running can be resumed. RM mode shall be operated in depot.

3.3.12 Cut Off Mode

This mode shall used in case of On Board ATC failure. In this mode, the train speed is controlled entirely by the Train Operator in accordance with line side signals and verbal instruction from controller. The rolling stock provides equipment that limits speed less than 25 Kmph. If safety cut out switch is handled, On Board ATC power supply is shut down.

3.3.13 Computer Based Interlocking System (CBI)

The entire line including turn back track, transfer track, sidings will be equipped with CBI system for operation of points & 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 CBI system is used for controlling vehicle movements into or out of stations automatically from a workstation. Interlocking 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 based on 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 axle counters, relays, point operating machines, power supply etc.

3.3.14 Track Vacancy Detection

Primary mode of track vacancy detection system on main line shall be through Radio and secondary detection can be through Axle Counter.

The Axle counters have been used in vital train detection schemes on a large scale in Europe and outside of Europe. Also, an Axle counter is a cost-effective alternative to track circuits when applied correctly and are available from several manufacturers. In view of advantages of Axle counter, the track detection system by Axle Counter is recommended for secondary detection system.

Axle counter is used to detect the track occupancy and to count the number of axles by which train detection is discontinuously performed. It is not affected by weather conditions, and achieves reliable train detection. It interfaces with interlocking system in order to respond to functional errors on the basis of self-diagnosis as well as to transmit the information.

The axle counter consists of the following equipment: -

- ➢ Detection Point (or counting head)
- ➢ Evaluator

3.3.15 Wayside Signals

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

3.3.16 Cab Signalling

Cab signalling is a railway safety system that communicates track status information to the cab, crew compartment or driver's compartment of a train. The train driver can see the information continuously. The DMI (Driver Machine Interface Display) is the device that displays driving information in the driver cab. Information is transmitted by the wayside radio equipment to on board Radio equipment & vice versa. The data is computed by the on-board equipment and displayed on a screen on DMI for monitoring/controlling the running of train.

Vital information concerning the safe working of the train is displayed directly in the driving cab on the DMI. The DMI displays:

- ➢ Brake details: distance to first brake application.

- Speed information: current train speed, permitted speed, target speed on circular speed gauge with speed pointer preferably with disguise color.
- Auxiliary driving information: state of brakes (service brake, emergency brake), state of the connection between the on-board and the track side equipment.

The DMI is also the interface between the driver and the on-board equipment to get driver information, train characteristics or request for shunting operation.

3.3.17 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 type electrical point machine capable of operating with either 3 phase, 50 Hz. 380V AC or 110V DC.

3.3.18 Train Depot: Signalling

All depot lines except the workshop area shall be interlocked. A CBI with workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. Track vacancy detection using Radio & Axle Counter will be used in the depot as well.

The Depot shall be equipped with all mode of train operation including UTO mode except depot workshop line. The trains shall be controlled from DCC and OCC as well. A test track with similar Signalling and Train control system as adopted on Main Line shall be provided at Depot.

3.3.19 Signalling Mode Of Operation

There are six signalling modes of operation which shall be available but only one single signalling mode shall be active at any one instant of time. These five Modes are mentioned as under:-

a) Restricted Manual (RM) Mode for Depot.
b) Automatic Train Protection (ATP) Mode
c) Automatic Train Operation (ATO) Mode
d) Unattended Train Operation (UTO) Mode
e) Run on Sight Mode (ROS) Mode
f) Automatic Train Reversal / Turn Back (ATB) Mode

3.3.20 Half Height Integrated Platform Gate (PG)

The Integrated Platform Gate system shall provide a barrier between the track and the platform accessible to passengers. The system shall improve the safety of passengers by isolating the platforms from the track unless there is a train stopped at its correct position. PG system shall be around 1.5 Meter heights and it shall consist of sets of bi-parting doors installed along the full length of platform.

The PG system shall comprise Automatic Sliding Gates (PGs), Platform End Doors (PEDs), Emergency Escape Doors (EEDs) and Fixed Screens (FSS) to form a barrier along the edge of the platform adjacent to the track. Platform Gates shall correspond to the location of each of the train doors when the train has berthed at its correct position. Each platform end shall be closed by a Platform End Door. The remaining portion of PG facade shall be provided with manually openable Emergency Escape Doors and Fixed Screens.

The PG system shall be integrated with structure and architecture of the station and operationally with Signalling System as well as Rolling stock System. The interface between Signalling System and PG shall be designed to fail safe Signalling standards and according to relevant International standard. All vital control and detection circuits of PG system shall be double cut.

Opening and closing of PG and Train doors shall be synchronous. Train movement should not be permitted until it is confirmed that both Train doors and Platform Gates are properly closed. The PG shall be quiet in operation and all the elements of the PG installations (fixed and moving) shall be sufficiently rigid to avoid generation of noise by panel excitation.

3.3.21 Display of CCTV images from Train to OCC

For monitoring of train saloons, there shall be provision at OCC for displaying live video streams for the onboard CCTV cameras on each train as selected by the OCC operator on large video screen & MMIs. Onboard camera shall be provided by rolling stock, Signaling/Telecom shall provide the radio infrastructure for transmission of CCTV live stream from train to OCC through use of one of the available ISM band (preferably 5.8 GHz band) frequency/ network subscriber's bandwidth. It shall be finalized at the time of detailed design stage. Data transmission network of CCTV & CBTC shall be separate and redundancy in radio units.

Provision shall be made for displaying a minimum of four live streams from a train at OCC. Signaling shall also provide sufficient size large video screen display and MMI at OCC as per requirement. Display shall be sufficient good quality of operator to view required simultaneous live streams. However, actual bandwidth requirement, number of live streams per train, size of large video screen, etc. shall be finalized as per requirement during design stage.

3.3.22 Centralized Traffic Control (CTC)

The Metro operation shall be managed from the Central Traffic Control located in Operation control Centre (OCC) that is in charge of managing real time traffic, safety of movement, rolling stock, on-board staffing, and work maintenance. The primary objective of the CTC system is to operate the train in UTO/ATO mode (in CBTC) and construct the routes of the trains from the origin up to the destination automatically / manually under normal / abnormal conditions, the CTC system will provide effectively alternatives to minimize the delay of the train.

It supplies all the information required to the centralized traffic control operator in order to check the normal operations of the trains. The CTC system interfaces to the external systems (interlocking, Radio equipment, SCADA, PIDS, PAS, etc.) to monitor and control the traffic and to ensure the safe operations of trains.

The CTC system shall meet the following requirements:

- The systems and communication lines shall be in redundant configuration and will ensure reliability and safety through continuous operations of the system.
- The OCC is interfaced with signaling devices set along the track and allow the operator to access different functionalities for traffic management with a man-machine interface (MMI).
- MMI allows the command acquisition, alarms display, and the viewing of control images.
- Each equipment units used for servers and industrial MMIs will be suitable for the metro rail environment with high MTBF. The servers for the OCC shall be self diagnostic and fault noticing functions.
- Operation during emergency situation can be planed through the back-up CTC (BCC) when OCC is not functional.
- The suitable software for each operator workstation and server is configured to achieve the convenience of the operation.

OCC shall monitor the train operations and control the operations of train so that the trains can operate safely & efficiently. The functions of the operating room will be supported by the LDP (Large Display Panel), and Workstations for the operators. The LDP in the operating room shows the entire track line of the Metro Rail in real-time so as to monitor it any time.

3.3.23 Fall- Back Block Working System

A Fall-Back block working system shall be used by using secondary detection (axle counters) & Track Side Signals in case of failure of CBTC System or wayside communication link become unavailable.

The Fall-Back Block working system shall follow fixed block working, it can temporarily be worked to maintain safety and smooth operation with the help of Line Side Signals provided at each station / interlocking. When the Fall-Back Block working system is operated, it is necessary to check no other trains exist in the protection area to keep safety operation at first on priority.

3.3.24 Rooms For Signalling at OCC & Stations

The OCC is composed of several rooms that have specific functions. In a basic configuration, four rooms are directly concerned by the Signalling System: the Operation Room, the Central Signalling Equipment room, the maintenance room and power supply room**.**

A) Operation Room:

The Operational Room is the place from where the operators can monitor and control the traffic on the Line, using dedicated workstations and Direct Line large projection Display.

B) Central Signalling Equipment Room

This room includes all equipment managing the Signalling System included in the OCC control area.

As per site requirement, additional devices (other than signaling i.e Telecom and AFC System) can be considered in the Central signalling room. Also, this room shall be available at Central location as well as interlocking stations (SER, Station Equipment Room).

C) Maintenance room

All signalling devices information and technical alarms are displayed on workstations and manual or automatic commands are possible from these workstations. This room shall be available at Central location as well as interlocking stations.

D) Power supply room

The room contains Uninterrupted Power Supply (UPS) necessary for the signalling technical room, the maintenance room and the operation room. The power supply arrangement is designed in order to provide uninterrupted power in case of general power breakdown. It includes all the equipment that provides power supply for OCC rooms (Signaling, Telecom, AFC equipments). UPS room should be available adjacent to Signalling Equipment rooms at Stations and OCC. UPS room shall be available at Central location at all stations.

The minimum surface areas required for each room at stations are:

- The signaling technical room : 40m^2
- The maintenance room : 30m^2
- The power supply room : 50m^2

At the OCC, BCC and the Depot, the areas required shall be as per final configuration of the equipment and network configuration keeping space for further expansion.

3.3.25 Back Up of the OCC (BCC)

In order to decrease the risks of disruption due to a local disaster such as fire, flood, building collapse, etc., a Main CTC (OCC) and a fall back CTC (BCC) shall be provided & both shall be located in different areas.

The OCC may be located at terminal station inside the premises of the station or in Depot. The BCC could be located around other terminal station / locations / Depot. The BCC shall be similar to OCC, and also, BCC shall provide full redundancies of all systems and communications.

- The OCC is normally on-line and used by the Operators to control the Metro Line traffic. Operation & Maintenance Control.
- The BCC is normally off-line. It will be used to control the Line only in case the OCC is accidentally unavailable. Besides this BCC being normally off-line, will be also available for other purposes such as training, testing, replay without disturbing the live traffic.

3.3.26 Power Supply

Uninterrupted Power Supply provision is must for the Signalling System to have high availability. The concept of the power supply system is of immense importance, because the availability of the Signalling System entirely depends on its power supply.

All devices along the line are computerized devices and therefore need to be fed with low-voltage power supply. The low-voltage power supply shall be designed in a way to ensure the quality and reliability of the supply to all components of the Signalling System. The Uninterrupted Power Supply System shall have sufficient backup time and in built redundancies to ensure very high of Availability and reliability.

The solutions that are usually implemented on metro rail include:

- Redundancy of mains feeder (delivery from multiple cables/sources),
- Back-up of the AC supply by means of uninterrupted power supplies and associated batteries,
- Batteries capacity based on system consumption and autonomy with Back-up time requirements.
- Architecture and dimension of the system allowing failures and/or maintenance without service disruption (possibility to switch off one or several converters or other modules without impact).

The Uninterrupted Power Supply system shall be designed for use of Signalling equipments, Telecom equipments, AFC equipment & PSD equipments as per requirement.

3.3.27 Standards

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

Table 3.1

Description	Standards
Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide in redundancy. The system will conform to IEEE 1474 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 etc.
Block Working	Moving Block working concept may be followed in CBTC System and Fixed Block working in failure of CBTC system.
Default Mode of Operation	The system shall be capable of Unattended Train Operation (UTO), however, the mode of operation may be decided /

Description	Standards
	finalized by metro at detail design stage.
Maximum Safe Speed of Operation	90 Km/h
Grade of Automation	GOA4 (UTO) / GOA3 (DTO)
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 in depot (except workshop line) may be through radio (CBTC System) and secondary detection it may be through Axle Counter.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and less maintenance cost.
Uninterrupted power Supply at stations as well as for OCC	Uninterrupted Power Supply System is Common for Signalling, Telecommunications, AFC and PSD systems.
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 in redundancy.
Fall Back CTC	Backup OCC (BCC)
Platform Gate	Half height Integrated Platform Gate System
On board CCTV Stream	Display of CCTV images from Train to OCC on Large Video Screen and MMIs
Cables	Outdoor cables will be steel armoured as far as possible.
Fibers cable	Fibers required for Signaling System shall be provided by Telecom wing.
Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for Signal and Train Control System.
Immunity to External	All data transmission on telecom cables/OFC/Radio. All

Description	Standards
Interface.	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 equipment shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.

3.3.28 Space Requirement For Signalling 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 Interlocking stations for Signalling Equipment Room shall be generally 40 sqm. For UPS Room (common for Signalling, Telecommunication, AFC and PSD systems) at all stations, the area required shall be approximately minimum 50 sqm.

At Non-interlocking stations, Signalling & PSD Equipments shall be installed in the Telecommunication Equipment Room (TER) available at the station.
At the OCC and the Depot, the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion.

3.3.29 Maintenance Philosophy For Signalling Systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and Telecommunication equipment 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 equipment to rectify the faults and undertake minor repairs. Cards / modules /

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

3.4 TELECOMMUNICATION SYSTEM

3.4.1 Introduction

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

3.4.2 Overview

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

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:

- Radio System
- Backbone network using Optical Fiber Cable (OFC)
- Ethernet & WAN Network.
- Station to Station dedicated communication
- Telephone System with Telephone Exchanges, Telephones and their Recording
- Centralized Recording System (CDRS)
- Centralized Clock System
- Closed Circuit Television (CCTV) System
- Passenger Information & Display System within the station & trains and from Central Control to each station, Integrated Passenger Announcement System
- Train Traffic Control, Maintenance Control, Emergency Control, Assistance to Train Traffic Control.
- Data Channels for Signalling, SCADA, Automatic Fare Collection
- Power Supply of Telecommunications, and Cables for Telecommunications etc.

3.4.3 Telecommunication System and Transmission Media

A) Fibre Optic System (FOTS) - Main Telecommunication Bearer

The main bearer of the bulk of the Telecommunication network is proposed with optical fiber cable system. An OFC system shall provide a transmission network of Voice, Data, Ethernet, Video, and Signals among all Stations, Depot and OCC with sufficient transmission bandwidth to cater for the operational need of Metro line. The size of the OFC will fully meet with the applications need of the Metro line and commercial exploitation of the Telecommunication Network of Metro line. A minimum 96 / or 144 Fibers optical fiber cable with redundancy (cable on both side of track) is proposed to be laid. The optical fiber cable shall provide common transmission backbone network for Telecom and other systems which are formed by the two outdoor single mode optical fiber cables, one laying along the up-track and other one along the down-track. Additional 144 fiber optical fiber cables may be laid along track as per present commercial requirement for revenue.

B) Gigabit Ethernet Network (WAN)

A totally IP Based High Capacity, highly reliable and fault tolerant, MPLS Ethernet Network shall be provided. IP network shall have important data therefore Ethernet requires high reliability. Considering the rapidly increased demand during the operation for top-level backbone network 10Gbps Equipment is proposed. The communications network shall be configured as LAN and WAN – LAN shall be responsible for train operations and maintenance tasks within each passenger station and WAN shall be responsible for mutual communications between the stations and between depot and the central computer system. To maximize the reliability and survivability, each equipment and transmission line are configured as a dual system.
Redundant Layer-3, Layer-2 switches and Routers at each station, depot & OCC shall be provided to meet requirement of other Telecom systems (like CCTV, AFC system, maintenance management system and Wi-Fi network at station, PA, Clock, PIDS , Telephone System, SCADA etc) and to support comparatively unimportant facilities for the operation.

Layer-3 Core switch at OCC shall be provided to cover all requirements for Centralized Management and Control facility of all equipment used in line. Data lines of sufficient quantity and bandwidth shall be provided to other systems between Central Terminal Unit and Remote Terminal Unit.

3.4.4 Telephone Exchange

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

3.4.5 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 Station shall be required along the proposed Mumbai Metro Line 12 i.e. from Kalyan to Taloja.

3.4.6 Passenger Announcement System (PAS)

The PAS shall be provided to broadcast voice messages to passengers /staff in all stations/ Depot from the locally as well as from OCC. It includes a network of amplifier and speakers linked to the station. The system capable of 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.

The PAS and Passenger Information Display System (PIDS) shall be coordinated automatically to provide real time passenger audio broadcast and visual information at each station. Live audio broadcast relating to emergency, fire and evacuation messages from OCC and Station Control Room shall be recorded in the Centralised digital recording system at OCC. FOTS WAN network shall be used for transportation of data from Station/Depot to OCC vice versa.

3.4.7 Passenger Information Display System (PIDS)

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

3.4.8 Centralized Clock System

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

3.4.9 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 end to end IP based Full HD IP cameras using backbone of FOTS WAN network and shall consist of a mix of Fixed Cameras and Pan/Tilt/Zoom (PTZ) Cameras. Cameras shall be extended /located at areas where monitoring for security, safety and crowd control purpose is necessary. All Videos shall be extended at Video Wall located at security control room at OCC.

Intelligent Video Analytic (Track protections, abandoned object detection, Perimeter protection, Movement detection, Platform track protection from falling object, Camera Tempering, Overcrowding / Congestion detection, Excessive Queuing, Rule based detection, Face detection & tracking features etc) shall be provided in cameras of specific locations like Platforms, Vulnerable locations, etc. Alarm shall be generated and relevant data and video shall be transfer to OCC/Stations/Security Rooms through optical fiber network.

3.4.10 Voice Recording System (VRS)

A Centralized Digital Voice Recording System (CDRS) shall be provided at OCC to record all telephone conversations of all dispatchers at OCC & Depot. Live audio broadcast relating to emergency, fire & evacuation messages from OCC and Station Control Room shall be recorded in the Centralized digital recording system at OCC. Radio conversation shall be recorded at OCC. Emergency announcement on Train borne PA system initiated from Radio console at OCC shall also be recorded. The interface/Tapping shall be at IP network or over unified link.

The CDRS shall be of sufficient channels and shall be equipped with sufficient recording capacity for minimum four weeks continuous operation.

3.4.11 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 provide the Access only to the Authorized Personnel in operational rooms and shall not allow the same Card for Travel in metro. The System Shall be controlled and monitored centrally from the OCC.

3.4.12 Network Monitoring and Management

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

3.4.13 Technology

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

Table - 3.2: Technologies for Telecommunication Systems

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

3.4.14 Space Requirement for Telecom Installations

Adequate space for proper installations of all Telecommunication equipment at each 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 Telecommunication equipments shall be approximately 40 sqm. The Telecommunication Room shall be used for Signaling, Telecommunication, AFC & PSD systems equipments at non- interlocking stations. In interlocking station, Telecommunication Room shall be used for Telecommunication, AFC & PSD systems equipments. Uninterrupted Power Supply (UPS) System shall be common for Signaling, Telecommunication, AFC & PSD systems equipments at input stage and installed in UPS room at every station, depot and OCC which is approximately 50 sqm at station. These areas shall also cater to local storage and space for maintenance personnel to work.

At the OCC, the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion.

3.4.15 Maintenance Philosophy for Telecom Systems

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

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

3.5 AUTOMATIC FARE COLLECTION SYSTEM

3.5.1 Introduction

Metro 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, amendable for quick fare changes and require overall less manpower. In view of the above computer based automatic fare collection system is proposed**.** Seamless ticketing is now being thought of for Mumbai Metro Rail.

Automatic Fare Collection system is recommended to be adopted as this will enable the commuters to travel hassle 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.

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 AFC system shall be of Contactless Smart Token / Card type. For multiple journeys, the stored value smart card shall be utilized and for the single journey, the smart media shall be as utilized as contactless smart token and QR Code / bar code / NFC based ticketing. The equipment 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.

It is proposed, the smart NCMC (National Common Mobility card) standard model for implementation of AFC system in Mumbai Metro. The AFC system as per the guidelines issued by Govt of India shall enable seamless travel by different metros and other transport systems across the city besides retail shopping and purchases.

The AFC system shall support the EMV (Europay, MasterCard, and Visa) and RuPay based open loop ticketing following the NCMC standard model for interoperability with other operators by use of non-proprietary standard so that the interface is scalable to other networks (transit operator/ retail outlets/parking/Toll etc) in Mumbai. The AFC equipments shall support EMV, RuPay, QR, NFC (Near field communication) based ticketing, integration of clearing house, smart card host system of Financial Institutions and integration of mobile application with AFC system.

3.5.2 Gate

Retractable Flap Type Control Gate is proposed which offer high throughput, require less maintenance and are latest in modern systems internationally. All these gates will have a functionality of Auto Top on smart cards in case balance goes below the threshold value (as per choice / business rule). The type of control gate may be finalised at detailed design stage.

The gate should also capable to NFC enabled Mobile Tickets or any latest type of Ticket media at the time of procurement/installation. The AFC system shall provide access control solutions, offering both access control devised and hardware which can be tailored to accept any ticket media readily available in market (Barcode, QR code, NFC etc).

3.5.2.1 Gate Function

a) Gate arrays shall be the normal-means of controlling entry to and exit from the paid areas. Control shall be by means of actuating a physical barrier on recognition of a valid ticket or card by the gate. The barrier may be a bi-parting leaves, centre flaps, end flaps or other configuration however the use of tripod or turnstile type gates is not acceptable. The gate shall be capable of operating either in normally open or normally closed mode.

b) Where required, barriers shall be provided to separate paid and unpaid areas of the concourse. The barriers shall meet local public safety requirements and be aesthetically merged with station engineering.

3.5.2.2 Features

a) **Power Failure** - In the event of a total power failure to the gates, the gates shall open to allow unrestricted user access. All latch gates shall automatically unlatch where electric locks are installed.

b) **Concourse Emergency Mode** - All AFC gates shall open whenever the Concourse Operating Mode is in emergency. An Emergency Push Button independent of the SC shall be provided in each Excess Fare Office.

c) **Ergonomics** - The engineering of the gate arrays should be such that the passenger uses reader placed on the right hand side while passing through the gate. The display and Contact less Smart Card (CSC) reader associated with each gate shall be grouped such that they bias the passenger towards the aisle through which the passenger should pass.

3.5.2.3 Types of Gates

a) **Passenger Entry Gate**: - The Passenger Entry Gate shall control the entry of passengers into the paid area by validating the fare media.

b) **Passenger Exit Gate**: - The Passenger Exit Gate shall control the exit from the paid area by validating the fare media.

c) **Passenger Reversible Gate**: - The Passenger Reversible Gate shall combine the features of the Entry and Exit gates. It shall be capable of being switched by the Station Computer from entry mode to exit mode and vice-versa depending on the operational requirements of passenger flow. Reversible Gates shall also function automatically, based on the side from where the Passenger approaches first.

d) **Staff / Emergency Gate**: - Normally situated adjacent to the Excess fare Office and kept open during emergency situations.

3.5.2.4 Spacing

Spacing for passenger gates shall be based generally on the following dimensional criteria:

a) Gate Centre spacing: - Standard gates 880mm
b) Aisle width: - Standard gates 465 - 580mm

3.5.2.5 Gate Enclosure

a) The gate enclosure shall be fabricated of stainless steel. The gate shall be finished to conform to the architectural requirements of the station.
b) The degree of protection provided by the enclosure against dust, splashing, intrusion of foreign objects shall meet or exceed the standard IP54 (IP43 for token acceptor slot, if any), as defined by British Standards.

3.5.2.6 Tail Gating Prevention:

Minimum distance for detection shall be less than 20 cm and methodology shall be in accordance with that being used in AFC operations.

3.5.3 Ticket Vending Machine (TVM)

The TVM should provide the convenience for the passengers to procure ticket on their own, without the need to queue at the ticket sale counter.

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

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

3.5.4 Function

a) Enable passengers to purchase tickets for journey.
b) The touch-point including the screen interface should be customizable in terms of the text, graphics and video. It should be able to support the promotion of any preferred products.
c) The machines shall accept payment in the form of bank notes, coins and credit / debit cards and shall interact with the passengers via a touch screen display and receipt printer.
d) A reject button shall be provided to enable a passenger to abort a transaction before a token issue cycle has commenced.
e) The bank note reader shall accept notes inserted in any orientation (any way up or round) and change shall be provided via a combination of note and coin re-circulating mechanism, which minimises the number of times the station staffs need to replenish the machines with change.

3.5.5 Physical

The TVM's hardware and peripherals should come equipped with durable housing. It shall be made from stainless steel and shall be freestanding or recessed into the walls of the TVM rooms as required by the station architecture. Separate tamper-proof coin boxes and note vaults shall be provided.

Minimum 2 TVM machines shall be provided at every entry to station to dispense journey ticket.

3.5.6 Types of Ticket

(a) The system shall provide, or be capable of processing, the following types of ticket:

- Single Journey Ticket (SJT)
- Daily Pass
- Staff/Employee Pass (EP)
- Stored Value (SV) (at least 16 configurable types)
- Period Pass (PP)

(b) Each ticket type shall be capable of being associated with at least four fare tables (One full fare and two concession fares).

3.5.7 Ticket Media

a) **CSC (for Stored Value, Employees Pass etc.)**

Contactless media shall be to ISO/IEC 14443 & ISO 18092 standard (minimum EAL4 Security Criteria for CSC) and also to support common mobility card specifications of Ministry of Urban Development (GOI).

The system must support minimum standard & specification for CSC & devices and recommendations to be used for the implementation of National Common Mobility program in the multimodal and multi operator environment within the practical limits of transport.

b) **Other Media (for Single Journey Tickets)**

Media for Single Journey Tickets shall be determined at design stage, which can be a token. Choice of SJT media shall take financial and usage constraints into account.

3.5.8 Ticket Reader/Add Value Machines

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

3.5.9 Recharge Card Terminal Machine (RCTM)

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

3.5.10 Security

(i) Revenue Protection

The AFC machines shall resist tampering by either passengers or unauthorized staff.

(ii) Revenue Security

- The AFC machines and system shall provide a complete audit trail of all transactions, transfers of cash and other payments.
- Cash handling equipment and systems shall be an integral part of the audit trail.
- Data & Revenue Security shall be ensured by a Key Management System (KMS) which needs to issue a Hardware SAM for each AFC equipment in use in the system. The SAM shall be used to authenticate the equipment and the transaction integrity.

(iii) Data Security

- In the event the SC fails, each item of equipment shall be able to operate autonomously without loss of data.
- Security of communications between the AFC equipment, SC and CC system shall ensure no loss of data in transmission.

3.5.11 Station Computer (SC)

- Station Computer (SC) enables the overall control and monitoring of each item of AFC equipment within the station and transfer of data to the Central Computer (CC).
- The SC shall include the power and data communication links to each item of AFC equipment and CC system interface.
- It shall enable printing of reports at stations. The reports shall include accounting and statistical information. It shall include any other reports required for AFC operation.
- The SC shall be able to download data to the AFC machines individually or as groups.
- The SC shall receive maintenance data from AFC equipment and transmit the same to CC for monitoring and use of the same as an effective maintenance tool.
- The SC shall be able to monitor certain critical functions of the AFC system and collect data for warnings and alarms.
- If there is loss of communication between the SC and AFC equipment (Gates, TOM etc.) then the equipment shall operate in stand-alone mode utilizing the most recent data from the SC. AFC equipment (Gates, TOM etc.) shall store data up to seven days for transmission when SC communication is restored.
- In the event of loss of communication with the CC the SC shall utilize the most recent operational data received from the CC and shall be capable of storing at least thirty days of transaction data.

3.5.12 Equipment Control

The normal method of control of the equipment shall be by the SC. The SC shall enable all AFC equipment control (put in service, taken out of service and initiated etc.) without the requirement for communication with the CC.

3.5.13 Central Computer System

Central Computer System shall be redundant configuration and placed at OCC. It is connected to Station Computer and equipments via redundant secured link provided in Telecom Chapter.

a) The Central Computer System (CC) shall collect and analyze information received from the station computers. It shall produce network-wide revenue and traffic data and monitor the performance of all AFC equipment.

b) A Central Computer (CC) System shall generate the necessary management reports from the CST, CSC and transaction information received from the Station Computer Systems.

c) The CC shall hold and download CST and CSC parameters, Configuration Data (CD), AFC device software and fare table information to each SC from where they shall be distributed to the station AFC equipment.

d) The CC shall automatically collate all CST, CSC and usage data (UD) from the SC to provide accurate audit and traffic statistics for the line.

e) The CC shall be located in a dedicated computer room in the Administration Building or Operations Control Centre.

f) The CC shall maintain a blacklist of invalid tickets. Blacklisted tickets shall be rejected by the AFC Gates.

g) The CC shall support a Fare Table with adequate number of stations.

3.5.14 Central Clearing House System (CCHS)

The CCHS system shall be installed at OCC for sharing revenue between different operators. The Central Clearing House System (CCHS) shall handle all transactions for multiple applications and seamlessly integrate AFC System with different operators. The CCHS shall have all the functionalities required, thereof, for clearing and settlement between different registered Operators.

The CC should be able to interface with Central clearing house system (CCHS). The CCHS system already proposed for Mumbai Metro rail may be used for Mumbai Metro Line 12 requirement also.

3.5.14 AFC Equipment Requirement

The AFC equipment required at various locations of Mumbai Metro Line 12 i.e. from Kalyan to Taloja are tabulated at Annexure for projection years 2021 and 2031.

However, the exact number and type shall depend on the final station layout and traffic being catered to.

3.5.15 Standards

The standard proposed for AFC systems are as under:

Table 3.3

Standards	Description
Fare media	a) Contactless Smart Token – For single journey. Token are captured at the exit gate. b) Contactless Smart Card – For multiple journeys. Contactless readers shall be as per ISO 14443 standards. The System should also capable to NFC enabled Mobile Tickets (ISO18092 or equivalent) or any latest type of Ticket media (Barcode, QR code etc).
Gates	Computer controlled retractable flap type automatic gates at entry and exit. There will be following types of gates : - Entry - Exit - Reversible The System shall support the EMV and RuPay based open loop ticketing following the NCMC standard model for interoperability.

Standards	Description
Station computer, central computer and AFC Network	All the Fare Collection Equipment shall be connected in a local area network with a station server controlling the activities of all the machines. The station servers will be linked to the AFC central computer situated in the operational control center through the optic fiber communication channels. The centralized control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
Ticket office machine (TOM/ EFO)	Manned Ticked Office Machines shall be installed in the station for selling cards / token to the passengers. Also TVM's shall be provided for Automatic Ticket Vending.
Ticket Readers	Ticket Reader shall be installed near EFO for passengers to check information stored in the token / cards.
Portable ticket decoder(PTD)	PTD will be used to check the card/token during travel
Recharge card terminal machine	RCTM will be used to recharge the card using bank note/debit card/credit card/pre paid card
UPS	Common UPS of S&T system will be utilized.
Fibers	Fibers required for AFC systems shall be provided by Telecommunication wing.
Maintenance philosophy	Being fully Contactless system, manpower requirement for maintenance is much less compared to system with magnetic tickets. However, adequate facilities to be provided similar to that of S & T systems.

3.5.16 Integration of AFC with other Lines and Modes of Transport

In Mumbai, different mode of transport 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, Waterway, Parking, Toll etc so that these systems may also be integrated with common smart card based fare products. This will facilitate the passengers as they need not carry different cards for different applications.

Fig 3.5 Entry/Exit Gates

Fig 3.6: Ticket Office Machine

Fig 3.7: Ticket vending machine

Fig. 3.8 Ticket Reader/Add Value Machine

Annexure 3.1

Table 3.4

AFC Equipments for Mumbai Metro Line 12 i.e. from Kalyan to Taloja (Projection for 2021)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	APMC Market Kalyan	5949	10448	99	174	4	7	5	2	4	2	2
2	Ganesh Nagar	11170	2857	186	48	7	2	9	2	4	2	2
3	Pisavali Gaon	816	1700	14	28	2	2	2	2	4	2	2
4	Golavli	390	501	7	8	2	2	2	2	4	2	2
5	Dombivli MIDC	224	152	4	3	2	2	2	2	4	2	2
6	Sagaon	1109	885	18	15	2	2	2	2	4	2	2
7	Sonarpada	334	285	6	5	2	2	2	2	4	2	2
8	Manpada	958	2932	16	49	2	2	2	2	4	2	2
9	Hedutane	0	47	0	1	2	2	2	2	4	2	2
10	Kolegaon	1012	353	17	6	2	2	2	2	4	2	2
11	Nilje Gaon	420	584	7	10	2	2	2	2	4	2	2
12	Vadavli (Khu.)	0	264	0	4	2	2	2	2	4	2	2
13	Bale	69	0	1	0	2	2	2	2	4	2	2
14	Waklan	0	0	0	0	2	2	2	2	4	2	2
15	Turbhe	0	240	0	4	2	2	2	2	4	2	2
16	Pisarve Depot	0	0	0	0	2	2	2	2	4	2	2
17	Pisarve	552	2708	9	45	2	2	2	2	4	2	2
18	Taloja	768	2519	13	42	2	2	2	2	4	2	2
	TOTAL					**43**	**41**	**46**	**36**	**72**	**36**	**36**

Annexure 3.2

Table 3.5

AFC Equipments for Mumbai Metro Line 12 i.e. from Kalyan to Taloja (Projection for 2031)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	APMC Market Kalyan	12579	5956	210	99	8	4	11	2	4	2	2
2	Ganesh Nagar	2036	803	34	13	2	2	2	2	4	2	2
3	Pisavali Gaon	360	793	6	13	2	2	2	2	4	2	2
4	Golavli	465	134	8	2	2	2	2	2	4	2	2
5	Dombivli MIDC	597	919	10	15	2	2	2	2	4	2	2
6	Sagaon	2177	790	36	13	2	2	2	2	4	2	2
7	Sonarpada	712	351	12	6	2	2	2	2	4	2	2
8	Manpada	981	1538	16	26	2	2	2	2	4	2	2
9	Hedutane	255	704	4	12	2	2	2	2	4	2	2
10	Kolegaon	2510	1200	42	20	2	2	2	2	4	2	2
11	Nilje Gaon	694	1643	12	27	2	2	2	2	4	2	2
12	Vadavli (Khu.)	0	2440	0	41	2	2	2	2	4	2	2
13	Bale	2809	0	47	0	2	2	2	2	4	2	2
14	Waklan	116	0	2	0	2	2	2	2	4	2	2
15	Turbhe	632	1852	11	31	2	2	2	2	4	2	2
16	Pisarve Depot	0	408	0	7	2	2	2	2	4	2	2
17	Pisarve	549	3025	9	50	2	2	2	2	4	2	2
18	Taloja	8391	13306	140	222	6	9	7	2	4	2	2

Assumptions :-

A. **Each Station has only 2 access**
B. **Minimum AFC equipments at a station with "2 access-1 for entry , 1 for exit": 2 entry gates, 2 exit gates, 2 EFO, 2 TOM,4 AVM/TR, 2 TVM**
C. **Throughput of gate: 25 passengers per minute, TOM : One per access**
D. **50% passenger are assumed on Smart card and 50% on single journey token**

3.6 ROLLING STOCK

3.6.1 Introduction

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

3.6.2 Optimization of Coach Size

The following optimum size of the coach has been chosen for this corridor as mentioned in Table 3.6.

Table 3.6 - Size of the coach

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

**Maximum length of coach over couplers/buffers = 23 m*

3.6.3 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, Rolling Stock with 3.2 m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 42 seated, 240 standing thus a total of 282 passengers for a Driving motor car, and 50 seated, 248 standing thus a total of 298 for a Trailer/Motor car is envisaged.

Following train composition is recommended:
3-Car Train: DMC+TC+DMC
6-car Train: DMC+TC+MC+MC +TC+DMC

Table 3.7 shows the carrying capacity of Heavy Rolling Stock.

Table 3.7 - Carrying Capacity of Medium Rail Vehicles

Particulars	Driving Motor car		Trailer car / Motor car		3 Car Train		6 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush	Normal	Crush
Seated	42	42	50	50	134	134	284	284
Standing	120	240	124	248	364	728	736	1472
Total	162	282	174	298	498	862	1020	1756

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

3.6.4 Weight

The weights of driving motor car, trailer car and motor car have been estimated as in Table 3.8, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 3.8 - Weight of Light Rail Vehicles (TONNES)

	DMC	TC	MC	3 Car Train	6 Car Train
TARE (maximum)	42	43	42	127	254
Passenger					
(Normal)	10.53	11.31	11.31	32.37	66.3
(Crush @6p/sqm)	18.33	19.37	19.37	56.03	114.14
(Crush @8p/sqm)	23.40	24.70	24.70	71.5	145.6
Gross					
(Normal)	52.53	54.31	53.31	159.37	320.30
(Crush @6p/sqm)	60.33	62.37	61.37	183.03	368.14
(Crush @8p/sqm)	65.40	67.70	66.70	198.5	399.60
Axle Load @6 person/sqm	15.08	15.59	15.34	15.25	15.33
Axle Load @8 person/sqm	16.35	16.92	16.68	16.54	16.65

The axle load @ 6persons/sqm of standing area works out in the range of 15.08T to 15.59T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should, therefore, be designed for **17 T axle load.**

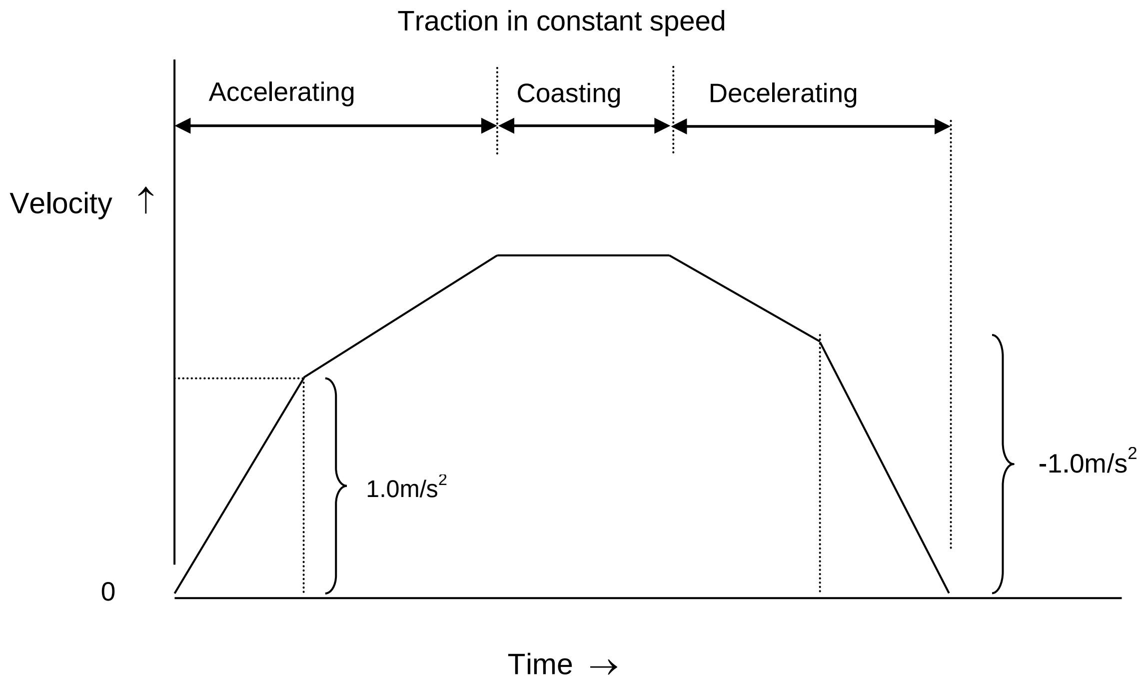
3.6.5 Performance Parameters

The recommended performance parameters are:

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

Here AW3 load mean 8 persons per square meter of standee area

AW2 load mean 6 persons per square meter of standee area



The above performance parameters are broad and may be finalized during design stage.

3.6.6 Coach Design and Basic parameters

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

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

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

3.6.7 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.

3.6.7.1Car body

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

The car bodies with aluminium require long and complex extruded sections which are still not manufactured in India, while stainless steel sections are available in India. However both stainless steel (SS) and Aluminium car body construction can be mentioned in the technical specification. Both Aluminium and stainless steel car body construction has its advantages and disadvantages, e.g. Aluminium is lightweight compared to SS, though it requires periodic painting for upto 4-5 times during service life, whereas SS is having high strength and has better aesthetic look, but it is heavier in weight compared to Aluminium.

3.6.7.2 Bogies

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

3.6.7.3 Braking System

The brake system shall consist of –

(i) An electro-pneumatic (EP) service friction brake
(ii) A fail safe, pneumatic friction emergency brake
(iii) A spring applied air-release parking brake
(iv) An electric regenerative service brake

(v) Provision of smooth and continuous blending of EP and regenerative braking

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

3.6.7.4 Propulsion System Technology

In modern trains, cars with microprocessor controlled three phase induction motor drive with VVVF control are recommended. The drive consists of self-ventilated 3-phase AC squirrel cage induction motor and a power converter-inverter system with microprocessor control gate drive. 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 AC 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.

The AC catenary voltage is stepped down through a transformer and fed to power converter-inverter (CI). In CI, AC voltage output of transformer is converted to DC voltage through converter connected 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. IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. In addition also have provision for over current, phase unbalance, over temperature protection for traction motor.

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.

3.6.7.5 Interior and Gangways

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

Interior View

3.6.7.6 Passenger Doors

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

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

Passenger Doors

3.6.7.7 Air–conditioning

With heavy passenger loading of 6 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

3.6.7.8 Cab Layout and Emergency Detrainment Door.

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

Driving cab

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

3.6.7.9 Communication

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

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

3.6.7.10 Noise and Vibration

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

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

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

3.6.7.11 Passenger Safety Features

(i) ATP/ATO/UTO

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

(ii) Fire

The rolling stock is provided with fire retarding materials having low fire load, low heat release rate, low smoke and toxicity inside the cars. The electric cables used are also normally low smoke zero halogen type which ensures passenger safety in case of fire. There shall be provision for fire/heat detectors in electrical cubicles inside the train. Also, as per MoHUA guidelines para-9 two fire extinguishers per car in saloon area. One fire extinguisher per cab to be provided.

(iii) Emergency door

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

(iv) Crash worthiness features

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

(v) Gangways

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

Gangways

(vi) Obstruction deflection device(ODD):

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

The salient features of the proposed Rolling Stock are enclosed as Annexure-3.2

Annexure-3.3

Salient Features of 3.2m wide SG Rolling Stock for MRTS

S.No.	Parameter	Details
1	**Gauge** (Nominal)	1435mm
2	**Traction system**	
2.1	Voltage	25 kV AC
2.2	Method of current collection	Overhead Current Collection System
3	**Train composition:**	
3.1	3 car trainset 6 car trainset(from year 2031 onwards)	DMC+TC+DMC DMC+TC+MC+MC+TC+DMC
4	**Coach Body**	Stainless Steel/Aluminum
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	3.2 m
5.3	Length over body (approx)	
	- Driving Motor Car (DMC)	21.84 m
	- Trailer Car (TC)	21.74 m
	- Motor Car (MC)	21.74 m
	Maximum length of coach over couplers/buffers:	*22 to 23m (depending upon Kinematic Envelop and SOD)*
5.4	Locked down Panto height (if applicable)	4048 mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity-@ 6 standees/sqm**	
7.1	Coach carrying capacity	
	DMC	282 (seating - 42; standing - 240)
	TC	298 (seating - 50; standing - 248)
	MC	298 (seating - 50; standing - 248)
7.2	Train Carrying capacity	
	3 Car Train 6 Car Train (In year 2031)	862 (seating – 134, standing – 728) 1756 (seating - 284; standing - 1472)
8	**Weight (Tonnes)**	
8.1	Tare weight (maximum)	
	DMC	42
	TC	43
	MC	42
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DMC	18.33 (@ 6 persons per sqm of standee

S.No.	Parameter	Details		
		area)		
	TC	19.37 (@ 6 persons per sqm of standee area)		
	MC	19.37 (@ 6 persons per sqm of standee area)		
8.3	Gross weight in tons (@ 6 persons per sqm of standee area)			
	DMC	60.3		
	TC	62.4		
	MC	61.4		
9	**Axle load(T) (@ 8 persons per sqm of standee area)**	**17 (System should be designed for 17T axle load)**		
10	**Maximum Train Length - Approximate**			
10.1	3 car trainset 6 car trainset	≈69 m ≈138 m		
11	**Speed**			
10.1	Maximum Design Speed	90 Kmph		
10.2	Maximum Operating Speed	80 Kmph		
12	**Wheel Profile**	UIC 510-2/RDSO wheel profile		
13	**Noise Limits(ISO 3381and 3095 -2005) Vibration (ISO-2631-1 1997, ISO 2631-4 2001), as per MoHUA circular on Standardisation of Broad Parameters of Rolling Stock for Metro Railways in India**			
13.1	Interior Noise Level ($L_{PAeq20sec}$)			
	Location(Section)	**Interior Noise Measurements in Maximum dBA**		
		Stationary		**Running (Elevated and At Grade)**
		Elevated	**Underground**	**Elevated**
	All cars except in driving cab(Elevated and at grade)	68	75	68
	Driving cab(Elevated and at grade)	68	72	68
13.2	Exterior Noise Levels ($L_{PAeq20sec}$)			
	Maximum Level of Exterior Noise in dBA @ 7.5 m from centre of track on either side LpAEq20sec75dB(A)			
	Stationary	**Running at 75 kmph**		
	67	82		
14	**Traction Motors Ventilation**	Self		
15	**Acceleration on level tangent track**	1.0 m/sec^2 @ AW3		

S.No.	Parameter	Details
		1.2 m/sec^2 @ AW2
16	**Deacceleration on level tangent track**	1.0 m/sec^2 @ AW3 1.1 m/sec^2 @ AW2 (>1.35 m/sec^2 during emergency)
17	**Type of Bogie**	Fabricated
18	**Secondary Suspension springs**	Air
19	**Brakes**	- An electro-pneumatic (EP) service friction brake- An electric regenerative service brake - Provision of smooth and continuous blending of EP and regenerative braking - A fail safe, pneumatic friction emergency brake - A spring applied air-release parking brake - Tread Brakes - Brake Electronic Control Unit (BECU) - Independent for each bogie
20	**Coupler**	
	Driving Cab end of cars (DMC)	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
21	**Detrainment Door**	Front
22	**Type of Doors**	Sliding
23	**Lighting**	LED based with dimmer control
24	**Passenger Seats**	Stainless Steel
25	**Cooling**	
25.1	Transformer	Forced
25.2	CI & SIV	Self/Forced
25.3	TM	Self-ventilated
26	**Control System**	Train based Monitor & Control System (TCMS)
27	**Traction Motors**	3 phase VVVF controlled
28	**Temperature Rise Limits**	
28.1	Traction Motor	Temperature Index **minus** 70°C
28.2	CI & SIV	10°C temperature margin for Junction temperature
28.3	Transformer	IEC specified limit **minus** 20° C

S.No.	Parameter	Details
29	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load.
30	**PA/PIS including PSSS (CCTV)**	Required
31	**Passenger Surveillance**	Required
32	**Battery**	Ni-Cd
33	**Headlight type**	LED
34	**Coasting**	8% (Run time with 8% coasting shall be the 'Run Time in All out mode **plus** 8%')
35	**Gradient (max)**	4%
36	**Sharpest Radius**	Bogie shall be able to negotiate 100m(in Mainline) and 90m (in depot)
37	**Train Operation**	UTO(GoA4) with CBTC signaling system

CHAPTER - 4

CIVIL ENGINEERING

4.1 GEOMETRIC DESIGN NORMS

4.1.1 General

The proposed corridor is an extension of Line-5 and will be implemented with track on Standard Gauge (SG) 1435mm.

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

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

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

As regards the type of alignment i.e. At-grade, Elevated and Underground depends upon the ROW. If ROW is 20 m or more, Elevated alignment is preferred over Underground as the cost of Underground alignment is 2 to 2½ times of Elevated alignment. The Merits and demerits of Elevated and Underground alignments are detailed at Annexure- 4.1

4.1.2 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. On elevated section minimum radius of 125m has been used at two locations having speed potential upto 40 km/h. For maximum permissible speed on curve with various radii, Table 4.1 may be referred.

Horizontal Curves:

Table 4.1- Horizontal Curves

Description	Elevated Section
Desirable Minimum radius	200m
Absolute minimum radius	120m*
Minimum curve radius at stations	1000m
Maximum permissible cant (C_a)	125 mm
Maximum desirable cant	110mm
Maximum cant deficiency (C_d)	85mm

* not used in this corridor.

Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth riding on the curves and to counter act centrifugal force. It is necessary to provide frequent vertical curves along the alignment due to change in gradients at various locations in the corridor. In case of ballast less track, it is desirable that the vertical curves and transition curves of horizontal curves do not overlap. These constraints may lead to reduced lengths of transition curves at certain locations. The transition curves have certain minimum parameters:

- Length of transitions of horizontal curves (m)
  - Minimum :0.44 times actual cant or cant deficiency (in mm), whichever is higher.
  - Desirable :0.72 times actual cant or cant deficiency (in mm), whichever is higher.
- Overlap between transition curves and vertical curves not allowed.
- Minimum straight between two Transition curves (in case of reverse curves): either 25 m or Nil.
- Minimum straight between two Transition curves (in case of same flexure curves): either 25 m or both curves should be converted in to the compound curve by introducing single transition between the two circulars.
- Minimum curve length between two transition curves: 25 m

4.1.3 Vertical Alignment and Track Centre

(a) Elevated Sections

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

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

(b) Gradients

Normally the stations shall be on level stretch. In exceptional cases, station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 2.0 %. However, where existing road gradients are steeper than 2% or for Switch Over Ramps gradient up to 4% (compensated) can be provided in short stretches on the main line.

(c) Vertical Curves

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

(d) Radius of vertical curves:

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

4.1.4 Design Speed

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

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

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS (ELEVATED AND AT-GRADE)
meters	mm	kmph	mm
3000	15	80	3650
2800	15	80	3650
2400	20	80	3650
2000	20	80	3650
1600	25	80	3650
1500	30	80	3650
1200	35	80	3650
1000	45	80	3700
800	55	80	3700
600	70	80	3750

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS (ELEVATED AND AT-GRADE)
meters	mm	kmph	mm
500	85	80	3750
450	95	80	3800
400	105	80	3800
350	110	75	3800
300	110	70	3850
200	110	55	3950
150	110	45	4050
150*	0	30	4050
120	110	40	4150
120*	0	25	4150

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

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

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

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

4.1.5 Codes and Standards

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

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

4.1.6 General technical requirements of the Rail System

The rail system shall be designed to:

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

The design of the Rail System shall also conform to:
i) Local building bye-laws;
ii) Relevant published standards of UIC;
iii) All statutory requirements, guidelines and directives; and
iv) Stipulations of fire service department.

4.2 ALIGNMENT

4.2.1 Introduction

4.2.1.1 First station of this extension is named as Ganesh Nagar and last station is Taloja. Since this corridor is South-West extension of Mumbai Metro Line-5 (Thane-Bhiwandi-Kalyan), thus Ganesh Nagar is not a terminal station rather it is followed by APMC Market Kayan Station.

4.2.1.2 Chainage of first station is taken as 843.771 m for reference.

4.2.1.3 Total length of this extension is 20.756 km. The entire corridor is proposed as elevated.

4.2.1.4 Seventeen stations have been proposed on this corridor. Names of stations are Ganesh Nagar, Pisavali Gaon, Golavli, Dombivli MIDC, Sagaon, Sonarpada, Manpada, Hedutane, Kolegaon, Nilje Gaon, Vadavli (Khu.), Bale, Waklan, Turbhe, Pisarve Depot, Pisarve and Taloja. 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; few stations could not be located at one km distance apart. The maximum and minimum inter station distances are 1804.966 m and 848.002 m respectively. Depot for this corridor has been planned near Pisarve Depot Station.

4.2.1.5 This is an extension of Metro line 5 (Thane-Bhiwandi-Kalyan) towards South-West direction. It connects Dombivli MIDC/ residential area, MMRDA's proposed growth centres, proposed NAINA area and Taloja MIDC area through Panvel Municipal Corporation area. This proposed metro line extension has been integrated with Taloja Metro station which is under implementation by CIDCO.

4.2.2 Station Locations

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

All stations will be two level stations. Concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level.

Stations on the road have been planned cantilever leaving 10.5m road width either side of the median.

4.2.3 Terminals

Since this is an extension of Metro line 5 (Thane-Bhiwandi-Kalyan). Thus this section has only one terminal station as mentioned below:

Taloja

This Station is proposed off the road (Dr. Ritesh Patil Road), about 0.6 km before CIDCO Metro Depot and is near Railway Line. Scissors Crossovers is proposed at the front end of station.

4.2.4 Crossovers

Crossovers will be provided at Dombivli MIDC and Bale. Scissors Crossovers will be provided at terminal station i.e. Taloja.

4.2.5 Depot

It is proposed to provide depot near Pisarve Depot Station, on the Private Agricultural Land. The total land for Depot will be 20 Ha.

4.2.6 Description of Alignment

4.2.6.1 Horizontal Alignment

The proposed alignment is an extension of Thane--Bhiwandi-Kalyan corridor. This extension will start from APMC Market Kalyan i.e. terminal station of Metro Line-5 having CH: -110.313 m and it continues onto Kalyan-Shilphata Road.

From chainage 300m the alignment goes off the road and from 400 m to 500 m it crosses railway line with a left hand curve of radius 170m. From chainage 600 m it aligns onto the median of Kalyan-Shilphata Road.

First station of this extension is Ganesh Nagar at 843.771 m chainage. Thereafter also it continues along the road median. From chainage 1086.813 m, it turns right with a curve of radius 125 m and negotiates Sambhaji Maharaj Chowk. It continues along the road median, crosses Shree Ram Chowk near chainage 1560 m and turns slight left from chainage 1626.15. Next station is Pisavali Gaon at chainage 2320 m; thereafter also the alignment continues along the road median. Next station is Golavli at chainage 3400 m. Alignment continues along the road median till chainage 3900 m (approx.), thereafter till chainage 4200 m it goes somewhat away from road median and then from ch. 4200 m (approx.) it again aligns along the median of road. Next station is Dombivli MIDC at chainage 4567.083 m. It continues along the road median and next station is Sagaon at chainage 5573.311 m. Sonarpada is proposed at chainage 6700 m at Manpada Circle. Thereafter also it continues along the road median till chainage 7182.381 m, from here it turns left with a curve of radius 250 m and enters into the private agricultural land onto the proposed DP road of MMRDA's proposed growth centres. After the proposed growth centres, it moves towards proposed NAINA area and further it continues towards Taloja MIDC area through Panvel Municipal Corporation area upto Navi Mumbai Taloja Metro station. Next station is Manpada at chainage 7689.746 m (Sonar-Pada Village). Next station is

Hedutane, proposed at chainage 8947.974m (Hedutane Village). After this station, the alignment turns right from chainage 9203.127 m with a curve of radius 125 m. Next station is Kolegaon at chainage 9978.357 m. (Hedutane Village). After this station, the alignment turns left near Kolegaon Village from chainage 10442.173 m with a curve of radius 140 m. Next station is Nilje Gaon at chainage 11093.376 m. It is on a straight alignment and is located near Nilje Village. Alignment crosses river from approx. chainage 12100 m to 12180.355 m. Next station is Vadavli (Khu.), proposed at chainage 12553.4 m in Vadavli Khrud Village. Next station is proposed in Narivali Village at chainage 13974.564 m and is named as Bale. The next station is Waklan proposed at chainage 15478.984 m near Waklan/ Turbhe village. Alignment continues in private agricultural land, next station is Turbhe at chainage 16326.986 m in Turbhe Village. Next station is Pisarve Depot proposed in Turbhe Village at chainage 17176.971 m near a pond. This station is proposed before the proposed depot location. Due to the proposed Depot, Road link of NH-4 to Pisarve Village will required to be diverted. Next station (Pisarve) is proposed in Pisarve Village at chainage 18981.937 m. From chainage 19376.592 m, alignment turns slightly left with a curve radius 350 m and it leaves private agricultural land and enters CIDCO Metro Depot from chainage 19483 m. From chainage 19726.266 m with a reverse curve of 150 m radius, the alignment moves onto right side of Taloja Phase 1 road. Taloja is the terminal station of this extension. It is proposed at chainage 20525.676 m. Dead end chainage of this corridor is 20645.675 m.

4.2.6.2 Co-ordinates of Horizontal Alignment

Table 4.3: Co-ordinates of Horizontal Alignment

S.No.	Chainage	Easting	Northing	Bearing			Remarks
				D	M	S	
1	-403.688	302952.443	2128141.346	214	38	33.273	Straight
2	-400.000	302950.347	2128138.312	214	38	33.273	Straight
3	-300.000	302893.217	2128056.243	216	57	44.232	319.195
4	-200.000	302814.97	2127996.144	245	44	49.28	695.337
5	-100.000	302723.463	2127955.816	24	61	49.059	Straight
6	0.000	302632.059	2127915.258	244	43	25.015	-615.534
7	100.000	302547.487	2127862.372	230	59	38.284	-505.181
8	200.000	302471.968	2127796.828	228	44	56.046	Straight
9	300.000	302398.424	2127729.174	220	45	18.127	-183.052
10	400.000	302358.413	2127639.096	18	75	55.514	-170
11	500.000	302375.11	2127541.956	153	23	43.275	-170
12	600.000	302434.819	2127462.025	140	15	29.466	Straight
13	700.000	302498.752	2127385.132	140	15	29.466	Straight
14	800.000	302562.685	2127308.238	140	15	29.466	Straight
15	900.000	302626.618	2127231.345	140	15	29.466	Straight
16	1000.000	302689.484	2127153.604	144	23	58.776	450
17	1100.000	302742.076	2127068.589	149	59	12.146	521.361
18	1200.000	302764.915	2126973.372	186	53	56.368	195.493
19	1300.000	302745.071	2126875.384	1	92	38.937	Straight

S.No.	Chainage	Easting	Northing	Bearing			Remarks
				D	M	S	
20	1400.000	302718.553	2126779.074	200	26	16.453	455.225
21	1500.000	302670.405	2126691.917	218	18	54.577	300
22	1600.000	302601.752	2126619.276	224	41	10.123	Straight
23	1700.000	302538.958	2126542.278	203	26	27.052	-125
24	1800.000	302521.826	2126444.161	18	6 1	37.17	Straight
25	1900.000	302503.541	2126346.317	20	4 7	22.693	142
26	2000.000	302445.957	2126264.866	216	55	18.65	-652.561
27	2100.000	302390.562	2126181.645	213	38	34.815	704.54
28	2200.000	302328.634	2126103.233	220	41	25.86	Straight
29	2300.000	302263.437	2126027.408	220	41	25.86	Straight
30	2400.000	302198.646	2125951.24	219	18	33.211	-1800
31	2500.000	302137.252	2125872.315	21	77	13.132	Straight
32	2600.000	302076.903	2125792.578	21	77	13.132	Straight
33	2700.000	302016.409	2125712.951	217	27	55.089	10000
34	2800.000	301955.533	2125633.616	217	24	11.486	-5214.684
35	2900.000	301895.311	2125553.783	216	55	47.435	Straight
36	3000.000	301835.108	2125473.936	217	46	59.813	1010
37	3100.000	301770.031	2125398.063	223	27	22.071	1010
38	3200.000	301699.699	2125326.979	22	4 5	42.970	Straight
39	3300.000	301629.111	2125256.146	22	4 5	42.970	Straight
40	3400.000	301559.032	2125184.811	223	53	44.636	Straight
41	3500.000	301489.627	2125112.819	224	26	20.358	2000
42	3600.000	301418.611	2125042.417	225	25	17.764	Straight
43	3700.000	301348.61	2124971.011	223	55	40.507	Straight
44	3800.000	301279.235	2124898.989	223	55	40.507	Straight
45	3900.000	301209.242	2124827.574	225	18	36.202	Straight
46	4000.000	301138.15	2124757.247	225	18	36.202	Straight
47	4100.000	301067.057	2124686.92	225	18	36.202	Straight
48	4200.000	300995.965	2124616.593	225	18	36.202	Straight
49	4300.000	300924.971	2124546.167	22	43	65.718	-1750
50	4400.000	300855.475	2124474.263	223	57	26.524	Straight
51	4500.000	300786.063	2124402.277	223	57	26.524	Straight
52	4600.000	300716.754	2124330.192	223	49	32.13	Straight
53	4700.000	300647.507	2124258.047	223	49	32.13	Straight
54	4800.000	300578.261	2124185.902	223	49	32.13	Straight
55	4900.000	300509.182	2124113.597	223	17	33.873	-7831.958
56	5000.000	300440.423	2124040.988	223	49	47.796	Straight
57	5100.000	300371.171	2123968.848	223	49	47.796	Straight
58	5200.000	300302.135	2123896.503	222	57	17.327	-2500
59	5300.000	300234.39	2123822.946	222	31	42.53	-3090.809
60	5400.000	300170.067	2123746.43	217	14	28.673	-1010
61	5500.000	300111.992	2123665.029	2	15	46.403	Straight

S.No.	Chainage	Easting	Northing	Bearing			Remarks
				D	M	S	
62	5600.000	300054.537	2123583.183	2	15	46.403	Straight
63	5700.000	299997.081	2123501.336	21	53	37.625	- 23945.684
64	5800.000	299940.002	2123419.227	214	41	46.092	Straight
65	5900.000	299883.08	2123337.008	214	41	46.092	Straight
66	6000.000	299826.157	2123254.79	214	41	46.092	Straight
67	6100.000	299769.011	2123172.728	215	17	20.822	5760.978
68	6200.000	299711.125	2123091.185	215	22	31.566	Straight
69	6300.000	299653.754	2123009.281	214	33	55.916	Straight
70	6400.000	299596.76	2122927.114	215	33	46.182	2356.529
71	6500.000	299538.325	2122845.964	21	54	69.046	Straight
72	6600.000	299479.873	2122764.826	21	54	69.046	Straight
73	6700.000	299421.42	2122683.688	21	5 4	69.046	Straight
74	6800.000	299362.968	2122602.551	21	54	69.046	Straight
75	6900.000	299308.211	2122518.979	208	28	36.375	-686.689
76	7000.000	299262.556	2122430.011	206	59	17.897	Straight
77	7100.000	299217.175	2122340.901	206	59	17.897	Straight
78	7200.000	299171.854	2122251.762	206	20	29.43	-780.394
79	7300.000	299142.066	2122156.899	18	62	04.131	-250
80	7400.000	299150.939	2122057.961	163	24	58.209	-250
81	7500.000	299197.639	2121970.289	140	29	52.286	-250
82	7600.000	299273.979	2121906.42	122	50	28.515	-2897.021
83	7700.000	299358.04	2121852.257	122	47	39.551	Straight
84	7800.000	299441.739	2121797.542	124	24	11.217	1650
85	7900.000	299522.486	2121738.576	127	52	32.115	1650
86	8000.000	299599.512	2121674.828	131	20	53.012	1650
87	8100.000	299672.536	2121606.531	134	49	13.909	1650
88	8200.000	299741.289	2121533.936	138	17	34.807	1650
89	8300.000	299805.519	2121457.311	141	45	55.704	1650
90	8400.000	299864.989	2121376.936	145	14	16.601	1650
91	8500.000	299919.483	2121293.106	148	42	37.499	1650
92	8600.000	299968.799	2121206.13	152	10	58.396	1650
93	8700.000	300012.756	2121116.326	155	39	19.293	1650
94	8800.000	300051.227	2121024.038	158	48	19.777	45162.104
95	8900.000	300087.379	2120930.801	158	48	21.445	Straight
96	9000.000	300123.532	2120837.565	158	48	21.445	Straight
97	9100.000	300159.685	2120744.329	158	48	21.445	Straight
98	9200.000	300195.838	2120651.093	158	48	21.445	Straight
99	9300.000	300212.276	2120554.021	190	36	15.28	125
100	9400.000	300158.511	2120472.858	236	22	30.095	134.738
101	9500.000	300067.721	2120431.254	247	13	26.109	Straight
102	9600.000	299975.518	2120392.541	247	13	26.109	Straight

S.No.	Chainage	Easting	Northing	Bearing			Remarks
				D	M	S	
103	9700.000	299883.393	2120353.647	24	65	53.972	-766.764
104	9800.000	299797.002	2120303.731	233	13	25.488	-420
105	9900.000	299723.212	2120236.397	224	55	16.12	Straight
106	10000.000	299652.599	2120165.589	224	55	16.12	Straight
107	10100.000	299581.985	2120094.781	224	55	16.12	Straight
108	10200.000	299511.372	2120023.973	224	55	16.12	Straight
109	10300.000	299440.759	2119953.165	224	55	16.12	Straight
110	10400.000	299370.145	2119882.357	224	55	16.12	Straight
111	10500.000	299302.678	2119808.796	212	30	34.715	-140
112	10600.000	299282.247	2119713.064	17	13	52.710	-140
113	10700.000	299328.855	2119626.696	135	14	20.19	-386.69
114	10800.000	299400.956	2119557.405	133	45	49.392	Straight
115	10900.000	299473.176	2119488.237	133	45	49.392	Straight
116	11000.000	299545.395	2119419.068	133	45	49.392	Straight
117	11100.000	299617.615	2119349.899	133	45	49.392	Straight
118	11200.000	299689.809	2119280.704	1	34	9 2.439	1231.946
119	11300.000	299754.273	2119204.542	146	34	12.264	410
120	11400.000	299798.693	2119115.225	160	32	40.753	410
121	11500.000	299820.229	2119017.826	17	43	19.243	410
122	11600.000	299817.606	2118918.108	188	29	37.732	410
123	11700.000	299790.981	2118821.974	202	27	12.174	438.762
124	11800.000	299748.677	2118731.374	205	30	14.393	Straight
125	11900.000	299705.62	2118641.118	205	30	14.393	Straight
126	12000.000	299662.562	2118550.863	205	30	14.393	Straight
127	12100.000	299619.505	2118460.607	205	30	14.393	Straight
128	12200.000	299578.121	2118369.601	201	14	26.643	-600
129	12300.000	299549.809	2118273.813	191	41	29.176	-600
130	12400.000	299537.779	2118174.656	18	21	11.959	-691.421
131	12500.000	299536.651	2118074.665	180	23	10.06	Straight
132	12600.000	299535.977	2117974.668	180	23	10.06	Straight
133	12700.000	299535.303	2117874.67	180	23	10.06	Straight
134	12800.000	299534.629	2117774.672	180	23	10.06	Straight
135	12900.000	299533.955	2117674.674	180	23	10.06	Straight
136	13000.000	299533.281	2117574.677	180	23	10.06	Straight
137	13100.000	299532.607	2117474.679	180	23	10.06	Straight
138	13200.000	299531.933	2117374.681	180	23	10.06	Straight
139	13300.000	299532.843	2117274.691	17	82	13.903	-2500
140	13400.000	299536.657	2117174.765	177	43	29.688	Straight
141	13500.000	299540.627	2117074.843	177	43	29.688	Straight
142	13600.000	299544.596	2116974.922	177	43	29.688	Straight
143	13700.000	299548.566	2116875.001	177	43	29.688	Straight
144	13800.000	299552.536	2116775.08	177	43	29.688	Straight

S.No.	Chainage	Easting	Northing	Bearing			Remarks
				D	M	S	
145	13900.000	299556.506	2116675.159	177	43	29.688	Straight
146	14000.000	299560.475	2116575.238	177	43	29.688	Straight
147	14100.000	299564.445	2116475.316	177	43	29.688	Straight
148	14200.000	299568.415	2116375.395	177	43	29.688	Straight
149	14300.000	299572.385	2116275.474	177	43	29.688	Straight
150	14400.000	299576.354	2116175.553	177	43	29.688	Straight
151	14500.000	299578.934	2116075.603	181	14	57.475	650
152	14600.000	299569.087	2115976.188	19	03	50.522	650
153	14700.000	299544.122	2115879.456	198	52	43.569	650
154	14800.000	299504.629	2115787.693	207	41	36.617	650
155	14900.000	299452.398	2115702.48	213	31	48.925	Straight
156	15000.000	299397.16	2115619.12	213	31	48.925	Straight
157	15100.000	299341.922	2115535.761	213	31	48.925	Straight
158	15200.000	299288.722	2115451.123	20	99	52.066	-800
159	15300.000	299245.566	2115360.986	20	22	53.839	-974.197
160	15400.000	299209.423	2115267.747	20	14	56.461	Straight
161	15500.000	299173.452	2115174.441	20	14	56.461	Straight
162	15600.000	299137.481	2115081.134	20	14	56.461	Straight
163	15700.000	299101.51	2114987.828	20	14	56.461	Straight
164	15800.000	299065.539	2114894.521	20	14	56.461	Straight
165	15900.000	299029.843	2114801.111	200	20	46.959	-3500
166	16000.000	299001.072	2114705.482	190	46	13.514	-425
167	16100.000	298993.666	2114605.953	17	97	32.33	-1623.322
168	16200.000	298995.578	2114505.972	178	53	40.671	Straight
169	16300.000	298997.507	2114405.99	178	53	40.671	Straight
170	16400.000	298999.436	2114306.009	178	53	40.671	Straight
171	16500.000	299001.365	2114206.027	178	53	40.671	Straight
172	16600.000	299003.294	2114106.046	178	53	40.671	Straight
173	16700.000	299005.223	2114006.065	178	53	40.671	Straight
174	16800.000	299007.152	2113906.083	178	53	40.671	Straight
175	16900.000	299009.082	2113806.102	178	53	40.671	Straight
176	17000.000	299011.011	2113706.12	178	53	40.671	Straight
177	17100.000	299012.94	2113606.139	178	53	40.671	Straight
178	17200.000	299014.869	2113506.158	178	53	40.671	Straight
179	17300.000	299016.798	2113406.176	178	53	40.671	Straight
180	17400.000	299018.727	2113306.195	178	53	40.671	Straight
181	17500.000	299020.656	2113206.214	178	53	40.671	Straight
182	17600.000	299022.585	2113106.232	178	53	40.671	Straight
183	17700.000	299024.515	2113006.251	178	53	40.671	Straight
184	17800.000	299026.416	2112906.269	179	10	48.653	1661.007
185	17900.000	299020.208	2112806.603	18	9 0	32.114	602.227
186	18000.000	299001.384	2112708.395	191	10	52.123	Straight

S.No.	Chainage	Easting	Northing	Bearing			Remarks
				D	M	S	
187	18100.000	298981.993	2112610.293	191	10	52.123	Straight
188	18200.000	298962.602	2112512.191	191	10	52.123	Straight
189	18300.000	298943.211	2112414.09	191	10	52.123	Straight
190	18400.000	298925.326	2112315.717	18	83	53.014	-1010
191	18500.000	298913.503	2112216.421	186	34	23.242	Straight
192	18600.000	298902.092	2112117.074	186	14	13.509	-1607.216
193	18700.000	298895.674	2112017.311	18	15	8 9.066	Straight
194	18800.000	298891.567	2111917.403	184	36	51.019	472.641
195	18900.000	298872.645	2111819.36	194	16	54.356	Straight
196	19000.000	298847.976	2111722.451	194	16	54.356	Straight
197	19100.000	298823.307	2111625.541	194	16	54.356	Straight
198	19200.000	298798.638	2111528.632	194	16	54.356	Straight
199	19300.000	298773.969	2111431.722	194	16	54.356	Straight
200	19400.000	298749.407	2111334.786	193	27	59.28	-822.438
201	19500.000	298737.93	2111235.758	178	34	54.255	-350
202	19600.000	298754.427	2111137.456	16	38	28.256	-641.535
203	19700.000	298785.435	2111042.386	16	14	8 4.498	Straight
204	19800.000	298823.942	2110950.579	14	48	31.198	-150
205	19900.000	298895.543	2110881.055	135	33	34.748	220.885
206	20000.000	298943.084	2110794.246	160	41	38.933	Straight
207	20100.000	298976.145	2110699.87	160	41	38.933	Straight
208	20200.000	299009.206	2110605.493	160	41	38.933	Straight
209	20300.000	299042.267	2110511.116	160	41	38.933	Straight
210	20400.000	299075.328	2110416.739	160	41	38.933	Straight
211	20500.000	299108.389	2110322.363	160	41	38.933	Straight
212	20600.000	299141.45	2110227.986	160	41	38.933	Straight
213	20645.678	299156.552	2110184.877	160	41	38.933	Straight

4.2.6.3 Vertical Alignment

Vertical alignment has been designed with consideration of 5.5 m clear head room on the road. Minimum height difference from existing road level and proposed rail levels is about 13.5 m at station locations and 8.5m other than station locations. Efforts have been made to maintain minimum radius of vertical curves of 2500 m. However it is not possible to maintain this at certain locations due to space constraints or overlapping with the transition length of Horizontal curves. At such locations minimum vertical curve radius is 1500m. Length of vertical curve provided is more than 20m. Overlap between transition curves and vertical curves are strictly avoided. All proposed stations are kept on level gradient. The maximum gradient used is not steeper than 3.522% and has been used at one location.

The proposed rail levels are given in **Table 4.4** and abstracts of gradients are given in **Table 4.5.**

Table 4.4: Proposed Gradients

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-403.688	53.500	457.188	19.500	19.500	0.000%	LEVEL
2	53.500	450.000	396.500	19.500	20.000	0.126%	RISE
3	450.000	720.000	270.000	20.000	29.000	3.333%	RISE
4	720.000	1002.831	282.831	29.000	29.000	0.000%	LEVEL
5	1002.831	1364.000	361.169	29.000	27.500	-0.415%	FALL
6	1364.000	1790.000	426.000	27.500	36.000	1.995%	RISE
7	1790.000	2220.000	430.000	36.000	44.000	1.860%	RISE
8	2220.000	2423.000	203.000	44.000	44.000	0.000%	LEVEL
9	2423.000	2746.685	323.685	44.000	32.599	-3.522%	FALL
10	2746.685	3290.000	543.315	32.599	28.000	-0.847%	FALL
11	3290.000	3574.204	284.204	28.000	28.000	0.000%	LEVEL
12	3574.204	3940.000	365.796	28.000	25.000	-0.820%	FALL
13	3940.000	4200.000	260.000	25.000	27.600	1.000%	RISE
14	4200.000	4460.000	260.000	27.600	27.000	-0.231%	FALL
15	4460.000	4670.000	210.000	27.000	27.000	0.000%	LEVEL
16	4670.000	5070.000	400.000	27.000	23.000	-1.000%	FALL
17	5070.000	5380.000	310.000	23.000	27.300	1.387%	RISE
18	5380.000	5675.000	295.000	27.300	27.300	0.000%	LEVEL
19	5675.000	6160.000	485.000	27.300	25.000	-0.474%	FALL
20	6160.000	6590.000	430.000	25.000	37.000	2.791%	RISE
21	6590.000	6980.000	390.000	37.000	37.000	0.000%	LEVEL
22	6980.000	7270.000	290.000	37.000	30.000	-2.414%	FALL
23	7270.000	7510.000	240.000	30.000	28.000	-0.833%	FALL
24	7510.000	7790.000	280.000	28.000	28.000	0.000%	LEVEL
25	7790.000	8140.000	350.000	28.000	23.000	-1.429%	FALL
26	8140.000	8490.000	350.000	23.000	25.500	0.714%	RISE
27	8490.000	8850.000	360.000	25.500	24.500	-0.278%	FALL
28	8850.000	9050.000	200.000	24.500	24.500	0.000%	LEVEL
29	9050.000	9300.000	250.000	24.500	22.600	-0.760%	FALL
30	9300.000	9550.000	250.000	22.600	27.500	1.960%	RISE
31	9550.000	9800.000	250.000	27.500	32.800	2.120%	RISE
32	9800.000	10080.000	280.000	32.800	32.800	0.000%	LEVEL
33	10080.000	10540.000	460.000	32.800	28.000	-1.043%	FALL
34	10540.000	10990.000	450.000	28.000	32.500	1.000%	RISE
35	10990.000	11280.000	290.000	32.500	32.500	0.000%	LEVEL
36	11280.000	11640.000	360.000	32.500	21.000	-3.194%	FALL
37	11640.000	12000.000	360.000	21.000	18.000	-0.833%	FALL
38	12000.000	12360.000	360.000	18.000	28.300	2.861%	RISE
39	12360.000	12660.000	300.000	28.300	28.300	0.000%	LEVEL
40	12660.000	13160.000	500.000	28.300	30.000	0.340%	RISE
41	13160.000	13870.000	710.000	30.000	27.000	-0.423%	FALL

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
42	13870.000	14080.000	210.000	27.000	27.000	0.000%	LEVEL
43	14080.000	14530.000	450.000	27.000	22.500	-1.000%	FALL
44	14530.000	14720.000	190.000	22.500	26.000	1.842%	RISE
45	14720.000	14940.000	220.000	26.000	22.600	-1.545%	FALL
46	14940.000	15380.000	440.000	22.600	23.000	0.091%	RISE
47	15380.000	15580.000	200.000	23.000	23.000	0.000%	LEVEL
48	15580.000	15886.507	306.507	23.000	20.000	-0.979%	FALL
49	15886.507	16220.000	333.493	20.000	24.700	1.409%	RISE
50	16220.000	16440.000	220.000	24.700	24.700	0.000%	LEVEL
51	16440.000	16740.000	300.000	24.700	21.000	-1.233%	FALL
52	16740.000	17060.000	320.000	21.000	25.500	1.406%	RISE
53	17060.000	17290.000	230.000	25.500	25.500	0.000%	LEVEL
54	17290.000	17650.000	360.000	25.500	28.800	0.917%	RISE
55	17650.000	18180.000	530.000	28.800	23.000	-1.094%	FALL
56	18180.000	18724.331	544.331	23.000	24.000	0.184%	RISE
57	18724.331	19080.000	355.669	24.000	24.000	0.000%	LEVEL
58	19080.000	19680.000	600.000	24.000	20.000	-0.667%	FALL
59	19680.000	20300.000	620.000	20.000	23.500	0.565%	RISE
60	20300.000	20645.678	345.678	23.500	23.500	0.000%	LEVEL

Table 4.5: Abstract of Gradients

S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. total Alignment length
1	Level	18	5033.570	23.91%
2	> 0% to = 1%	23	9612.618	45.67%
3	> 1% to = 2%	12	4119.493	19.57%
4	> 2% to = 3%	4	1330.000	6.32%
5	> 3% to = 4%	3	953.685	4.53%
	Total	**60**	**21049.366**	**100.00%**

4.2.7 Curvature

There are many sharp turns and curves along the road. This necessitates provision of curves for metro alignment also. The radius of curves is kept as low as 125 m to reduce the property acquisition. Total 49 curves have been provided in this extension. The details of curves and abstracts of horizontal curves are indicated in Table 4.6 and 4.7 respectively.

Table 4.6: Details of Horizontal Curves

Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle			Tangent (m)	Straight Length (m)
				L1	L2	D	M	S		77.842
1	Right	150	27.711	55	55	10	35	05	13.895	155.643
2	Left	400	72.082	50	50	10	19	29	36.139	109.332
3	Left	170	207.557	55	55	69	57	13	118.933	378.494

Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle			Tangent (m)	Straight Length (m)
4	Right	450	25.717	45	45	03	16	27	12.862	26.124
5	Right	125	38.354	55	55	17	34	48	19.329	65.639
6	Right	550	46.702	40	50	04	51	54	23.365	0.000
7	Right	300	68.350	50	55	13	03	14	34.324	65.292
8	Left	125	29.341	55	55	13	26	56	14.738	62.160
9	Right	142	25.570	55	55	10	19	02	12.820	0.000
10	Left	600	24.842	40	40	02	22	20	12.423	0.000
11	Right	500	27.833	45	45	03	11	22	13.920	160.708
12	Left	1800	92.161	20	20	02	56	00	46.091	156.022
13	Right	10000	57.758	10	10	00	19	51	28.879	68.277
14	Left	5000	30.501	20	20	00	20	58	15.251	118.631
15	Right	1010	110.511	30	30	06	16	08	55.311	178.070
16	Left	3500	41.398	20	20	00	40	39	20.699	71.102
17	Right	2000	33.263	20	20	00	57	10	16.632	59.808
18	Left	1500	19.105	20	20	00	43	47	9.552	166.792
19	Right	2000	28.246	20	20	00	48	33	14.123	372.611
20	Left	1750	26.316	15	15	00	51	41	13.158	187.809
21	Left	15500	25.649	10	10	00	05	41	12.824	281.558
22	Left	5000	30.576	20	20	00	21	01	15.288	26.426
23	Right	4500	35.860	10	10	00	27	23	17.930	156.762
24	Left	2500	32.822	20	20	00	45	08	16.411	65. 559
25	Left	1010	103.106	30	30	05	50	56	51.598	240.016
26	Left	8000	31.984	20	20	00	13	44	15.992	272.776
27	Right	5000	39.280	20	20	00	27	00	19.640	94.709
28	Left	5000	55.677	15	15	00	38	16	27.839	57.215
29	Right	2000	22.015	20	20	00	37	50	11.008	393.609
30	Left	490	25.095	50	50	02	56	03	12.550	246.702
31	Left	250	312.366	55	55	71	35	20	180.269	138.924
32	Right	1650	1017.061	20	20	35	19	01	525.268	402.396
33	Right	125	137.898	55	55	63	12	28	137.898	218.848
34	Left	420	108.488	55	55	14	47	59	54.548	553.812
35	Left	140	167.740	55	55	68	38	54	95.588	463.447
36	Right	410	463.363	50	50	64	45	10	259.958	383.633
37	Left	600	213.034	50	50	20	20	35	107.650	757.816
38	Left	2500	96.117	20	20	02	12	10	48.065	1097.695
39	Right	650	356.199	50	50	31	23	52	182.694	227.826
40	Left	800	133.806	40	40	09	34	59	67.059	512.194
41	Left	3500	42.931	20	50	00	42	10	21.466	0.000
42	Left	425	105.118	50	50	14	10	16	52.829	1670.353
43	Right	500	52.220	55	55	05	59	02	26.134	384.400
44	Left	1010	51.229	30	30	02	54	22	25.620	139.854
45	Left	1010	51.157	30	30	02	54	07	25.584	64.057
46	Right	375	25.586	55	55	03	54	33	12.798	484.646
47	Left	350	143.412	55	55	23	28	36	72.726	96.262
48	Left	150	26.382	55	55	10	04	38	13.225	0.000
49	Right	150	23.484	55	55	08	58	12	11.766	649.544

Table 4.7: Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length With TL (m)	% w. r. t. total curved length
1	>125m - 500m	21	4338.667	50.52%
2	>500m - 1020m	9	1780.586	20.73%
3	>1020m - 1500m	1	59.105	0.69%
4	>1500m - 2500m	8	1658.001	19.31%
5	>2500m - 5000m	7	556.223	6.48%
6	>5000m - 15500m	3	195.391	2.28%
	Total	**49**	**8587.973**	**100.00%**

4.3 CIVIL STRUCTURE AND CONSTRUCTION METHODOLOGY

4.3.1 Viaduct – Elevated Structure

4.3.1.1 Choice of Superstructure

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

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

In case of this extension, it is suggested to use Double U-Girder in the superstructure upto radius 300m because of the following merits:

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

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

4.3.2 Pre-Cast Construction

4.3.2.1 Casting of U-Girder

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

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

4.3.2.2 Erection of U-Girder

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

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

4.3.3 Structural System of Viaduct

4.3.3.1Superstructure

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

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

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

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

4.3.3.2Substructure

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

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

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

The transverse spacing between bearings would be about 3.2 m (however its exact dimension to be decided by the DDC).

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

4.3.4 Construction of Stations

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

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

4.3.5 Grade of Concrete

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

i)	Piles	-	M -35
ii)	Pile cap and open foundation	-	M -35
iii)	Piers	-	M -40

iv)	All precast element for viaduct and station	-	M -45
v)	Cantilever piers and portals	-	M -45/M -60
vi)	Other miscellaneous structure	-	M -30

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

4.3.6 Reinforcement and pre-stressed Steel

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

4.3.7 Road width required during construction

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

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

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

4.4 GEOTECHNICAL INVESTIGATIONS

4.4.1 General Geology & Related Characteristics:

The region around the project constitutes thick pile of nearly horizontal, subsequent flows of Deccan Trap basalt of Upper Cretaceous to Eocene geologic age. The thickness of individual flow of basalt varies from few meters to few tens of meters. Most of the flows exhibit amygdaloidal structure with few exceptions of massive / compact / compact porphyritic types. These flows broadly exhibit lithologic structure of “aa” type of flows having a very few exceptions of “pahoehoe” type. However, the “aa” type of flows have thin layer of tuff breccia with glassy and or earthy pyroclastic glassy material. Many places ground mass of amygdaloidal basalt contains earthy ash like pyroclastic material. Well jointed flows are noticed at some places. The flows of basalt more or less have uniformity in their lithologic characteristics, particularly in mineralogic, textural and structural characteristics. Most of the flows of basalt contain earthy pyroclastic glassy material in ground mass.

These flows of basalt are intruded with dykes at several places. Several nearly vertical fractures / shears without displacement are noticed. Most of the flows exhibit horizontality, however slight amount of dips have been noticed in the Mumbai region including Chembur.

As per IS1893-2002; the area of the site has been classified as volcanic rocks and minor basic intrusive. The Igneous rocks are generally of horizontal deposition. However, the inclination of the rock layers near the Mumbai region range between 5 to 15 degrees with the horizontal.

The surface of the rock, at several locations, is completely weathered. With depth, the completely weathered bedrock grades into the original bedrock. The core recovery and Rock Quality Designation (RQD) give an indication of the degree of weathering.

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

4.4.3 Methodology of Investigation

Methodology of Field Work:

a) **Drilling in Overburden:** The drilling was commenced by driving a casing of suitable diameter in the upper layers of the bore holes. Drilling was carried out as per IS 1892 -1979 through 150 mm dia. bore holes.

Standard Penetration Test (SPT):
SPT's were conducted as per IS 2131-1981. In a SPT test, a standard split spoon sampler is driven at the bottom of the borehole. The penetration resistance in terms of blows for 300mm penetration of the split spoon sampler is measured as 'N' Value. The blows are imparted by a standard weight of 63.5 kg falling through a height of 750 mm. The resistance is measured for 150 mm, 300 mm, and 450 mm penetrations. The resistance of first 150 mm is ignored since those blows are considered as seating blows due to the loosening of the strata. The resistance of next 300 mm is recorded as standard penetration value 'N`. If the sampler is driven less than 450 mm (total) then the penetration resistance is given for the last 300 mm of penetration. If the penetration depth is less than 300 mm and the blow count is more than 50 then the 'N' value is considered as 'Refusal' and actual penetration is recorded with the blows given.

b) **Drilling hard strata /Rock:** The hard stratum is confirmed by either the refusal from SPT or due to resistance during the drilling operation. Once the hard stratum is met with, further drilling is carried out by Nx core drilling with TC/Diamond bits. The work is done generally as per IS 6926-1973. Each run of the core drilling is properly recorded. At the end of each run the drill rod string with core barrel is extracted and core is recovered. The cores are carefully transferred to the core boxes and preserved. The core recovery percentage is recorded and also the core pieces transferred to the core box are numbered and labeled properly. Rock Quality Designation (RQD) is also recorded. Some of the cores are sent to the laboratory for conducting tests. Rock Core Recovery (C.R. % = (Cumulative Length of Cores/Length of run) x 100) and Rock Quality

Designation (RQD) is (RQD = (Total Length of core pieces of 100.0mm & above in Length / Length of run) x 100).

Laboratory Tests:

1. Laboratory tests were conducted on the collected disturbed and undisturbed soil samples and rock samples as per the relevant IS Codes.
2. Chemical tests were conducted on representative soil and ground water samples to determine pH value, chlorides percentage and sulphate percentage.

4.4.4 Field Investigation

Detailed field investigations have been carried out between June 2018 and August 2018 on the Metro corridor under study.

4.4.4.1 Borehole Details

Table 4.8: Borehole Location, Reduced Levels and Termination Depths

BH. No.	Location	Co-ordinates		Reduced Level (m)	Borehole Termination Depth (m)
		Northing	Easting		
BH-01	Near Kalyan Bail Bazar, Kalyan-Shil Road, Kalyan (W)	2127929	302662	6.228	21.00
BH-02	Near Shubhankar Hospital, Netivali, Kalyan-Shil Road, Kalyan (E)	2126960	302764	16.742	10.50
BH-03	Near BPCL Petrol Pump, Tata Power, Kalyan-Shil Road, Kalyan (E)	2125962	302212	27.041	11.00
BH-04	Near Hotel Suyog, Vicco Naka, Village-Golivali, Kalyan-Shil Road, Dombivali (E)	2125007	301389	13.790	9.70
BH-05	Near Jondhale Collage Bus Stop, Kalyan-Shil Road, Dombivali (E)	2124267	300670	13.396	13.10
BH-06	Opp. S. V. Business P. Ltd, Midc Ph – 2, Sonarpada, Kalyan-Shil Road, Dombivali (E)	2123432	299965	13.087	15.50
BH-07	Near Bpcl Petrol Pump, Manpada, Kalyan-Shil Road, Dombivali (E)	2122143	299153	18.787	14.50
BH-08	Back Side Of Premier Colony, Manpada, Kalyan-Shil Road, Dombivali (E)	2121794	299446	16.877	14.00
BH-09	Pipeline, Village-Hedutne, Katai-Ambernath Road, Dombivali (E)	2121009	300062	12.748	10.10
BH-10	Back Side Of Gavdevi Temple, Village-Hedutne, Dombivali (E)	2120286	299777	18.141	9.50
BH-11	Near Primary Health Centre, Village-Nilje, Dombivali (E)	2119538	299413	13.118	15.00
BH-12	Near Village Shirdhon, Dombivali (E)	2118730	299766	12.137	10.70
BH-13	Near Village-Vadavali Khurd,	2117708	299537	16.168	11.70

BH. No.	Location	Co-ordinates		Reduced Level (m)	Borehole Termination Depth (m)
		Northing	Easting		
	Dombivali (E)				
BH-14	Opp. Posu Bal Patil Vidyalay, Village-Bale-Wakalan, Dombivali (E)	2116650	299560	16.570	8.00
BH-15	Back Side Of Nandini Bear Shop, Dahisar-Wakalan Road, Village-Wakalan, Dombivali (E)	2115750	299503	16.805	8.50

4.4.5 Foundation Recommendations

Weathered bedrock is encountered at depths typically ranging between 1.0 m to 8.0 m below ground level. Foundations for proposed structures should be supported on hard rock. Depths to weathered and hard rock are summarized in below. Foundations installed on this hard rock can be designed for a net allowable bearing capacity of 130 t/m^2.

Table 4.9: Depth to Weathered Rock below GL

S. No.	Borehole No.	Depth to weathered rock (m)	Depth to hard rock (m)	Allowable bearing capacity (t/m^2)
1	BH-01	5.10	14.50	130
2	BH-02	3.00	5.50	
3	BH-03	1.60	6.00	
4	BH-04	3.00	4.70	
5	BH-05	6.50	6.50	
6	BH-06	3.10	8.50	
7	BH-07	8.00	9.50	
8	BH-08	4.50	7.50	
9	BH-09	5.00	5.00	
10	BH-10	1.00	1.00	
11	BH-11	1.70	3.50	
12	BH-12	3.00	5.50	
13	BH-13	1.54	3.00	
14	BH-14	1.00	2.00	
15	BH-15	1.00	3.50	
16	BH-16	3.00	4.50	
17	BH-17	4.50	8.50	
18	BH-18	7.50	11.50	
19	BH-18A	3.00	4.50	
20	BH-19	3.00	3.00	
21	BH-20	2.10	5.50	
22	BH-21	4.50	8.00	

A modulus of subgrade reaction of 10833 t/m3 can be utilized for design of Spread /raft foundation. Excavation sides should be sloped at a maximum of 1:1 or flatter. If adequate space is not available for side slope excavations bored cast in situ piles as recommended in 4.4.6 shall be utilized.

4.4.6 Bored Piles

As mentioned in the previous section, Bored cast in situ piles can be utilized for proposed corridor. Depth of rock socketing, representative diameter of piles and their safe pile capacities provided in Table 4.10 below.

TABLE 4.10: Safe Capacity of Piles

BH No.	Pile Diameter, D (mm)	Pile Rock Socketing in weathered rock	Cut of Level (mm)	Safe Vertical Downward Capacity (tons)	Safe Lateral Capacity (tons)	Safe Uplift Capacity (tons)
BH-1	800	6D	1200	245	25	95
	1000		1500	380	36	150
BH-2	800	5D	1200	220	25	80
	1000		1500	345	36	125
BH-3	800		1200	220	25	80
	1000		1500	345	36	125
BH-4	800		1200	220	25	80
	1000		1500	345	36	125
BH-5	800	4D	1200	365	25	80
	1000		1500	570	36	125
BH-6	800		1200	195	3.6	65
	1000		1500	310	5.0	100
BH-7	800		1200	195	25	65
	1000		1500	310	36	100
BH-8	800		1200	195	25	65
	1000		1500	310	36	100
BH-9	800	2D	1200	330	24	57
	1000		1500	520	35	85
BH-11	800	3D	1200	175	25	49
	1000		1500	270	36	75
BH-12	800	4D	1200	195	25	65
	1000		1500	310	36	100
BH-13	800	2D	1200	150	25	30
	1000		1500	235	36	50
BH-15	800	3D	1200	175	25	49
	1000		1500	270	36	75
BH-16	800		1200	175	25	49
	1000		1500	270	36	75
BH-17	800	5D	1200	220	25	80
	1000		1500	345	36	125
BH-18	800		1200	220	18	80
	1000		1500	345	25	125
BH-18A	800	1D	1200	325	25	50
	1000		1500	480	36	65

BH No.	Pile Diameter, D (mm)	Pile Rock Socketing in weathered rock	Cut of Level (mm)	Safe Vertical Downward Capacity (tons)	Safe Lateral Capacity (tons)	Safe Uplift Capacity (tons)
BH-19	800		1200	350	25	65
	1000		1500	510	36	85
BH-20	800	4D	1200	195	18	65
	1000		1500	310	25	100
BH-21	800		1200	195	25	65
	1000		1500	310	36	100

Maximum total settlement of piles installed as described above will be less than 12mm. The range of depth of fixity for lateral loads will be 1.5D in weathered rock.

4.4.7 Foundation Protection

Soil and Groundwater samples for chemical analysis were collected from boreholes at this site. Results of chemical analysis are summarized in Table given below. It is recommended to use ground water for construction purpose.

Table 4.11: Results of Chemical Analysis Soil Samples

Property	Range	Remarks (Limits as per IS456-2000)
pH	6.74 to 7.88	6 to 9
Sulphate as SO_3 (%)	0.005 to 0.010	<0.2% (Class I)
Chlorides as Cl (%)	0.022 to 0.034	No limit specified in IS456. However, a value <0.05% specified for Class I in CIRIA Sp. Publication No. 31.

Table 4.12: Results of Chemical Analysis of Ground Water Samples

Property	Range	Remarks (Limits as per IS456-2000)
pH	6.21 to 7.44	6 to 9
Sulphate as SO_3 (PPM)	4.80 to 8.23	<300 PPM (Class I)
Chlorides as Cl (PPM)	18.34 to 28.99	No limit specified in IS456. However, a range of <500-<2500 ppm specified for Class I in CIRIA Sp. Publication No. 31.

A 'Normal/Moderate' exposure condition was assigned to this site. Therefore, following precautions given in Table below are recommended to protect subsurface concrete and reinforcement as per IRC 78-2014 and updated amendments and IS 456:2000.

Table 4.13

	Shallow Foundation	Bored Piles
Grade of Concrete	M 25	M 35
Min. cement contents	300 kg/m^3	400 kg/m^3

	Shallow Foundation	Bored Piles
Max. W.C. ratio	0.5	0.4
Min. cover to reinforcement	50mm	75mm

4.5 UTILITY IDENTIFICATION

4.5.1 Introduction

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

Large number of sub-surface, surface and overhead utility services viz. sewers, water mains, storm water drains, telephone cables, O.H electrical transmission lines, electric poles, traffic signals, etc. are existing along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance. Meticulous planning therefore will have to be taken in tackling the issue of protection/diversion of these utility services.

4.5.2 Utilities owning Organizations/Departments agencies along the corridors

Organizations/Departments with concerned utility services in Mumbai are mentioned in **Table 4.14.**

Table 4.14: UTILITY RESPONSIBILITY DEPARTMENTS

S. No.	Name of Utility	Organizations/Departments
1	WATER SUPPLY	KDMC, MIDC, TMC, PMC, NMMC
2	SEWERAGE	KDMC, MIDC, TMC, PMC, NMMC
3	STORM WATER DRAINAGE	KDMC, MIDC, TMC, PMC, NMMC
4	MTNL	Office of DGM, Planning
5	ELECTRIC CABLES AND LINE	Reliance Energy, MSEB, MSEDCL (Maharashtra State Electricity Distribution Company Limited), MSETCL (Maharashtra State Electricity Transmission Company Limited), Tata underground distribution Tata overhead high tension transmission lines. Tata raw power supply for metro operation (traction & auxiliary load)
6	GAS PIPELINES	Mahanagar Gas Limited (MGL)
7	MOBILE PHONE	Vodafone TTML TATA Communications Airtel Bharat Sanchar Nigam Limited Reliance Telecom

4.5.3 Details of Above Ground Utilities

Affected above ground utilities have been identified based on topographical survey maps. The details have been placed in the following tables;

Table No. 4.15: Details of the HT tower line

S.No.	Location Chainage(m)	Position w.r.t alignment	Affected Length (m)
1	1398	Across	
2	1433	Across	
3	1480	Across	
4	1534	Across	
5	1765	Across	
6	1775	Across	
7	3318-3458	Along	140
8	3900-4185	Along	285
9	4500-4580	Along	80
10	7830	Across	
11	13220	Across	
12	13290	Across	
13	14175	Across	
14	14360	Across	
15	19215	Across	
16	19365	Across	

Table No. 4.16: Details of the Electric line

S.No.	Location Chainage(m)	Position w.r.t alignment	Affected Length (m)
1	566	Across	
2	600	Across	
3	1080	Across	
4	1260	Across	
5	1290	Across	
6	1605	Across	
7	1764	Across	
8	1882-1953	Along	71
9	1980-2100	Along	120
10	2215	Across	
11	2620-2670	Along	50
12	2773-2835	Along	62
13	6715-6835	Along	120
14	8928	Across	
15	9140	Across	
16	9223	Across	
17	13778	Across	
18	14617	Across	
19	14720	Across	
20	15350	Across	
21	17887	Across	
22	18705	Across	

Table No. 4.17: Other Affected Services

S. No	Description	Number
1.	Lamp Post	446
2.	Manhole	81
3.	Electric Pole	67

4.5.4 Details of Underground Utilities

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

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

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

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

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

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

Sewer Lines, Strom Water Drains and Water Lines: The sewer/drainage lines generally exist in the service lanes i.e. away from main carriageway. However, in certain stretches, these have come near the central verge or under main carriageway, as a result of subsequent road widening. The major sewer/drainage lines and water mains running across the alignment and likely to be affected due to location of column foundations are proposed to be taken care of by relocating on column supports of viaduct by change in span or by suitably adjusting the layout of pile foundations. Where, this is not feasible, lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility services lines.

4.6 LAND ACQUISITION

4.6.1 Land

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

Land Requirement for following Major Components

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

4.6.2 Land Requirement for Elevated Stretches

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

The normal viaduct structure of elevated Metro with double U-girder is about 9.9 m (edge to edge) wide. However, for reasons of safety a clean marginal distance/set back of about 5 m is necessary from either edge of the viaduct (or 10 m on both sides of the centre line) wherein no structures are to be located. This is necessary as the traction system as proposed is overhead 25 KV AC system with masts fixed on the parapets. Also, it ensures road access and working space all along the viaduct for working of emergency equipment and fire brigade. In stretches, where the elevated alignment has to be located away from road, a strip of 20-m width is proposed for acquisition.

In view of the constraints on space on ground, it is proposed to provide the concourse area on the mezzanine level. All the stations in elevated stretch including terminal station are planned with single side discharge platforms. Normally, the width required for stations is 21 m. The staircases giving access to concourse area from ground have been proposed as per site conditions and constraints. Nevertheless it is not possible to find open space at all the locations therefore acquisition of certain private structures is inevitable.

4.6.3 Land for Traffic Integration

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

4.6.4 Land for Depot

Depot for this corridor has been proposed in land identified by MMRDA at Pisarve Village. Hence an area of 20 ha Private-Agricultural land has been earmarked.

4.6.5 Land for Traction and Receiving Substation and Radio Towers

Two RSS, one near Sagaon and other at Depot near Pisarve Depot station are proposed to be located for this corridor. Hence, an area of 11,200m^2 (Private-Agricultural) has been earmarked. Exact location will be decided at the time of implementation of the project. No additional land proposed for locating radio towers. These will be accommodated in the land already acquired.

4.6.6 Land Requirement for Stations & Running section

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

To the extent possible the Entry and Exit points of stations were planned out of ROW of Road. For estimation of running section land, a 20 m wide strip is considered for the section proposed on private-agricultural land and for estimation of land for entry-exit at stations, four 450 sq.m parcels are considered at each station.

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

A large number of officers and staff will be required to be deployed permanently to take care of project implementation and post construction operational activities. Moreover Metro Office Complex and Metro Operation Control Centre (OCC) will also be required. Metro Office Complex will be same for all the proposed metro lines, therefore no separate office complex is proposed for this extension. It is proposed to keep the provision of **0.5 ha and 1 ha** of private-agricultural land for OCC and staff quarters respectively. Exact location of land has not been identified at this stage. It may be decided at the time of project implementation.

4.6.8 Temporary office accommodation

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

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

Table 4.18: Details of Temporary Land office accommodation

S. No.	Corridor	AREA (m^2)	
		Pvt. (Agri.)	Pvt.
1	Kalyan to Taloja	6000	2000
	Total	**6000**	**2000**

4.6.9 Casting Yard

Pre-cast girders are required for construction of elevated structures for which a large open area is required for setting up of casting yard. As far as possible, this area should be close to the site, easily accessible and away from habitation. Considering the various factors, it is proposed to setup four casting yards for the proposed extension. Accordingly a provision of **8ha** land has been proposed on temporary basis considering 2.0 ha of land for each casting yard for a period of four years.

4.6.10 Summary of Land Requirements

Abstract of land requirements for different components of this proposed extension are given in **Table 4.19 and Table 4.20**.

Table 4.19 Summary of Permanent Land Requirement (All figures in Sq. m)

S.No.	Description	Pvt. (agri.)	Pvt.	Total
1	Stations	21600	10800	**32400**
2	Running Section	249506.2	0	**249506.2**
3	Depot	200000	0	**200000**
4	Staff Quarters	10000	0	**10000**
5	Office Complex and OCC	5000	0	**5000**
6	RSS	11200	0	**11200**
	Total	**497306.2**	**10800**	**508106.2**

Total Permanent Land = 50.811 ha
Permanent Land (Pvt. Agri) = 49.731 ha
Permanent Land (Pvt.) = 1.08 ha

Table 4.20 - Summary of Temporary Land Requirement (All figures in Sq. m)

S. No.	Description	Area in sq. m	
		Pvt. (Agri.)	Pvt.
1	Temporary Office/ Site Office	6000	2000
2	Segment Casting Yard	60000	20000
	Total	**66000**	**22000**

Total land required for temporary acquisition is **6.6ha (Pvt. Agri) and 2.2 ha (Pvt.)**.

4.7 SAFETY & SECURITY SYSTEMS

4.7.1 General

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

4.7.1.2 Requirements

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

4.7.2 Fire Alarm System

4.7.2.1 General

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

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

4.7.2.2 Scope

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

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

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

4.7.2.3 System Components

Fire Alarm Control Panel

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

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

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

4.7.2.4 Addressable Pull Stations (Manual Call Point):

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

4.7.2.5 Intelligent Photo - Electric Smoke Detector:

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

4.7.2.6 Addressable Control Module:

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

4.7.2.7 Isolator Module:

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

4.7.3 Fire Hydrant System:

4.7.3.1 General

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

4.7.3.2 Scope

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

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

Fire Hydrant System comprises of the following:

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

Hydrant System is proposed to be installed at following Places

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

4.7.3.3 System Component

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

4.7.3.4 Landing Valve

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

4.7.3.5 Hoses

Hose is a flexible tube used to carry water

4.7.3.6 Hose Reel

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

4.7.3.7 Coupling

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

4.7.3.8 Fire Brigade Connector

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

4.7.4 Sprinkler System

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

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

Sprinkler System is proposed to be installed at following places

i. Building Passages.
ii. Basement Area.
iii. OCC room.
iv. Equipment room.
v. Store room.

4.7.5 Fire Extinguishers

4.7.5.1 General

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

4.7.5.2 Scope

Types of Extinguishers:

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

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

4.7.5.3 Description

Carbon Di Oxide (CO_2) Fire Extinguishers

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

4.7.5.4 ABC Dry Powder - Fire Extinguishers

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

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

4.7.5.5 Water Type Fire Extinguishers

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

4.7.5.6 Glow Signs

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

4.7.6 Closed Circuit Television

4.7.6.1 General

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

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

CCTV monitoring shall cover the following areas:

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

4.7.6.2 Description:

CCTV comprises of the following components:

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

4.7.6.3 Integrated Port Cameras:

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

4.7.6.4 Computer

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

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

4.7.6.5 Software

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

4.7.6.6 Server Software

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

Server maintains a catalog of settings for all clients. It also encodes & decodes of stored information through I P cameras.
Software enables the client to dynamically create connections between Cameras and workstations and view live or recorded video on the digital monitors (Audio, video, serial ports and digital I/Os)

4.7.6.7 Client Software

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

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

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

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

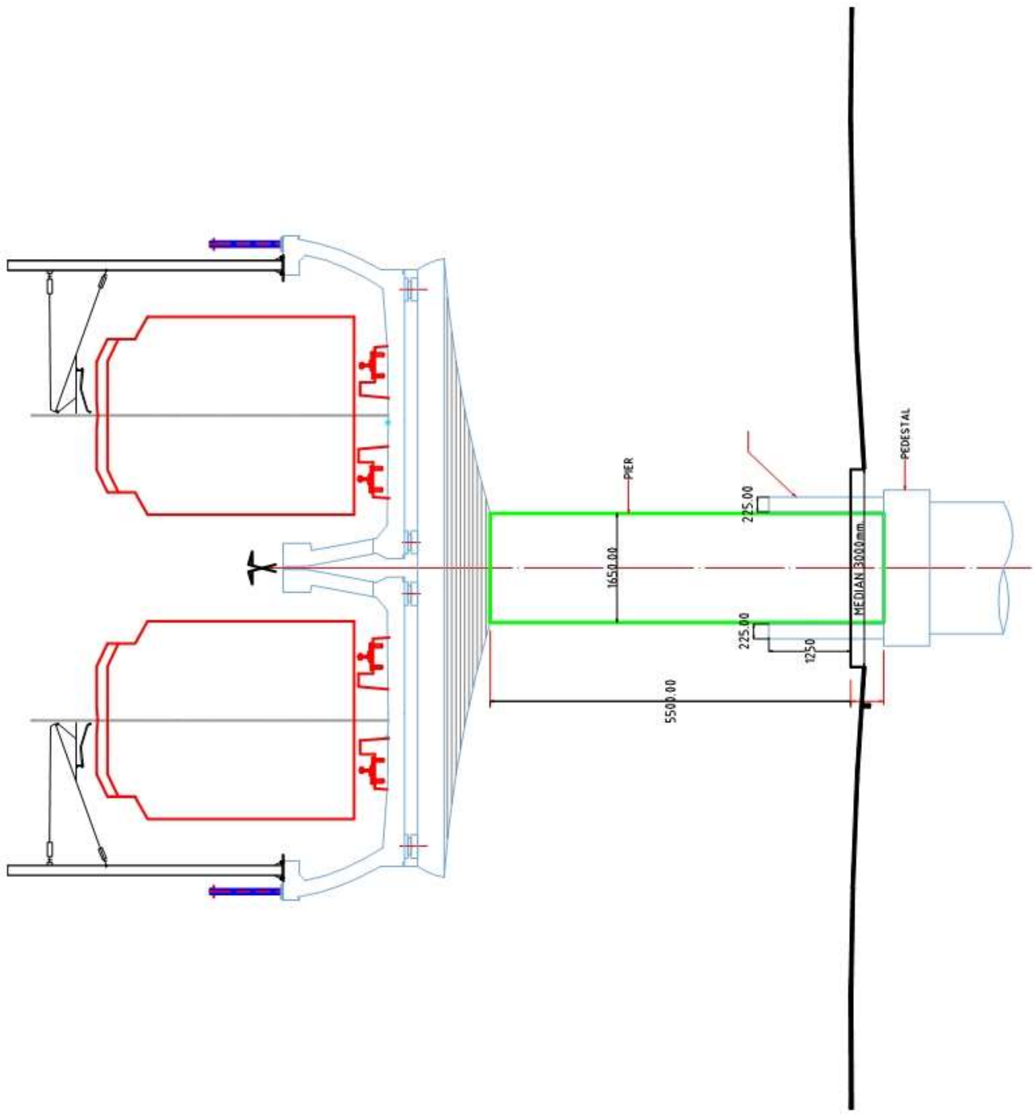
Client application is to control pan-tilt-zoom, iris, focus, presets and dome patterns of the PTZ camera for correct functioning of the system.
Software provides utility to play multiple exported clips simultaneously. It also provides the ability to play multiple clips in time sync with each other to understand the sequence of events occurred during an emergency.

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

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

Figure 4.1

TYPICAL CROSS SECTION OF THE VIADUCT WITH DOUBLE U GIRDER



SCALE:- NTS

Figure 4.2(a): Erection of Girder using Crane

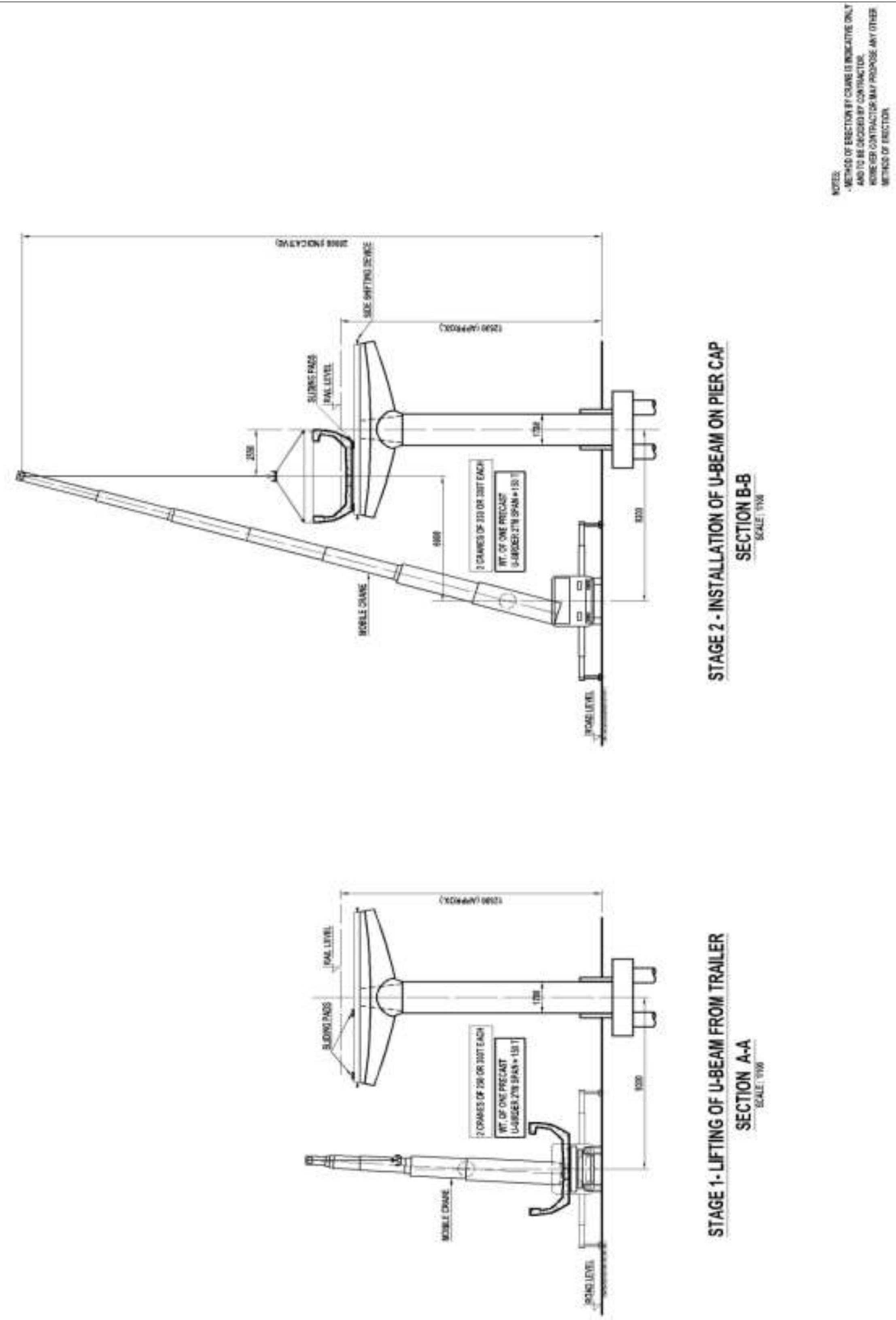
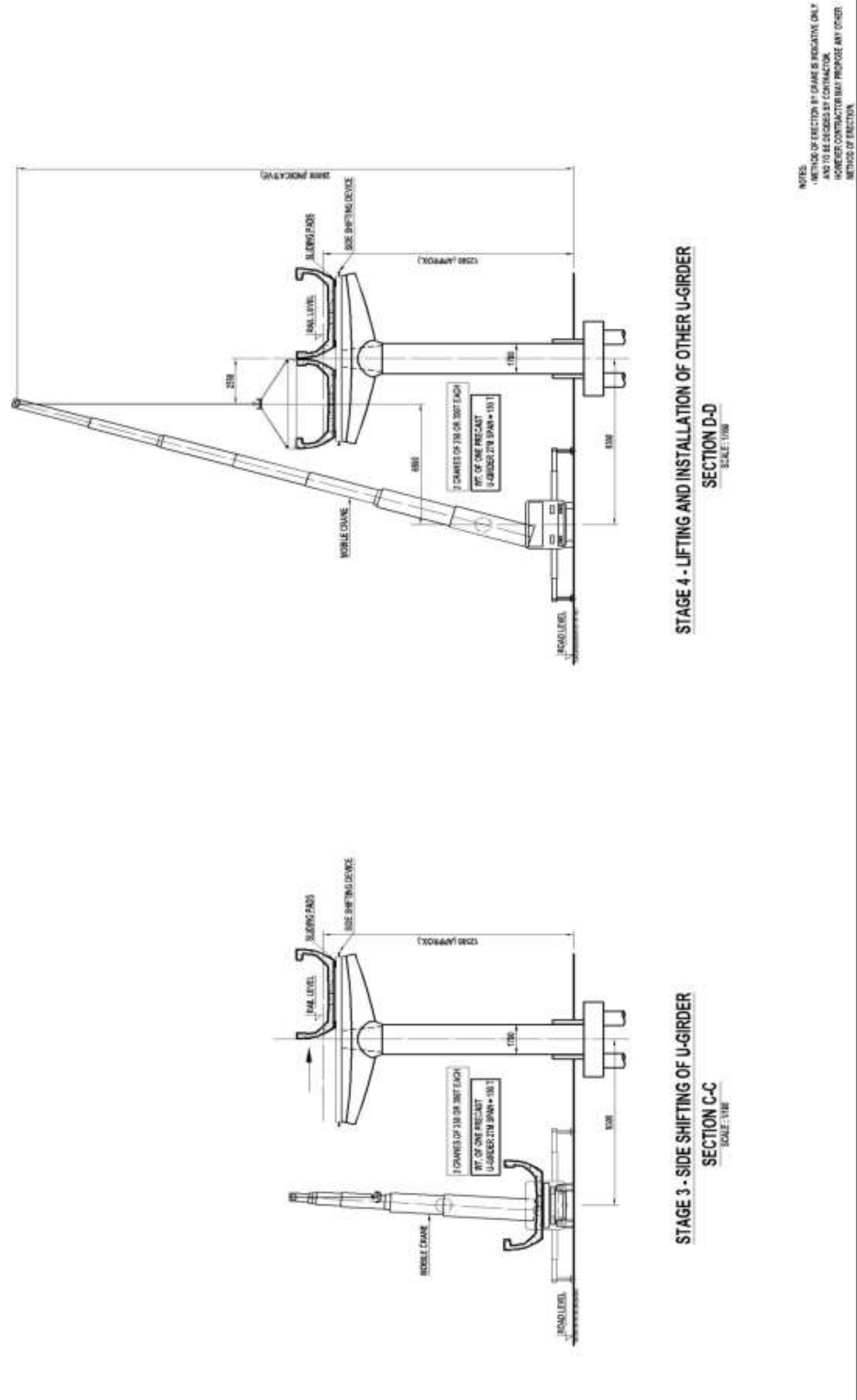


Figure 4.2(b): Erection of Girder using Crane

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CH: 843.771m
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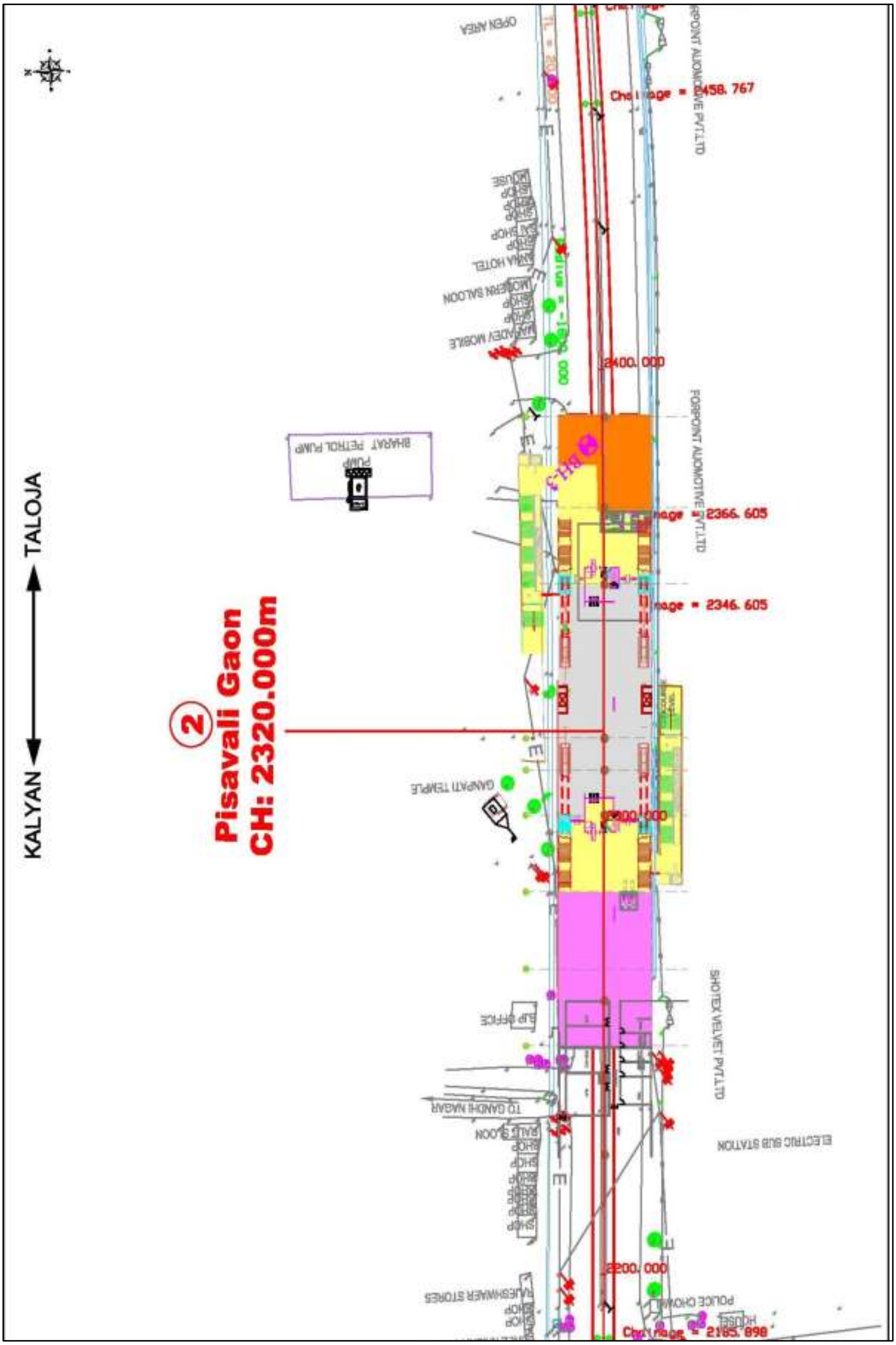
METRO JUNCTION BUS STOP
900. 000
800. 000
700. 000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FORPOINT AUTOMOTIVE PVT.LTD
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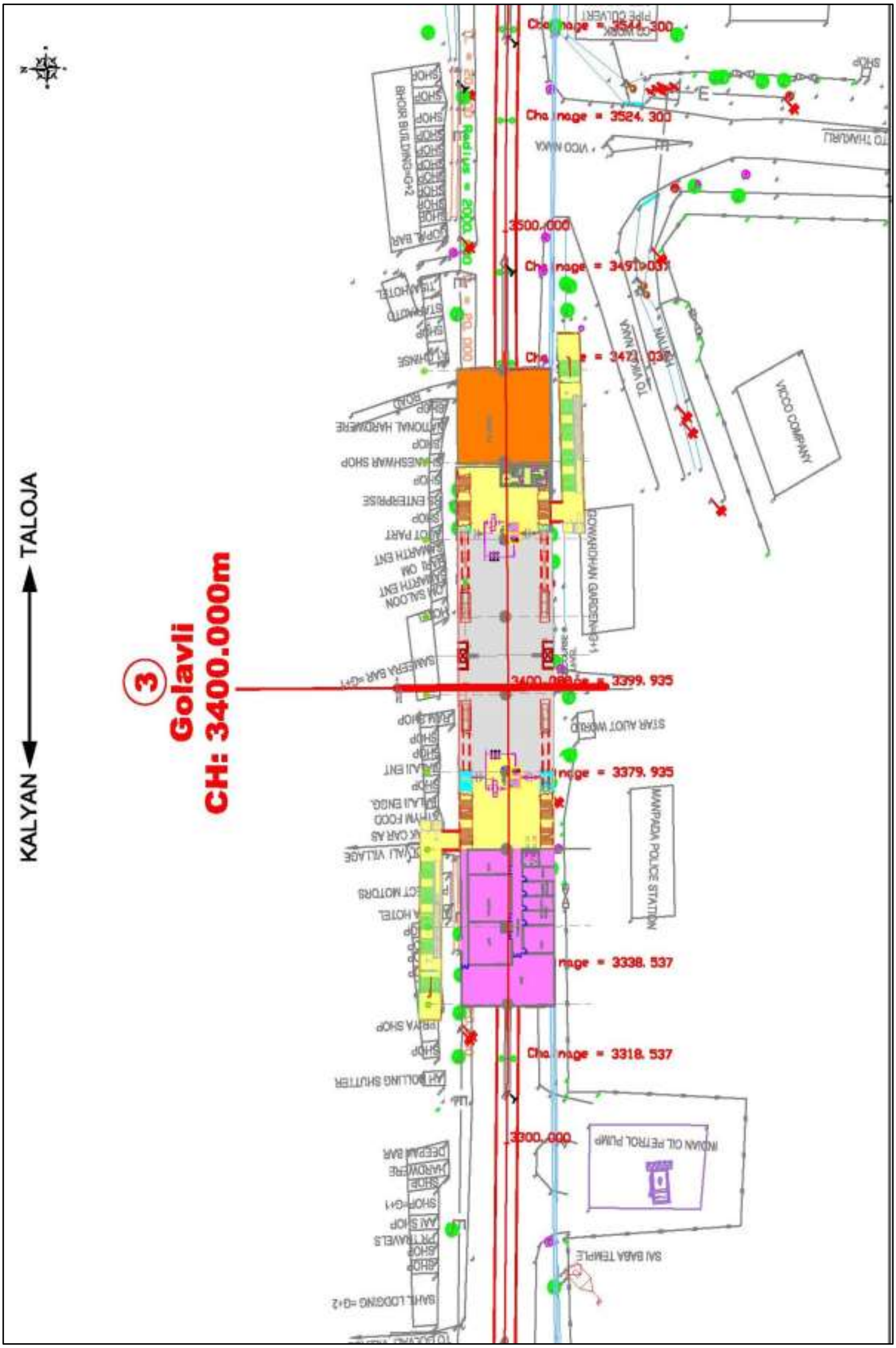
TO GANDHI NAGAR
POLICE CHOWKY
OPEN AREA
2400.000
2200.000



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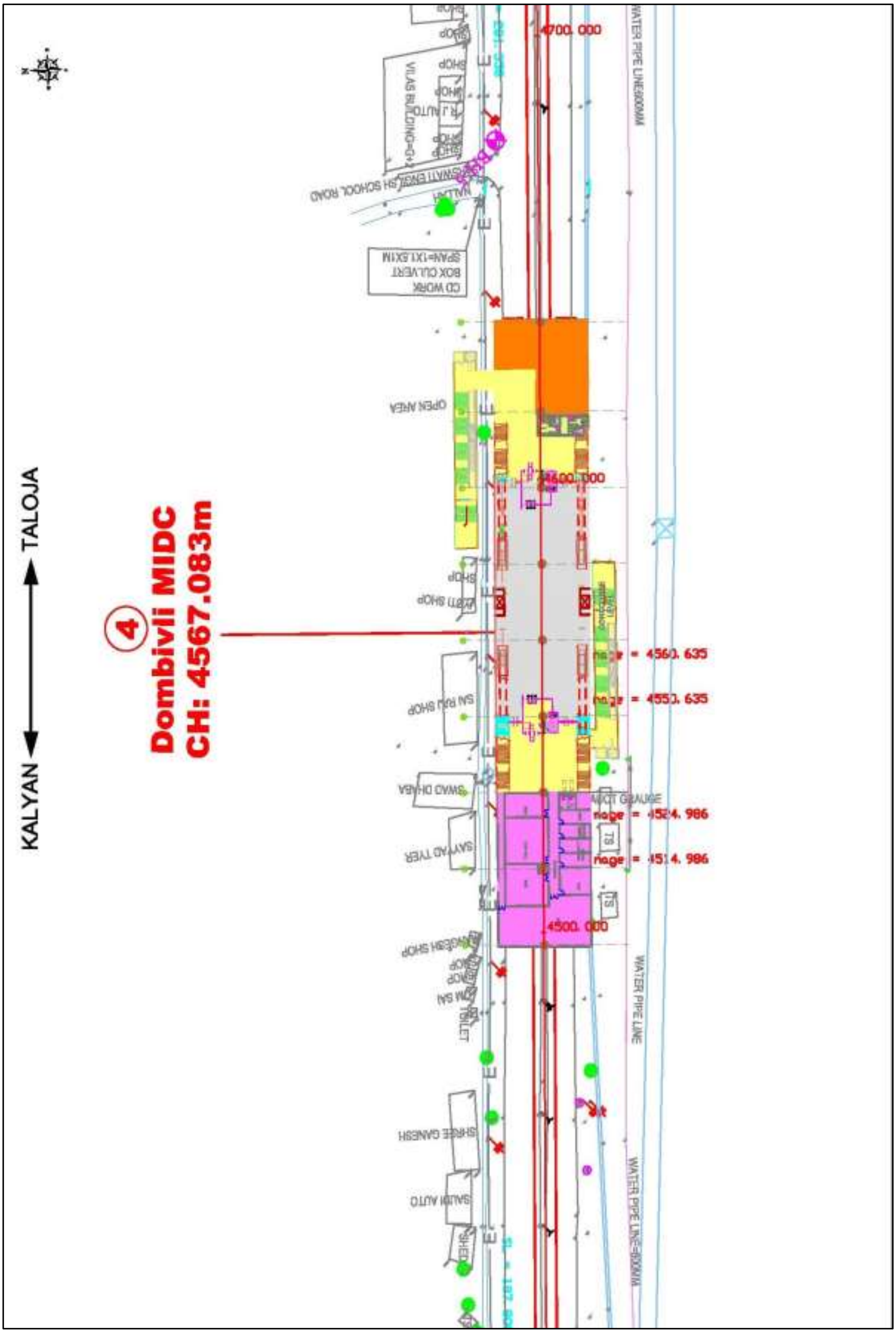
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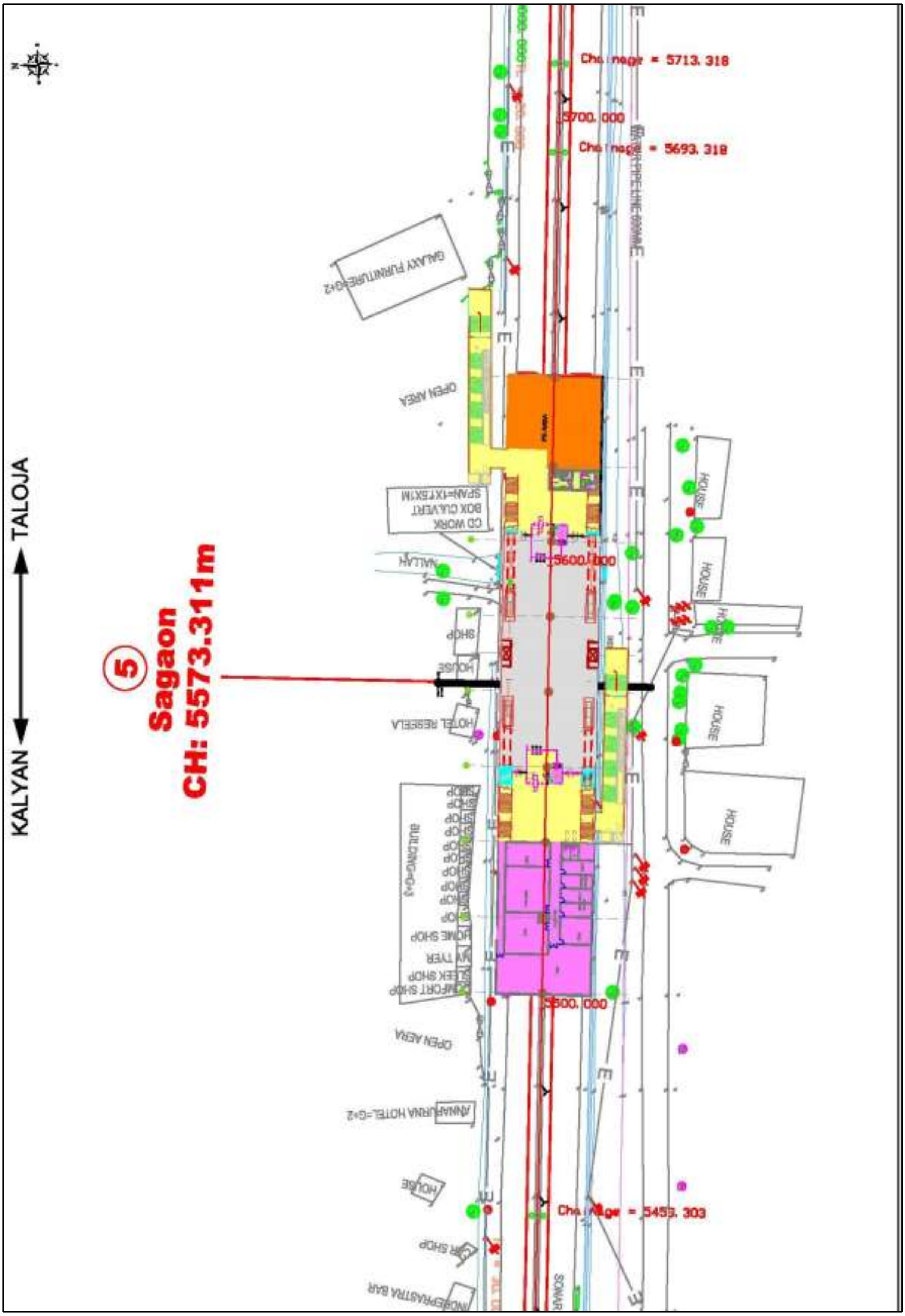
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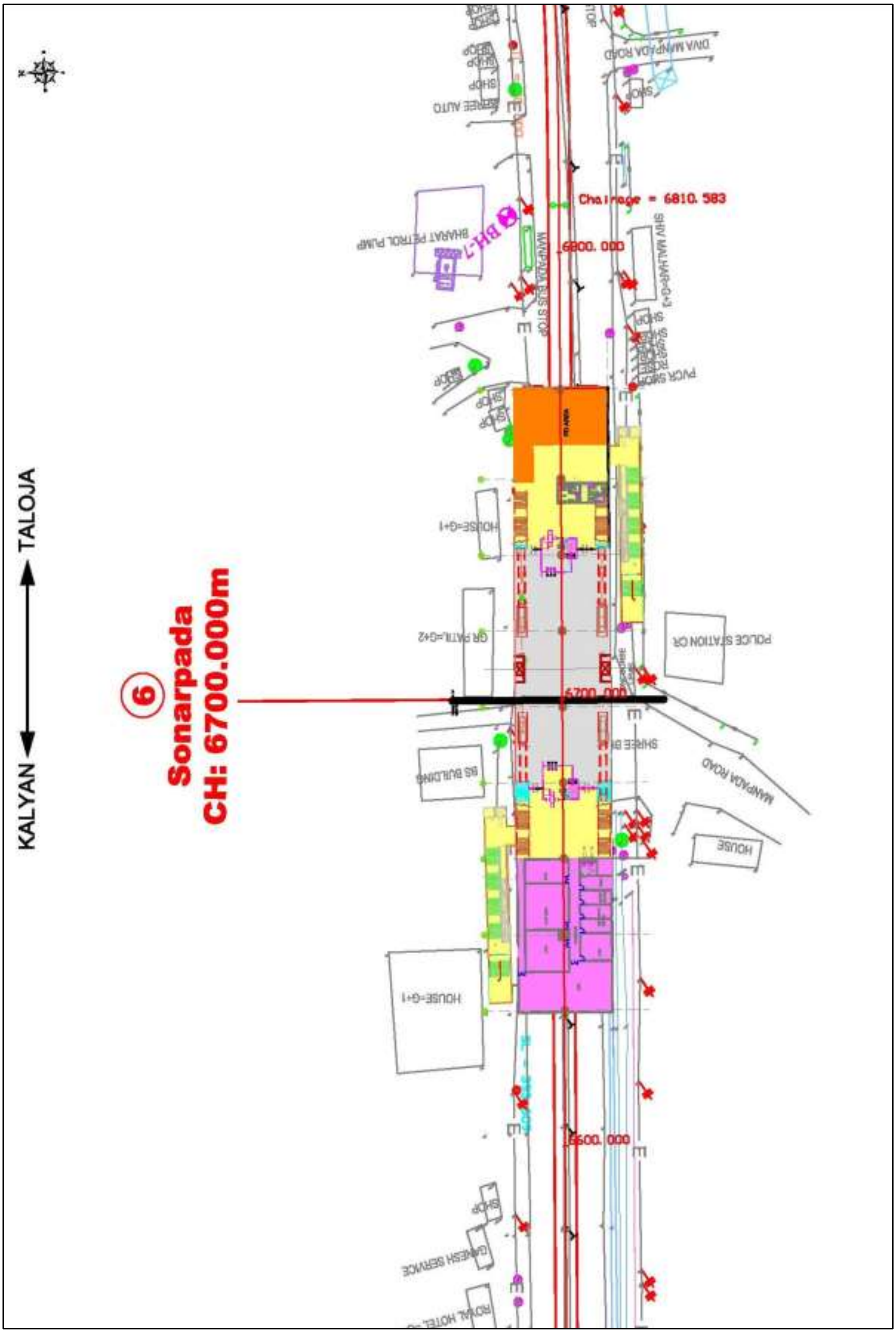
HOUSE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MANPADA BUS STOP
SHIV MALHAR=G+3
DIVA MANPADA ROAD
HOUSE=G+1
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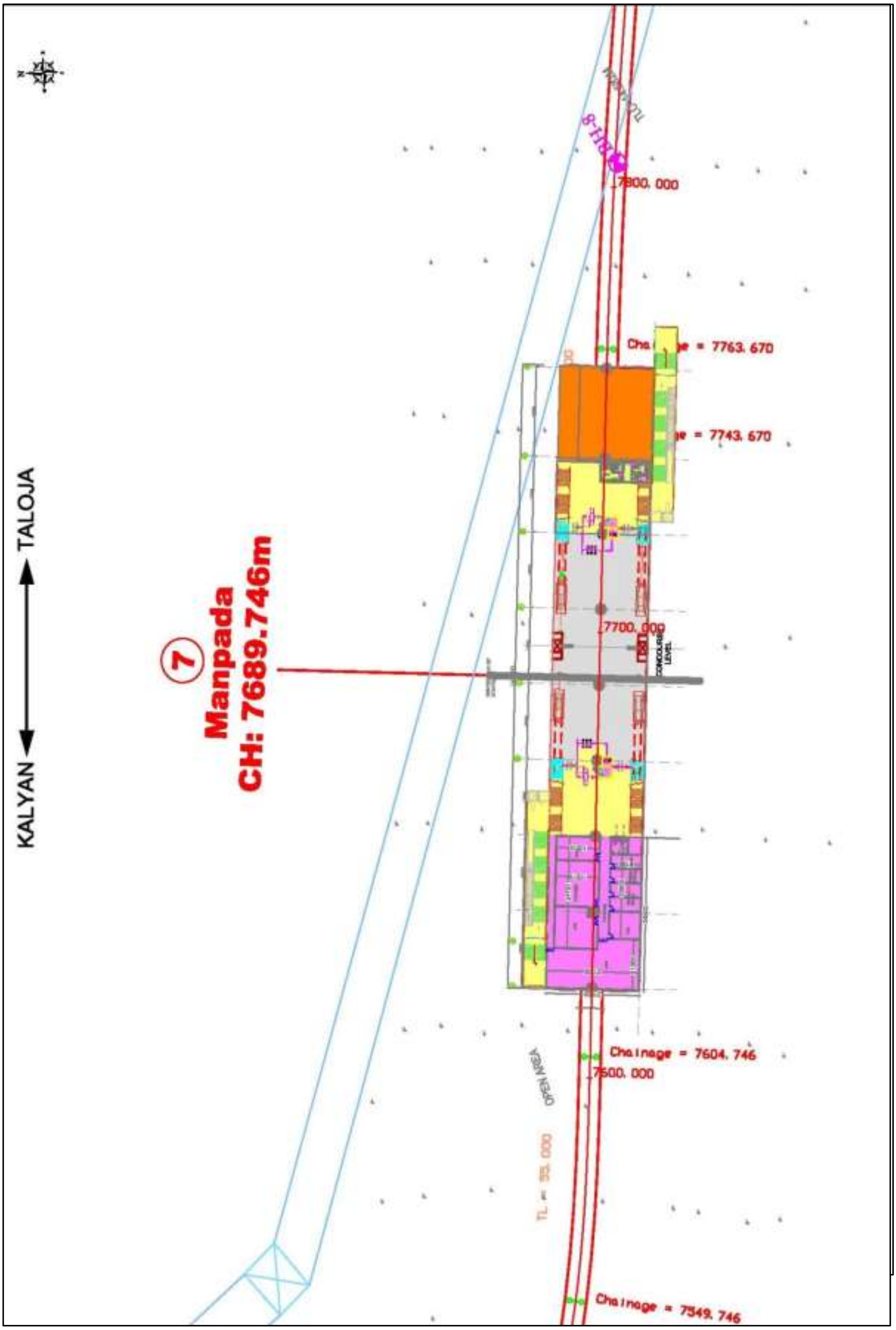
POLICE STATION CR
SS BUILDING
MANPADA ROAD
HOUSE
GANESH SERVICE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7600.000
OPEN AREA
TL = 55.000
Chainage = 7549.746


KALYAN
TALOJA
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HEDUTANE VILLAGE LAND
PRIVATE
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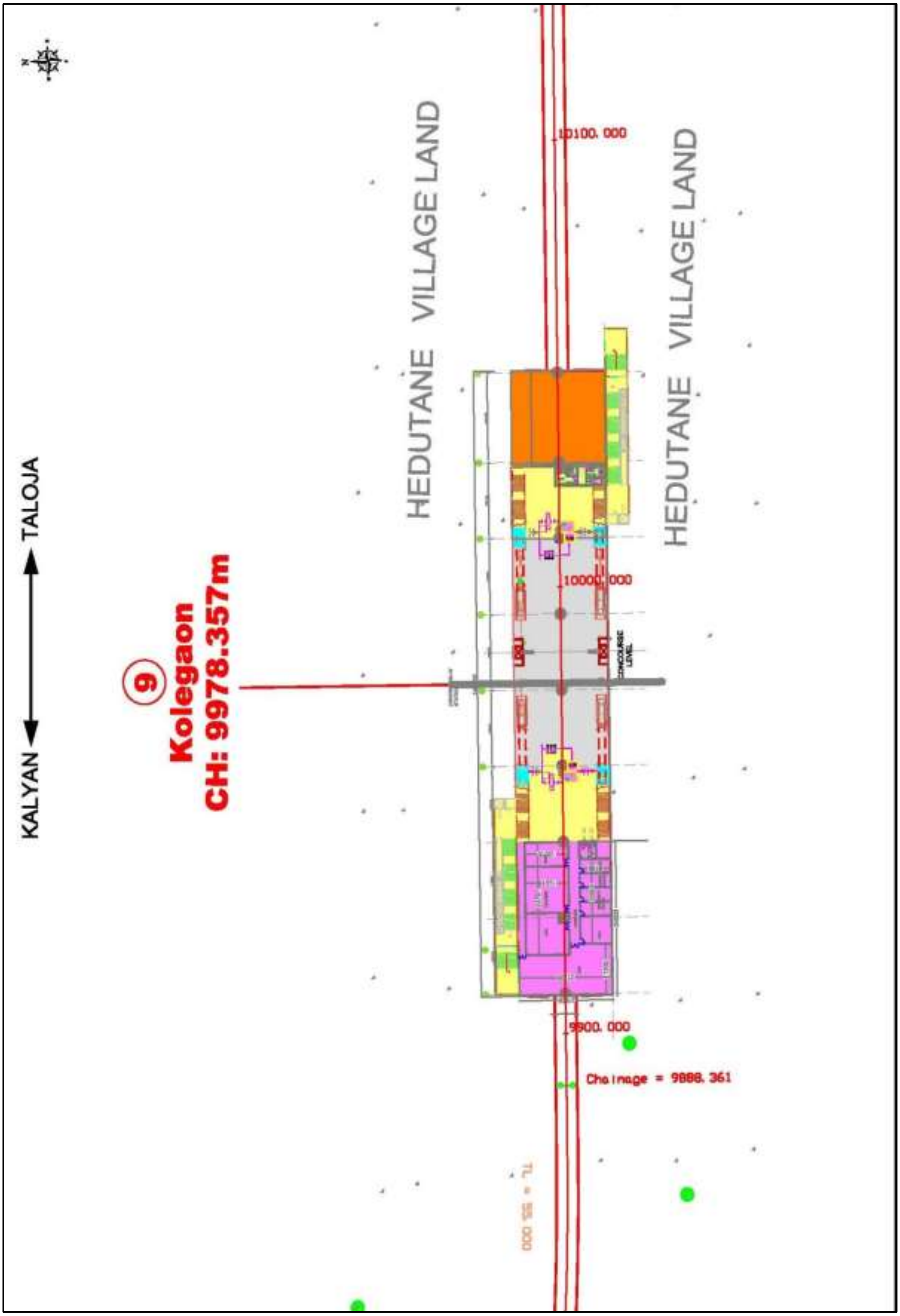
8900.000
BH-9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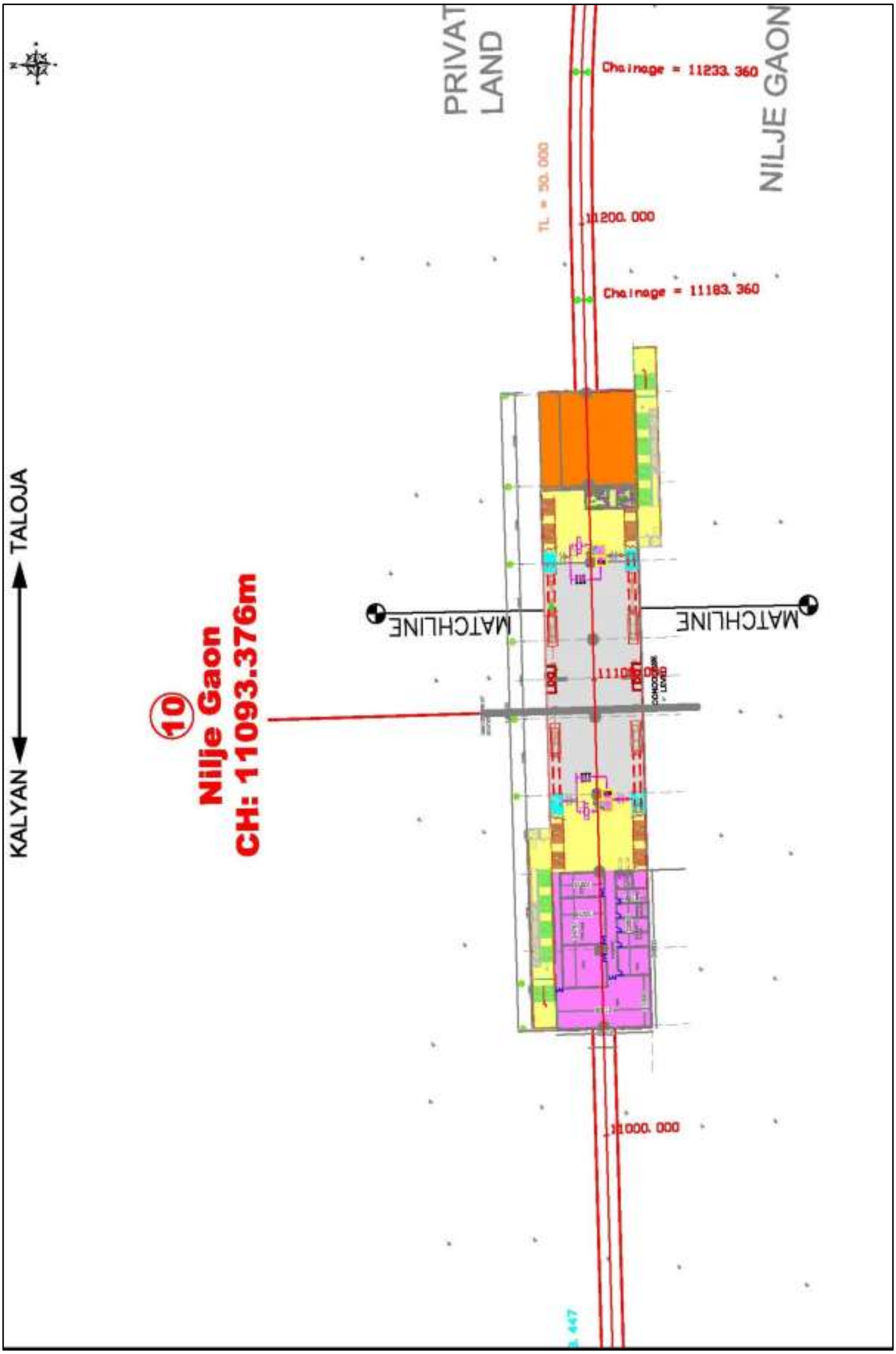
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MATCHLINE
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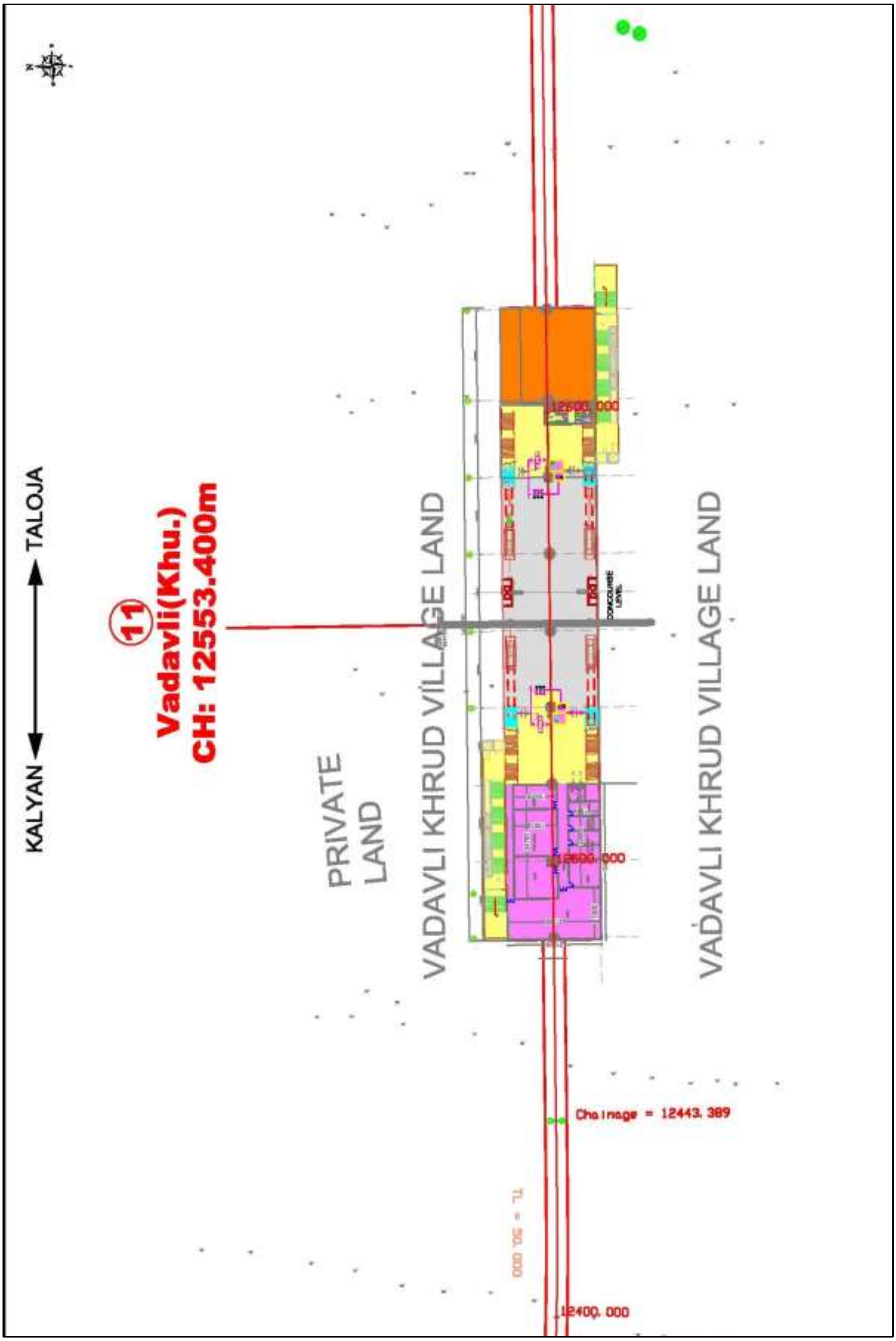
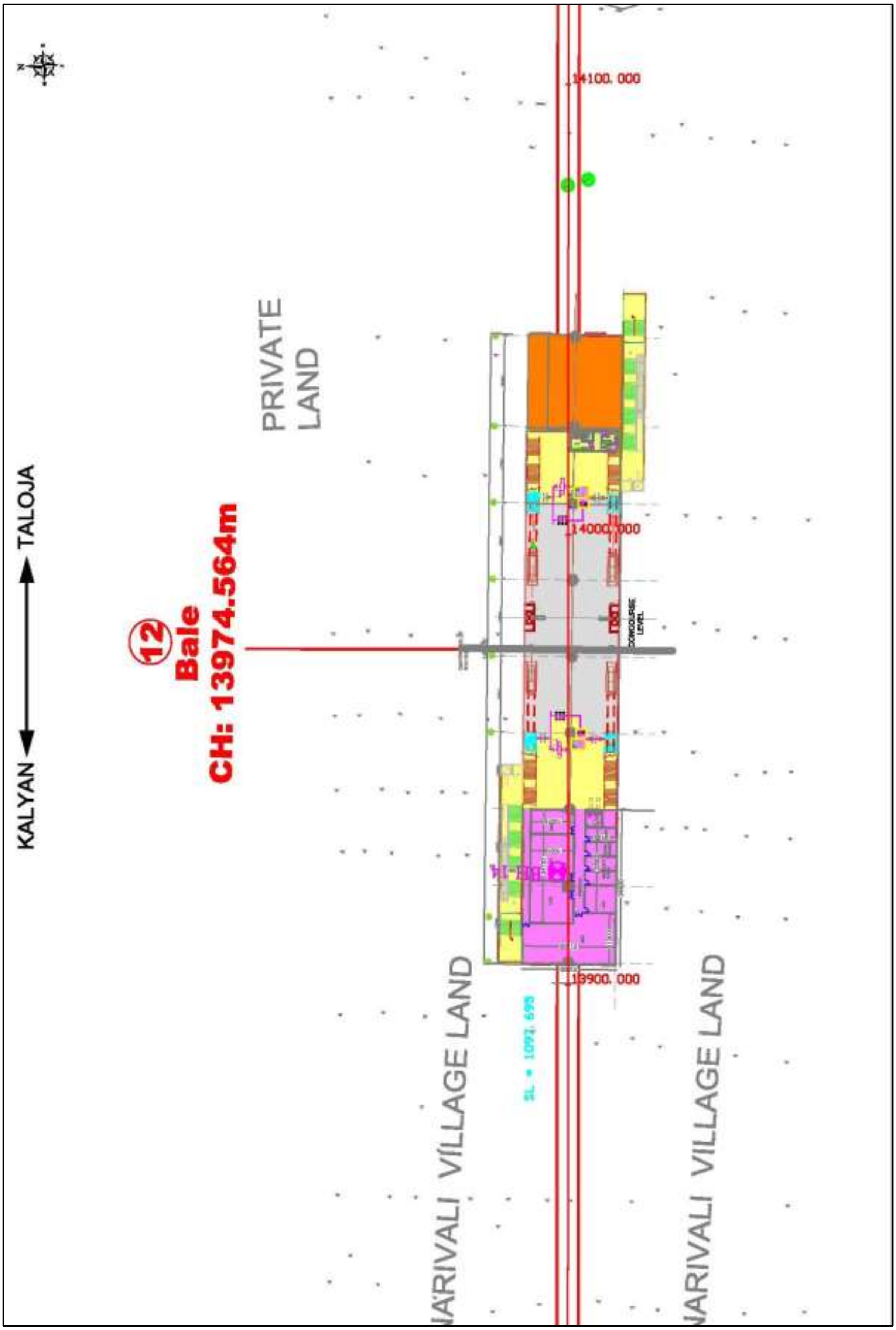
11000.000
TL = 50.000


KALYAN
TALOJA
11
Vadavli(Khu.)
CH: 12553.400m
PRIVATE LAND
VADAVLI KHRUD VILLAGE LAND
VADAVLI KHRUD VILLAGE LAND
12600.000
Chainage = 12443.389
12400.000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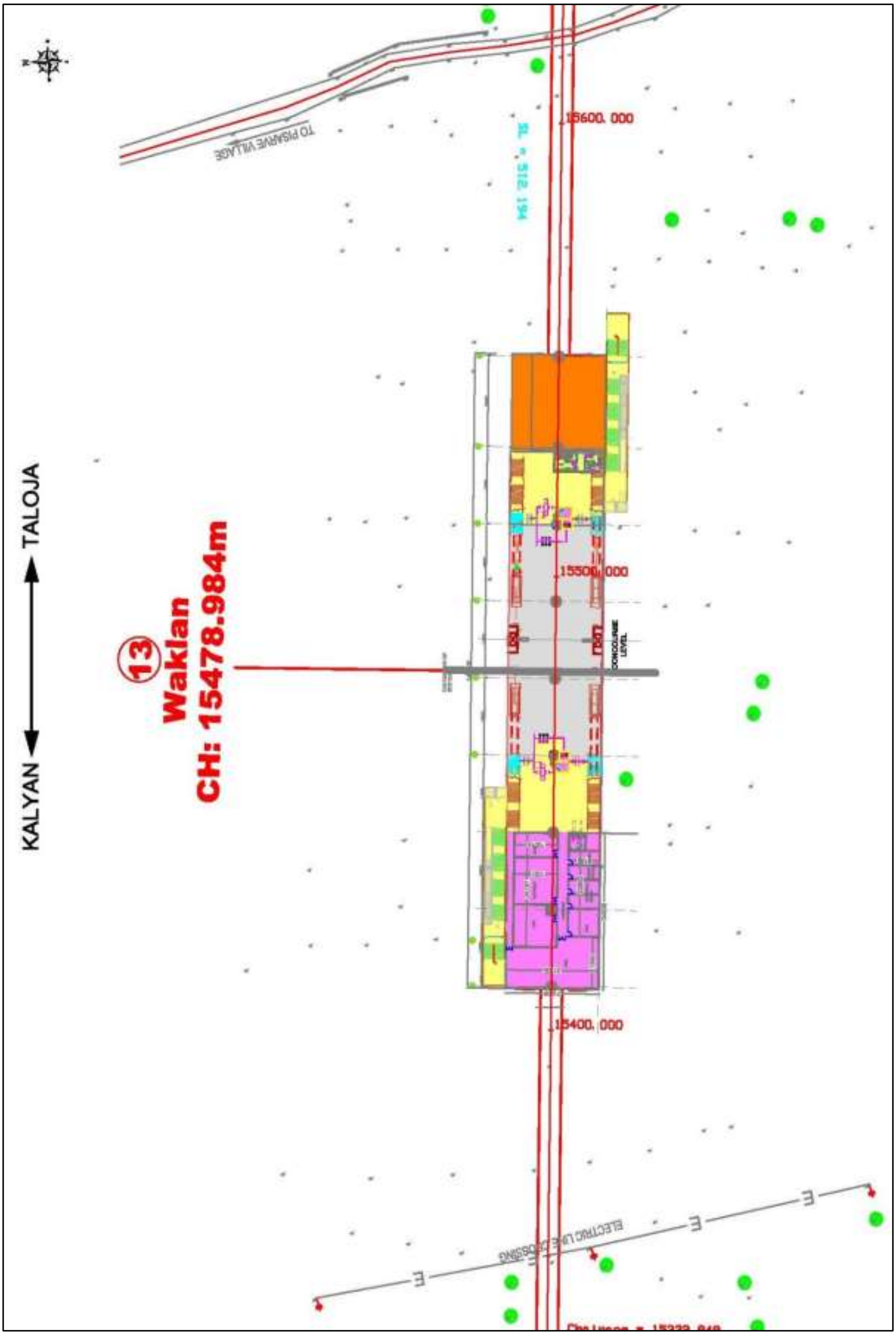
TALOJA
12
Bale
CH: 13974.564m
PRIVATE LAND
ARIVALI VILLAGE LAND
ARIVALI VILLAGE LAND
14100.000
14000.000
13900.000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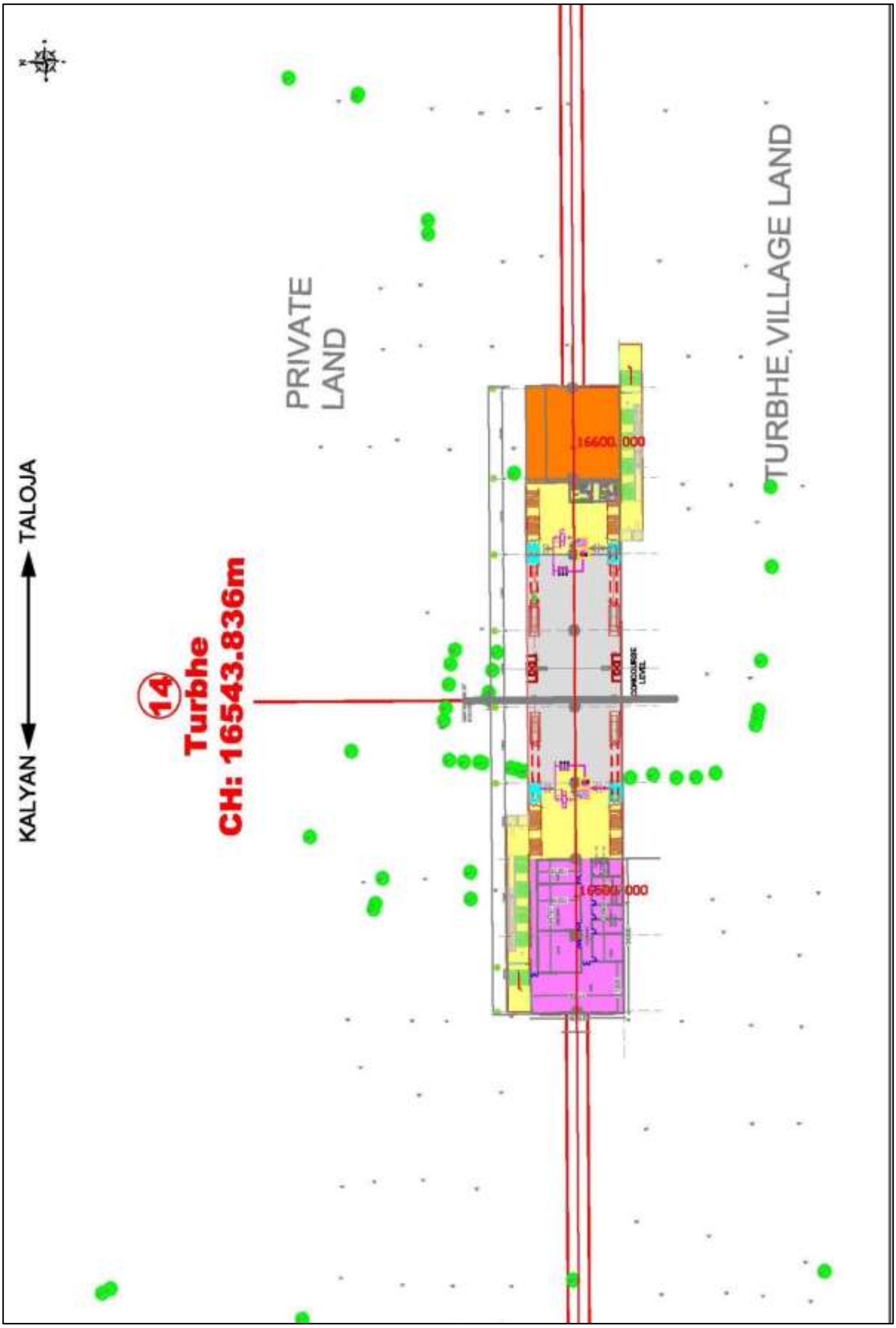
13
Waklan
CH: 15478.984m
15600. 000
15500. 000
15400. 000
TO PISARVE VILLAGE
ELECTRIC LINE CROSSING
CONCOURSE LEVEL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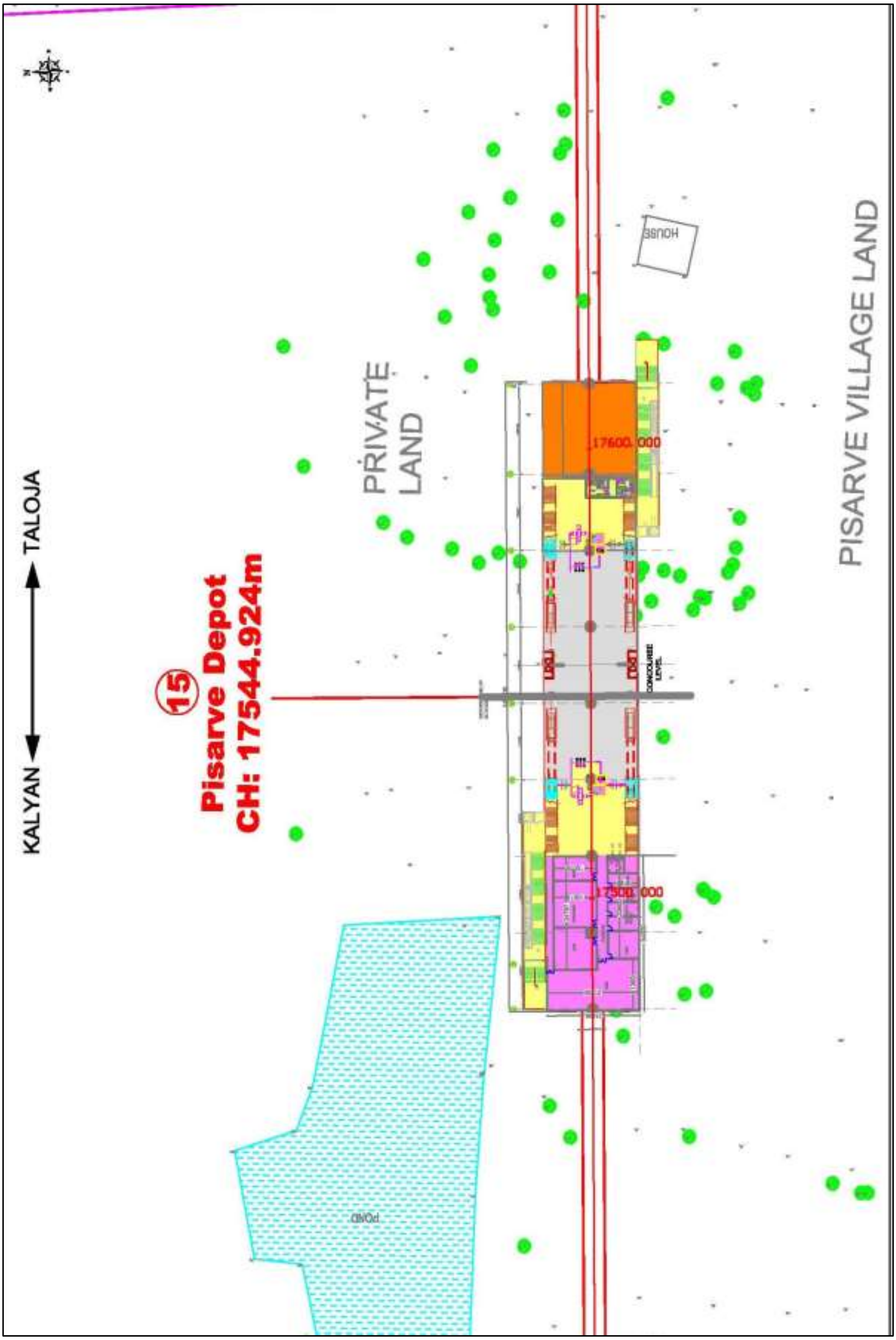
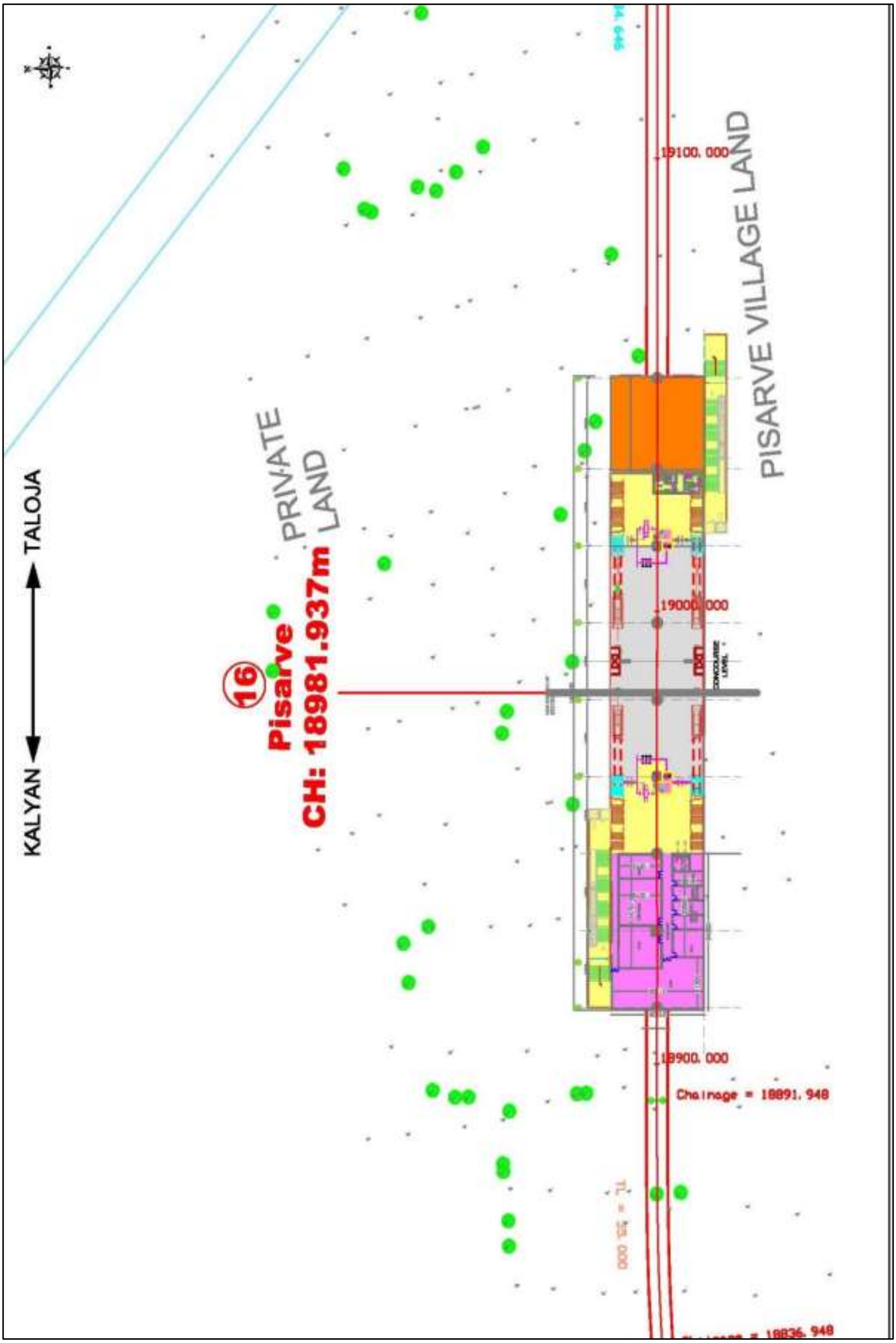
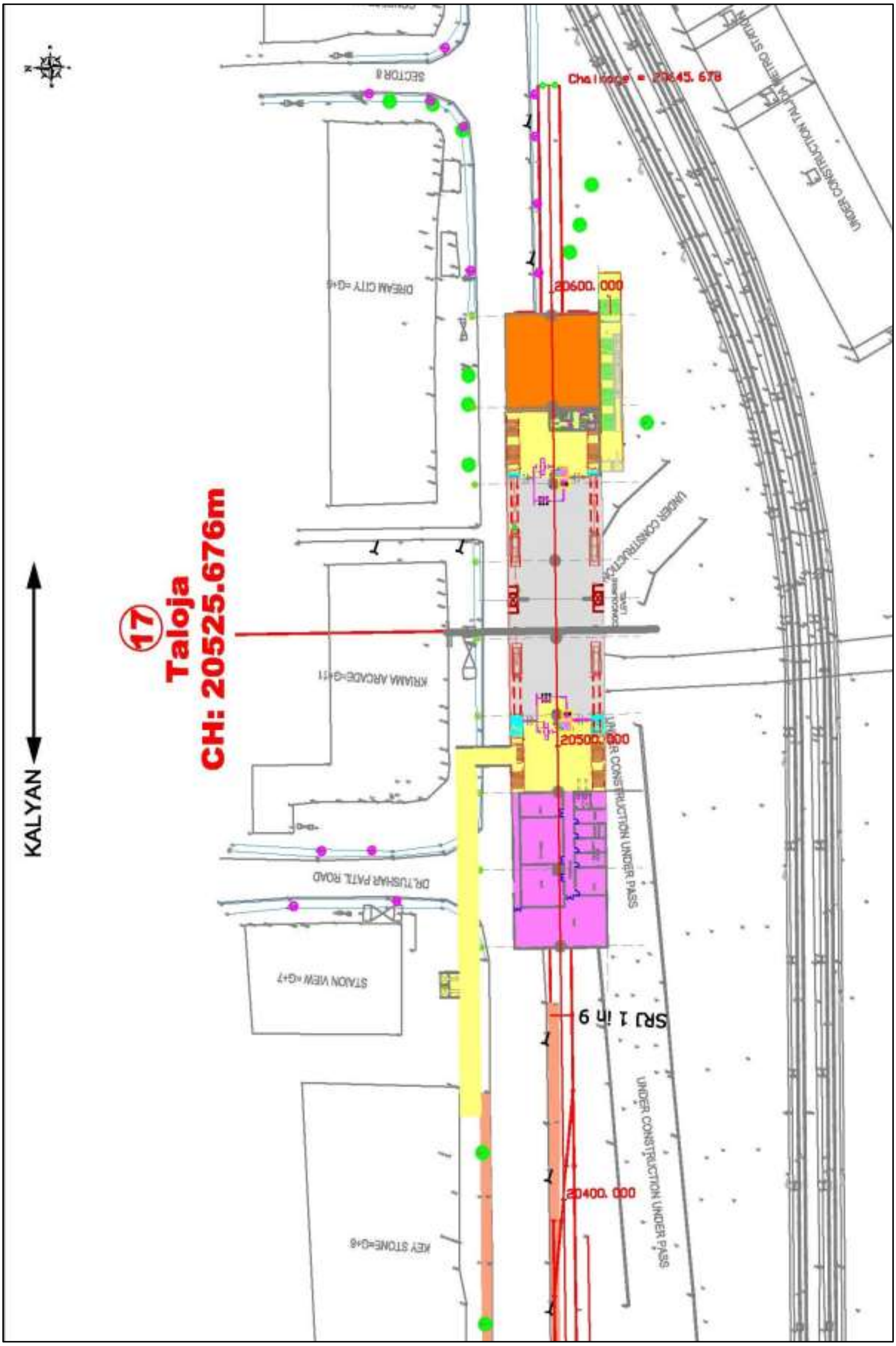
TALOJA
14
Turbhe
CH: 16543.836m
PRIVATE LAND
TURBHE VILLAGE LAND
16600.000


KALYAN
TALOJA
15
Pisarve Depot
CH: 17544.924m
PRIVATE LAND
PISARVE VILLAGE LAND
17600.000
17500.000
HOUSE
POND


KALYAN
TALOJA
PRIVATE LAND
PISARVE VILLAGE LAND
16
Pisarve
CH: 18981.937m
19100.000
19000.000
18900.000
Chainage = 18891.948


KALYAN
17
Taloja
CH: 20525.676m
20600.000
20500.000
20400.000
UNDER CONSTRUCTION UNDER PASS
DR.TUSHAR PATIL ROAD
SECTOR 8
KEY STONE=G+6

Annexure-4.1

SELECTION OF TYPE OF ALIGNMENT

The metro network may have the under-mentioned three types of alignments:

1. At-Grade
2. Elevated
3. Under-ground

1. At Grade - At-Grade type of alignment is technically feasible only in the areas where vacant land is available or a dedicated corridor of 14 meters width is provided in the mid of the road. However, the main limitation of providing At-Grade corridor is that city is divided in two parts and any crossing from one side to other side of At-Grade corridor has to be provided by grade separation i.e., either foot-over bridge or under passes. This alternative is the most economical. However, it should be noted that cost saving is only in Civil Engineering cost which is arrived if the land cost requirement for at grade alignment is taken into account and cost per km may come even more than elevated. Therefore, At-Grade type of alignment for metro systems in cities is normally ruled out.

2. Elevated – Elevated alignment is generally provided in the cities for metro network, but the pre-requisite is the right of way (ROW) of road should minimum be 20 meters. It will enable to provide a median of about 2.8 to 3.0 meters wide road, two lane each way (7 meters width) and foot-path 1.5 meter each way. The land requirement for elevated alignment is mainly for the exit and entries for the station. As the alignment pillars located on median of the roads, a rough estimate of land requirement is about 240 sq. meters on either side of the road, wherein even underground water tank and generator rooms can be accommodated under the staircase. Construction of elevated station is much easier, 8 meter wide strip for the platform length (say 185 meters) will be required temporarily for putting the pillars on the median. Small area of about 400 sq. meters is needed for execution of the work of exit and entries on either side of the road.

3. Under-ground – This type of alignment is adopted only in case when ROW is less than 20 meters and alignment has to necessarily pass through the area where no roads are available. In this case only station locations where metro stations can conveniently located are identified and these are joined by under-ground tunnels. However, under-ground station need much ground surface area than elevated station for the reasons that in case of under-ground station, there is a space requirement for chiller plants in addition to exit and entries, which may be almost same as required for elevated station. Normally, the construction of under-ground stations require the area with 240 meters length and 24 meters width which need to be cut open. Finding out such a big space for construction of under-ground station in a congested city and even on passenger roads is very difficult if not impossible. For construction of under-ground station, the traffic is

necessarily required to be diverted. Advantages and dis-advantages of these two types of alignments are given in the table below:

S. No.	Item name	Under-ground alignment	Elevated alignment
1.	Permanent land	More area required	Comparatively less area required
2.	Land requirement for construction	Much more area required. At least twice of what required for elevated station	Area requirement is much less than under-ground
3.	Construction time	At least 5 years	At least 3 and 1/2 years
4.	Cost of construction	2.25 to 2.50 times of elevated cost.	Much cheaper compared to underground
5.	Operation cost	1.25 to 1.5 times of elevated operation cost	Much cheaper compared to underground
6.	Security concern	Under-ground metro stations are more prone to terrorist attacks.	Less prone to terrorist attacks.
7.	Risk	More risk to the passengers during the disruption	Less risk compared to underground.
8.	Drainage Arrangement	Very exhaustive drainage arrangement needed	Very simple arrangement
9.	Ramp	In case of under-ground, when alignment is changes from under-ground to elevated, 11 meters width and 650 meters long land portion is needed for providing the ramp with physical barrier between 2 sides of the city.	There is no requirement of such ramp and land.

The rough estimate of under-ground and elevated alignments for 20 kms length has been made at the price level of March, 2015. The cost (without land and Taxes) of under-ground alignment comes to Rs. 412 crores and elevated Rs. 176 crores. It indicates that per kilometre of under-ground alignment replacing elevated alignment, the cost to the tune of 2.3 times has to be incurred.

In view of the above, the decision for opting a particular type of alignment has to be taken on techno-economic basis. For country like India, a balance has to be kept in two types of alignments for the reasons that we are already short of funds for our infrastructure projects. It is also recommended that underground alignment be opted only in the stretches where elevated alignment is not possible to provide.

To appreciate the magnitude of land requirement, Ground Level Plans of one Typical elevated station and underground station are put up at Figure-4.8 & Figure-4.9 to this appendix.

Figure -4.3 Typical Elevated Station Layout

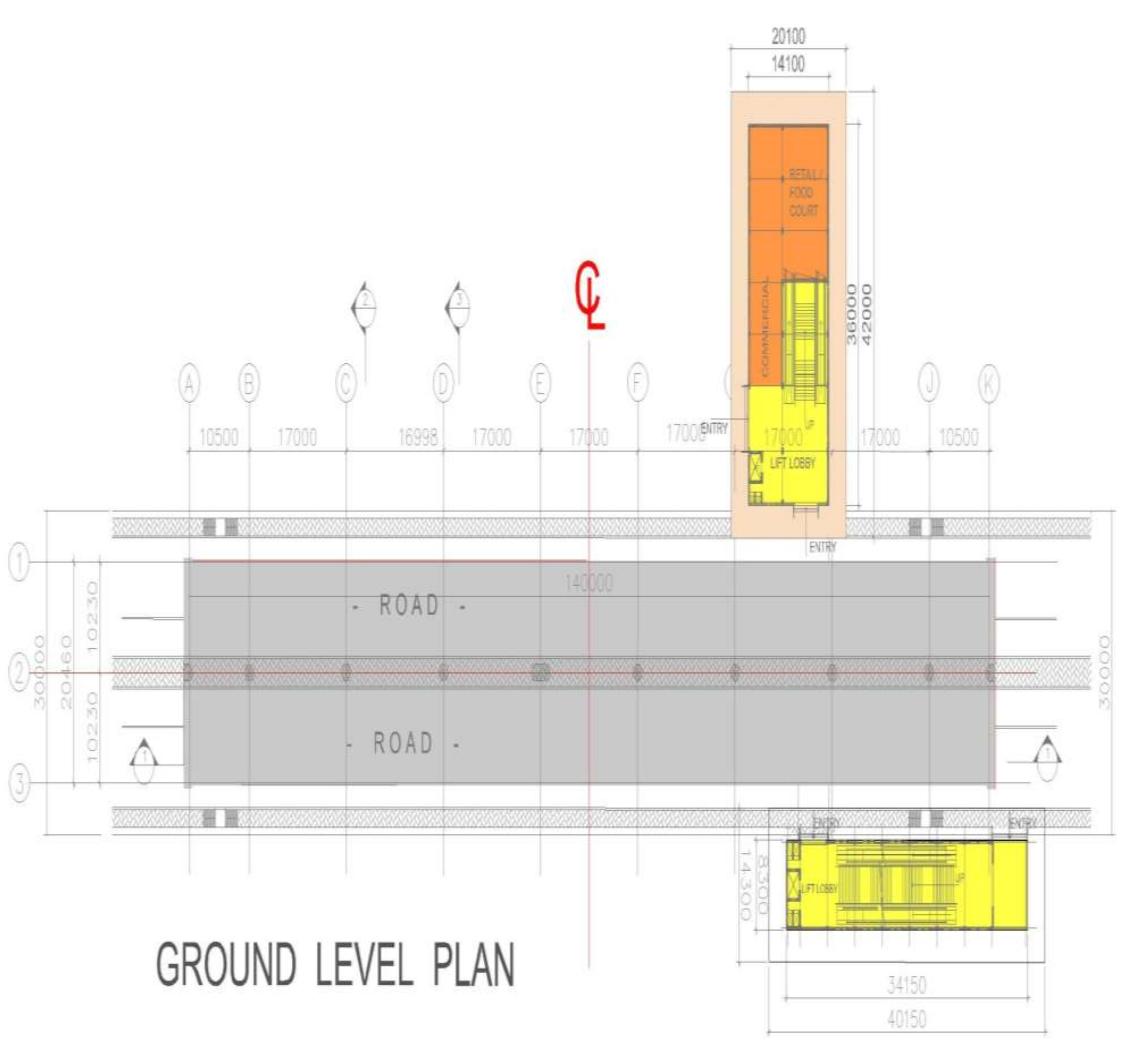
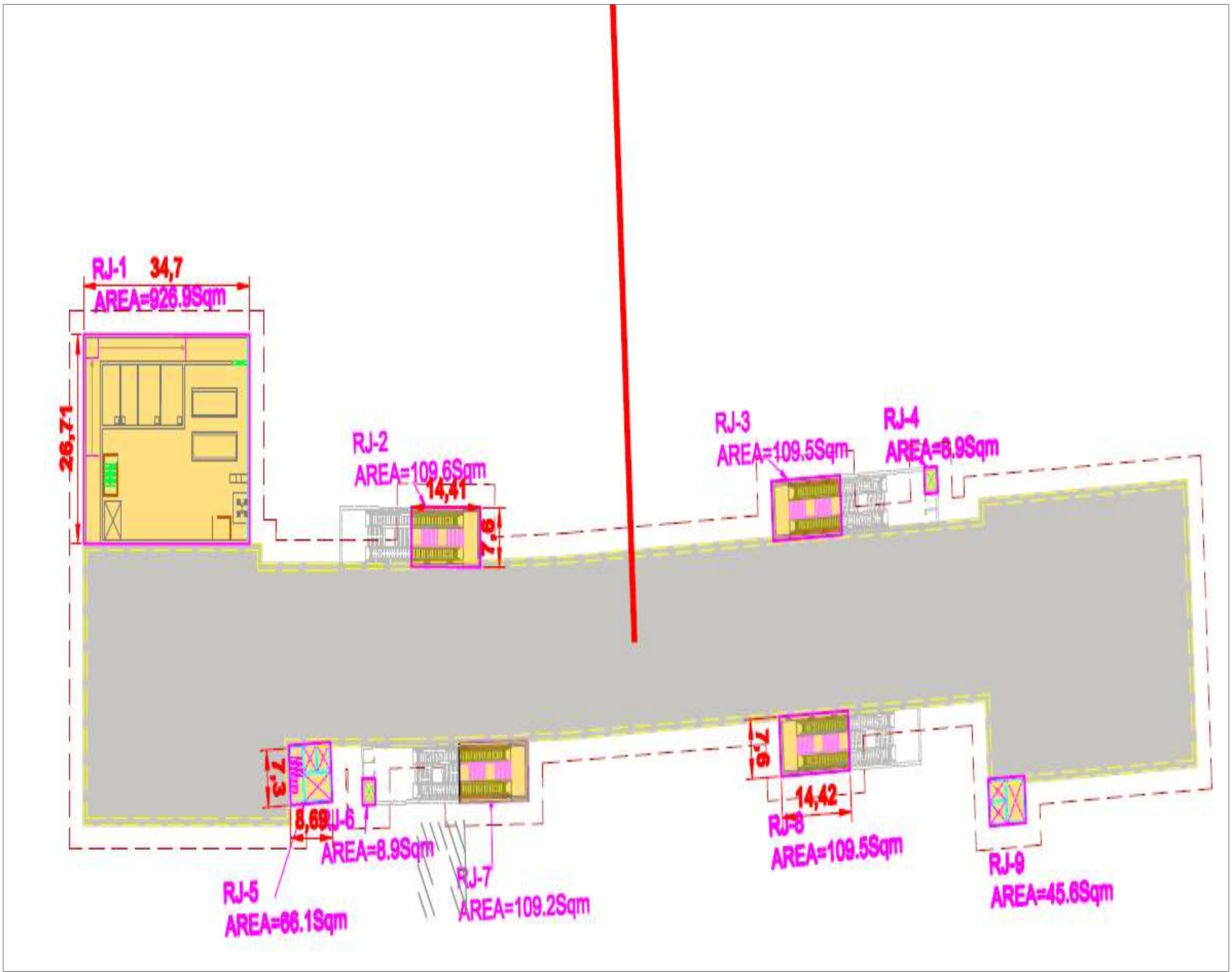


Figure-4.4 Typical Underground Station Layout

Ground Level Plan



CHAPTER - 5

STATION PLANNING

5.1 GENERAL

The proposed Corridor of Mumbai Metro Project has 17 elevated stations covering an approximated distance of 21 km. As far as possible, stations of this corridor are planned on or beside the road. This Corridor comprises Ganesh Nagar, Pisavali Gaon, Golavli, Dombivli MIDC, Sagaon, Sonarpada, Manpada, Hedutane, Kolegaon, Nilje Gaon, Vadavli (Khu.), Bale, Waklan, Turbhe, Pisarve Depot, Pisarve and Taloja Metro stations.

The locations of stations are defined so as to serve passenger requirements and to enable convenient integration with other modes of transport. Efforts have been made to propose station locations at a uniform inter-station distance wherever possible. Average inter-station distance is ~1 Kilometer, though it varies from 0.848 km to 1.805 km due to land-use and topographic reasons. Minimum Inter-station distance is 848.002 m, between Waklan and Turbhe. Maximum Inter-station distance is 1.805 km, between Pisarve Depot and Pisarve.

Figure-5.1: Key Plan of Kalyan - Taloja Metro Corridor (Line-12)

5.2 RAIL LEVELS AND ALIGNMENT

The rail levels in the stations are decided to provide sufficient clearance (Head room) for the traffic on the road. In this Elevated corridor, Rail Level is generally about 13 m to 8 m above the ground in order to maintain a clearance of 5.50 m between the Road and the Station Structure. The alignment is planned generally in middle of the road with a few stations off the road in order to keep the land acquisition to minimum, and a two-level station design has been proposed. Entry/exit structures to the proposed stations and traffic integration areas have been planned in the open spaces available on the road sides.

5.3 PLATFORMS

The stations have been planned with side platforms to avoid the viaduct structure from flaring in and out at stations, which obstructs the road traffic below. Care has been taken to locate stations on straight alignment.

5.4 SEQUENCE OF STATIONS

The sequence of stations along with their respective chainages, site and platform characteristics are presented in the Table 5.1.

Table - 5.1: Kalyan - Taloja Metro Corridor (Line-12)

S.No.	Station Name	Chainage (m)	Inter Distance Between (m)	Station Type	Remarks
1	Ganesh Nagar	843.771	954.1	Elevated	Side Platform
2	Pisavali Gaon	2320.000	1476.2	Elevated	Side Platform
3	Golavli	3400.000	1080.0	Elevated	Side Platform
4	Dombivli MIDC	4567.083	1167.1	Elevated	Side Platform
5	Sagaon	5573.311	1006.2	Elevated	Side Platform
6	Sonarpada	6700.000	1126.7	Elevated	Side Platform
7	Manpada	7689.746	989.7	Elevated	Side Platform
8	Hedutane	8947.974	1258.2	Elevated	Side Platform
9	Kolegaon	9978.357	1030.4	Elevated	Side Platform
10	Nilje Gaon	11093.376	1115.0	Elevated	Side Platform
11	Vadavli (Khu.)	12553.400	1460.0	Elevated	Side Platform
12	Bale	13974.564	1421.2	Elevated	Side Platform
13	Waklan	15478.984	1504.4	Elevated	Side Platform
14	Kurbhe	16326.986	848.002	Elevated	Side Platform
15	Pisarve Depot	17176.971	849.985	Elevated	Side Platform
16	Pisarve	18981.937	1804.966	Elevated	Side Platform
17	Taloja	20525.676	1543.7	Elevated	Side Platform

5.5 PLANNING AND DESIGN CRITERIA FOR STATIONS

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

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

3. The platform level at elevated stations is determined by a critical clearance of 5.5 m under the concourse above the road intersection, allowing 3.3 m for the concourse height, about 0.8 m for concourse floor and 1.8 m for structure of tracks above the concourse. Further, the platforms are 1.09 m above the tracks. This would make the rail level in an elevated situation at least 13 meters above ground.

4. The concourse contains automatic fare collection system in a manner that divides the concourse in two distinct areas. The “Unpaid Area” is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the “Paid Area”, which includes access to the platforms.

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

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

7. Station entrances are located with particular reference to passenger catchment points and physical site constraints allowing for required right-of-way in order to provide a minimum of lane width under the station building on either side of the median.

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The functions of such areas are given below in Table 5.2.

9. The DG set, Bore Well, Pump House and Underground Water Tanks would be located generally in one area on ground within the Entry / Exit structures.

10. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:
    - Minimum distance of travel to and from the platform and between platforms for transfer between lines.

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

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

12. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions such as delayed train service, fire etc.

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

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

5.5.1 Typical Elevated Station:

The stations are generally located on the road median and a few off roads. Total length of the station is ~140 m. All the stations are two-level stations. The concourse is planned along the whole length of the platform with staircases leading from either side of the road. The maximum width of the station at concourse is ~21 m. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level.

Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master’s Office, Waiting Room, Meeting Room, UPS & Battery Room, Auxiliary Service Station, Signal and Telecom Rooms, Train Crew Room & Supervisor's Office, Security Room, Station Store Room, Staff Toilets and Public Toilets, etc. The public zone is further divided into paid and unpaid areas. Water

Tanks, Pump Room and DG room is provided on the ground under the entry/ exit structure.

Since the station is in the middle of the road and a few off road, minimum vertical clearance of 5.5-m has been provided under the concourse. Platforms are at a level of about 14.0 meters from the road. To reduce physical and visual impact of the elevated station, stations have been designed as cantilevered structures with single column located at the central verge of the road.

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

Platform roofs, that can invariably make a structure look heavy, have been proposed to be of steel frame with Galvalume Sheets and aluminum (ACP) cladding to achieve a light look. Platforms would be protected from the heat and rains by providing an overhang of the roof and sidewalls are avoided, thereby enhancing the transparent character of the station building.

It is proposed to install solar panels on the station roof to reduce energy demand of the station and to recharge the entire Rain water of the station and the viaduct for recharging the Underground aquifers.

Table - 5.2: Station Accommodation

For Elevated Stations	
1. Station Control Room	2. Cleaner's Room
3. Station Master's Office	4. Security Room
5. Information & Enquiries	6. First Aid Room
7. Ticket Office	8. Miscellaneous Operations Room
9. Ticket Hall Supervisor & Access Fare Collection (AFC gates)	10. Platform Supervisor's Booth
11. Cash and Ticket Room	12. Auxiliary Substation / DG Room
13. Staff Area	14. Fire Tank and Pump Room
15. Staff Toilets	16. Commercial Outlets and Kiosks
17. Station Store Room	18. UPS and Battery Room
19. Refuse Store	20. Signaling / Communication Room
21. ECS Plant Room	22. ECS Supply and Exhaust Shafts
23. Water softening Plant Room	24. Sump, Seepage & Pump Room

5.6 PASSENGER AMENITIES

Passenger amenities such as ticketing counters/automatic ticket vending machines, RCTVM, ticketing gates, etc. are provided in the concourse. Uniform numbers of these facilities have been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase/escalators. Maximum capacity required at any station has been calculated and the most critical year for emergency operation has been adopted for all stations.

For this purpose, peak minute traffic is assumed to be 2% of the peak hour traffic. For checking the adequacy of platform area, stair widths and requirement additional of emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising waiting passengers at the platform (including two missed headways) and section load expected to be evacuated at the station in case of an emergency.

5.6.1 Concourse

Concourse forms the interface between street and platforms. In elevated stations, this is contained along the full length of the station. This is where all the passenger amenities are provided. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct paid and unpaid areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

The concourse is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines & AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the AFCs.

5.6.2 Ticketing Gates (AFC 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 (one for Normal passenger and one for Wheel chair bound passenger) 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.

5.6.3 Ticket Counters and Ticket Issuing Machines (TIMs), RCTVMs

It is proposed to deploy manual ticket issuing in the beginning of the operation of the line. At a later stage, automatic TIMS would be used for which space provision has been made in the concourse. Capacity of manual ticket vending counters is taken to be 5 passengers per minute and it is assumed that only 40% of the commuters would purchase tickets at the stations while performing the journey. The rest are expected to buy prepaid tickets or prepaid card, etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

5.6.4 Platforms

A uniform platform width of average 4.00 m wide side platforms have been proposed in all Elevated stations. These platform widths also have been checked for holding capacity of the platform for worst-case scenario.

5.6.5 Stairs, Escalators and Lifts

Provision has been made for escalators in the paid area i.e. from concourse to platforms. On each platform, one escalator has been proposed. In addition, two staircases are provided of width of 2.1 m are located on each platform connecting to the concourse.

These stairs and escalator together provide an escape capacity adequate to evacuate maximum accumulated passengers in emergency from platforms to concourse in 5.5 minutes. Lifts have been provided one each on either platform, to provide access for elderly and disabled. Since the rise to road from the concourse is about 8m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from Road to Concourse level also.

5.6.6 Fire Fighting Measures

Firefighting provisions in Elevated and Underground metro stations are in accordance with the National Building Code of India 2016 (part IV, Fire and Life Safety) (Fire protection Annexure J (Clause 6.4.4)

1. Ganesh Nagar

Chainage	843.771 m
Inter-Station Distance	954.084 m (from APMC Market Kalyan Station)
Rail Level	14.054 m
Platform Height from Ground	15.144 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on both sides of the Road
Location	The station is located on Main Road
Catchment Area	The station is situated at Main Road surrounded by Lokgram, Kachore Gaon and Kalyan East residential areas which will be the main source of passengers to the station

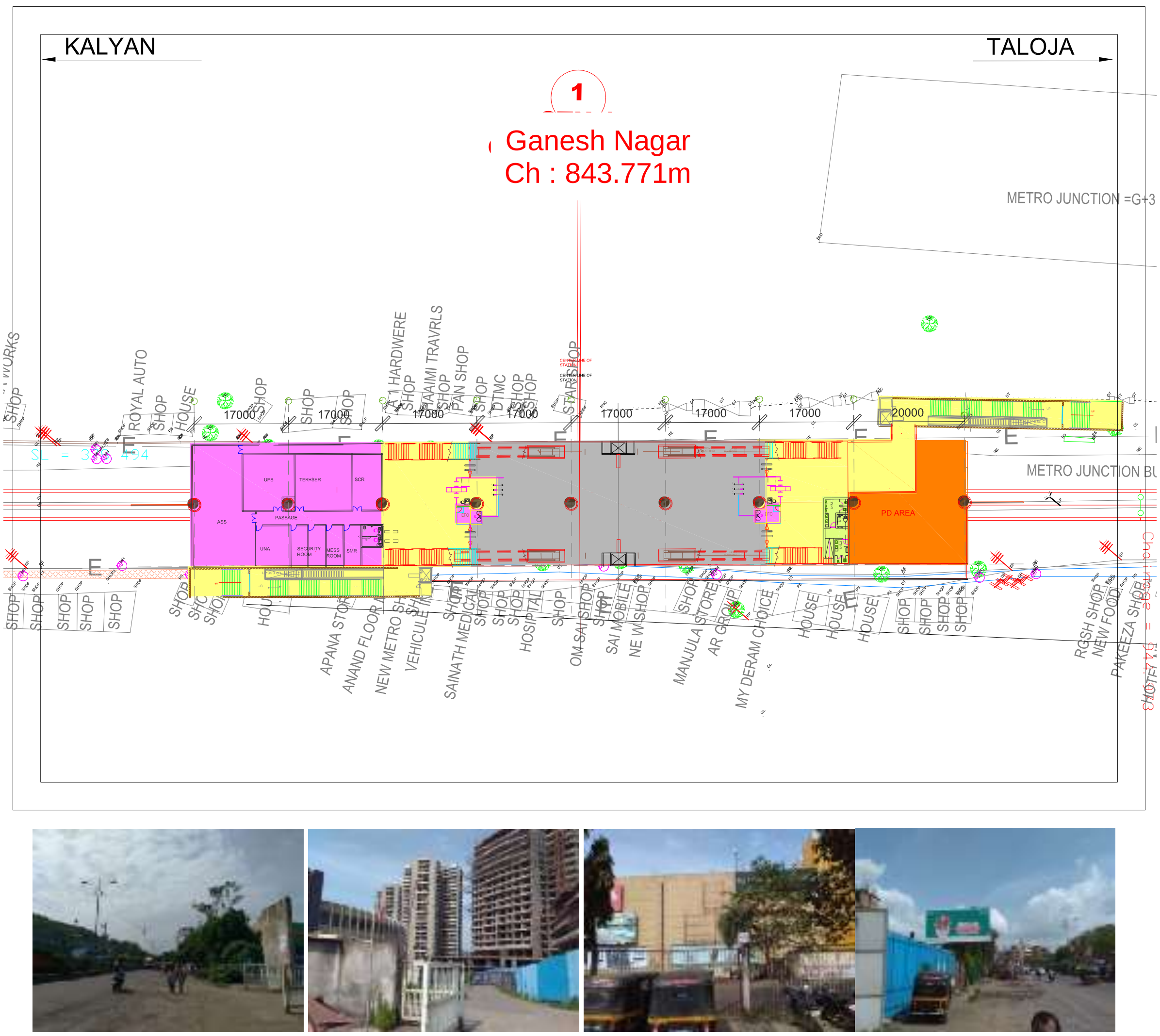


Figure 5.2: Site Conditions - Ganesh Nagar

2. Pisavali Gaon

Chainage	2320 m
Inter-Station Distance	1476.229 m
Rail Level	16.262 m
Platform Height from Ground	17.352 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on both sides of the Road
Location	The station is located on Main Road
Catchment Area	The station is situated at Main Road surrounded by Tata Power Company Ltd. and West Amardeep Colony residential areas which will be the main source of passengers to the station.

Figure 5.3: Site Conditions - Pisavali Gaon

3. Golavli

Chainage	3400.000 m
Inter-Station Distance	1080 m
Rail Level	12.41 m
Platform Height from Ground	13.5 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on both sides of the Road
Location	The station is located on Main Road
Catchment Area	The station is situated at Main Road surrounded by Golbali, and Milap Nagar residential areas which will be the main source of passengers to the station

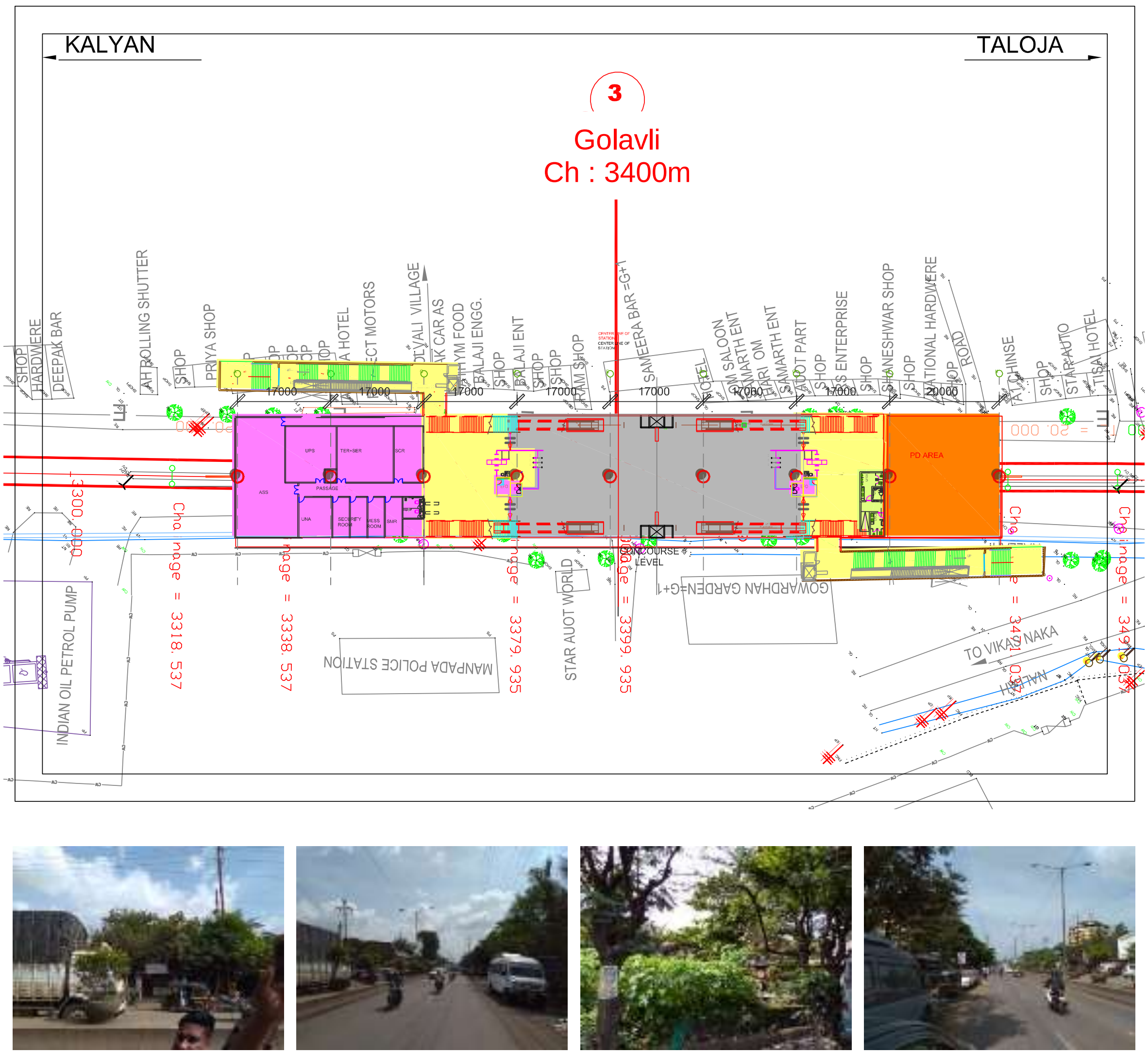


Figure 5.4: Site Conditions - Golavli

4. Dombivli MIDC

Chainage	4567.083 m
Inter-Station Distance	1167.083 m
Rail Level	13.5 m
Platform Height from Ground	14.59 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on both sides of the Road
Location	The station is located on Main Road
Catchment Area	The station is situated at Main Road surrounded by Gharda Colony and Dawadi Gaon residential areas which will be the main source of passengers to the station

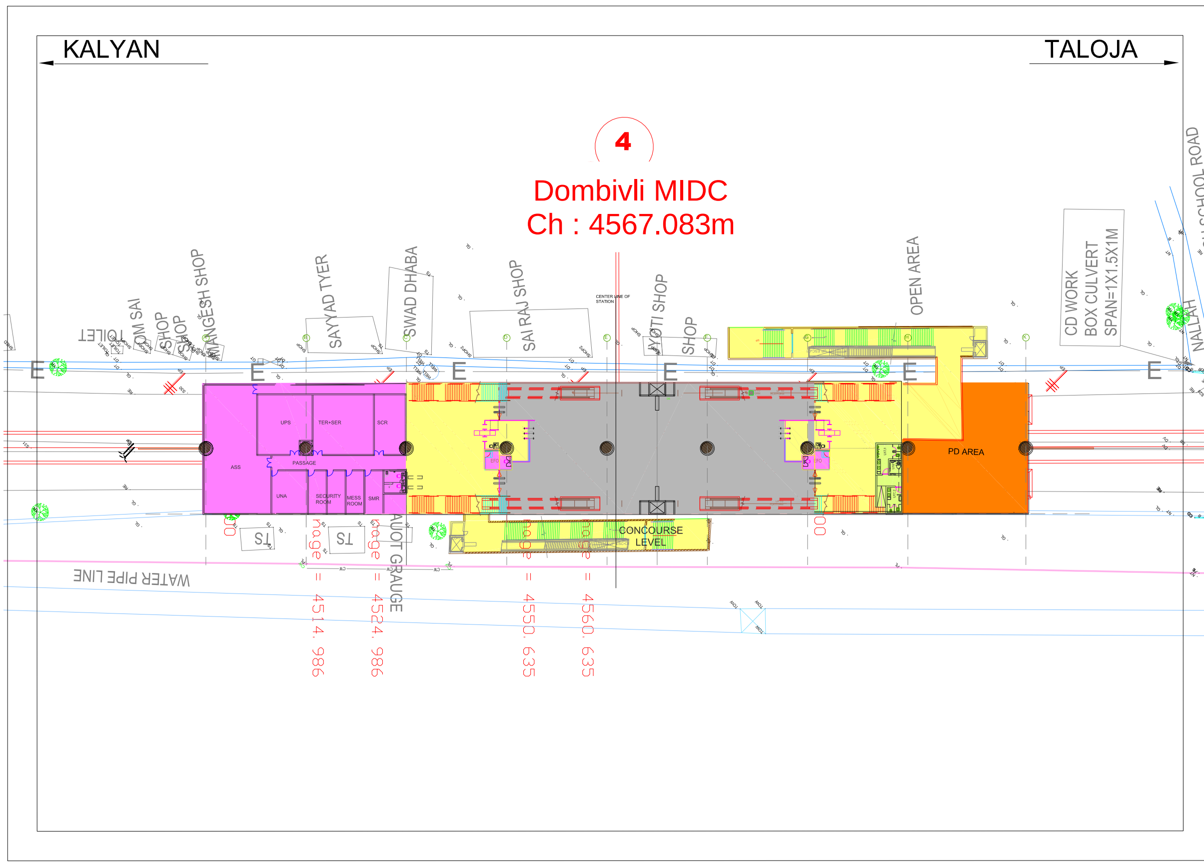


Figure 5.5: Site Conditions – Dombivli MIDC

5. Sagaon

Chainage	5573.310 m
Inter-Station Distance	1006.228 m
Rail Level	13.627 m
Platform Height from Ground	14.717 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on one side of the Road
Location	The station is located on Main Road
Catchment Area	The station is situated at Main Road surrounded by Sagaon, and Nandivali Panchanand residential areas which will be the main source of passengers to the station

Figure 5.6: Site Conditions - Sagaon

6. Sonarpada

Chainage	6700 m
Inter-Station Distance	1126.69 m
Rail Level	14.638 m
Platform Height from Ground	15.728 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on both sides of the Road
Location	The station is located on Main Road
Catchment Area	The station is situated at Main Road surrounded by Sandap Gaon and Bhadra Nagar residential areas which will be the main source of passengers to the station

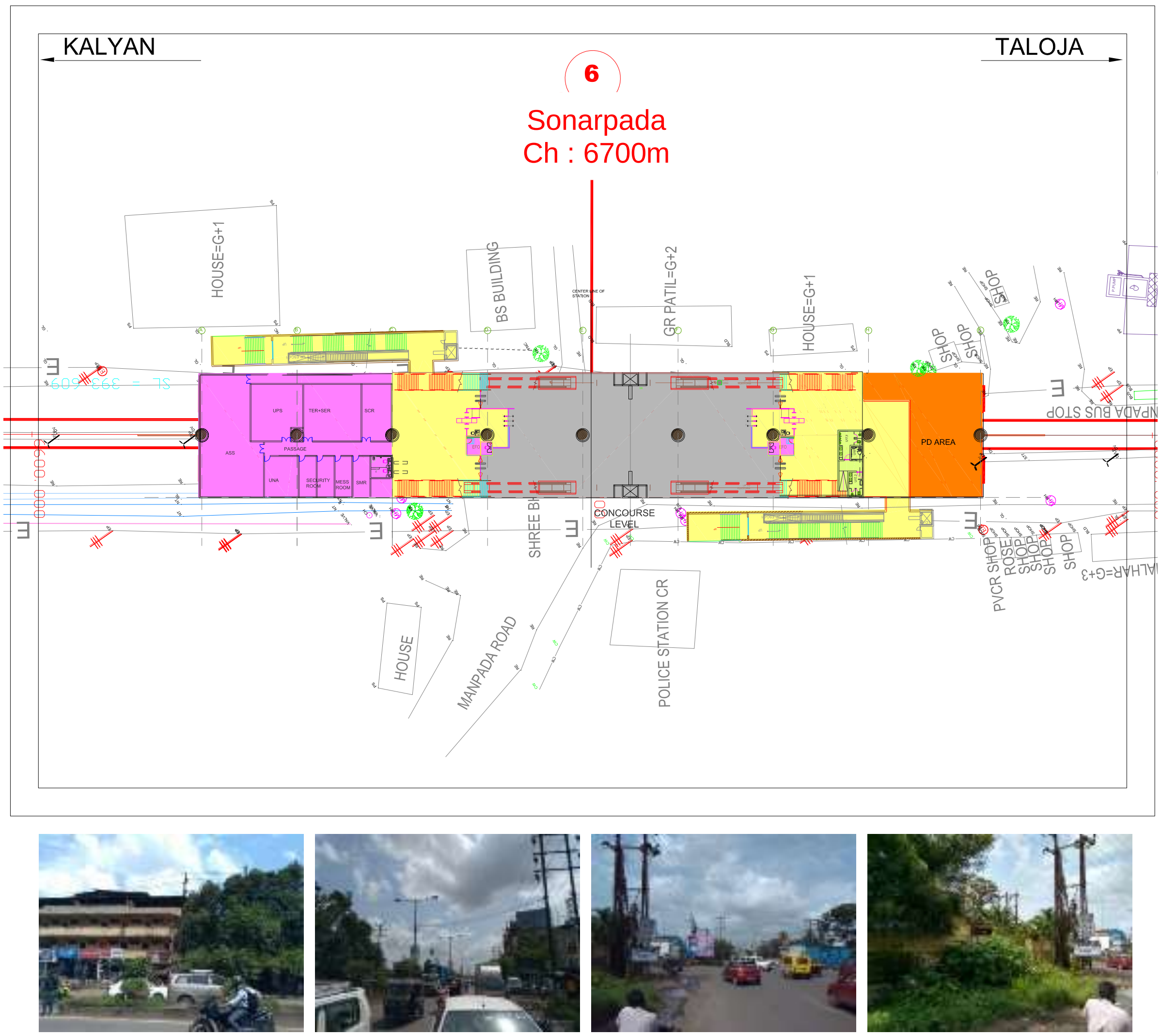


Figure 5.7: Site Conditions - Sonarpada

7. Manpada

Chainage	7689.746 m
Inter-Station Distance	989.746 m
Rail Level	14.774 m
Platform Height from Ground	15.864 m
Station Type	Elevated
Entry / Exit Stairs	Proposed on both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at Off Road surrounded by Sonar pada and Gharivali Village residential areas which will be the main source of passengers to the station

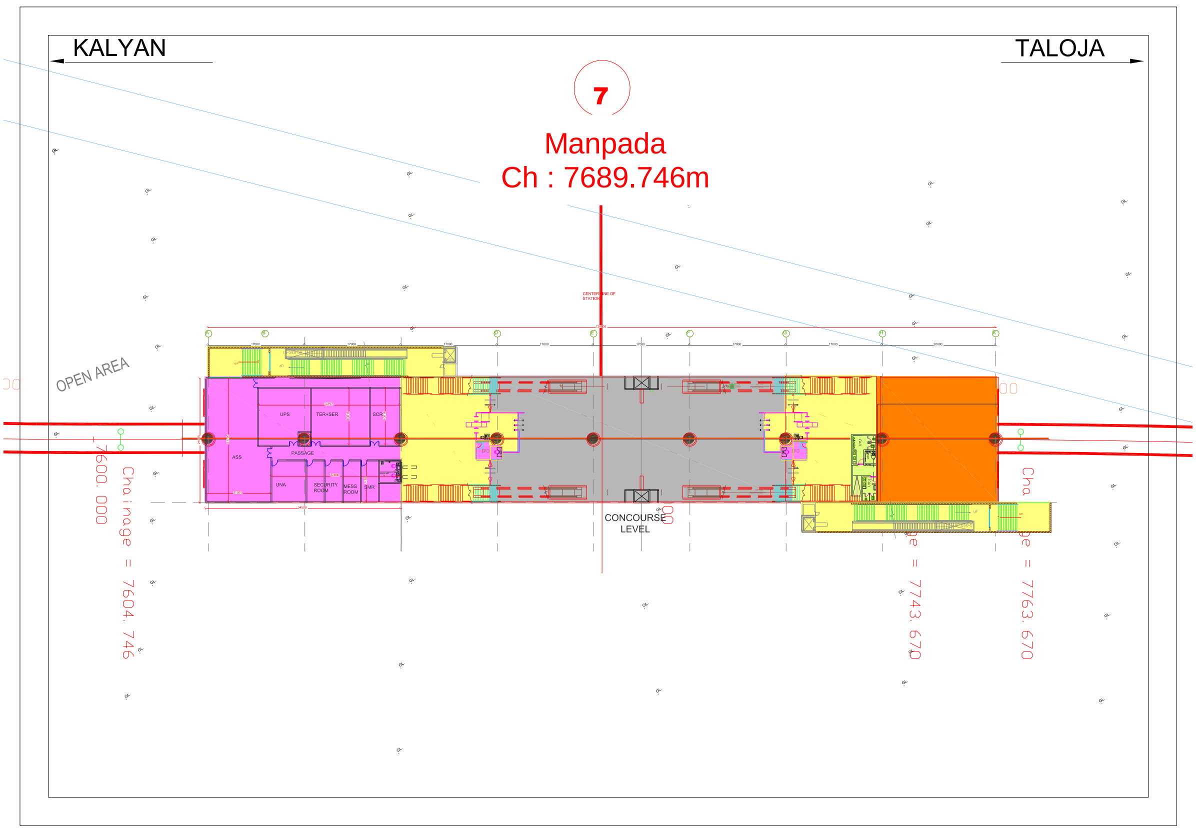
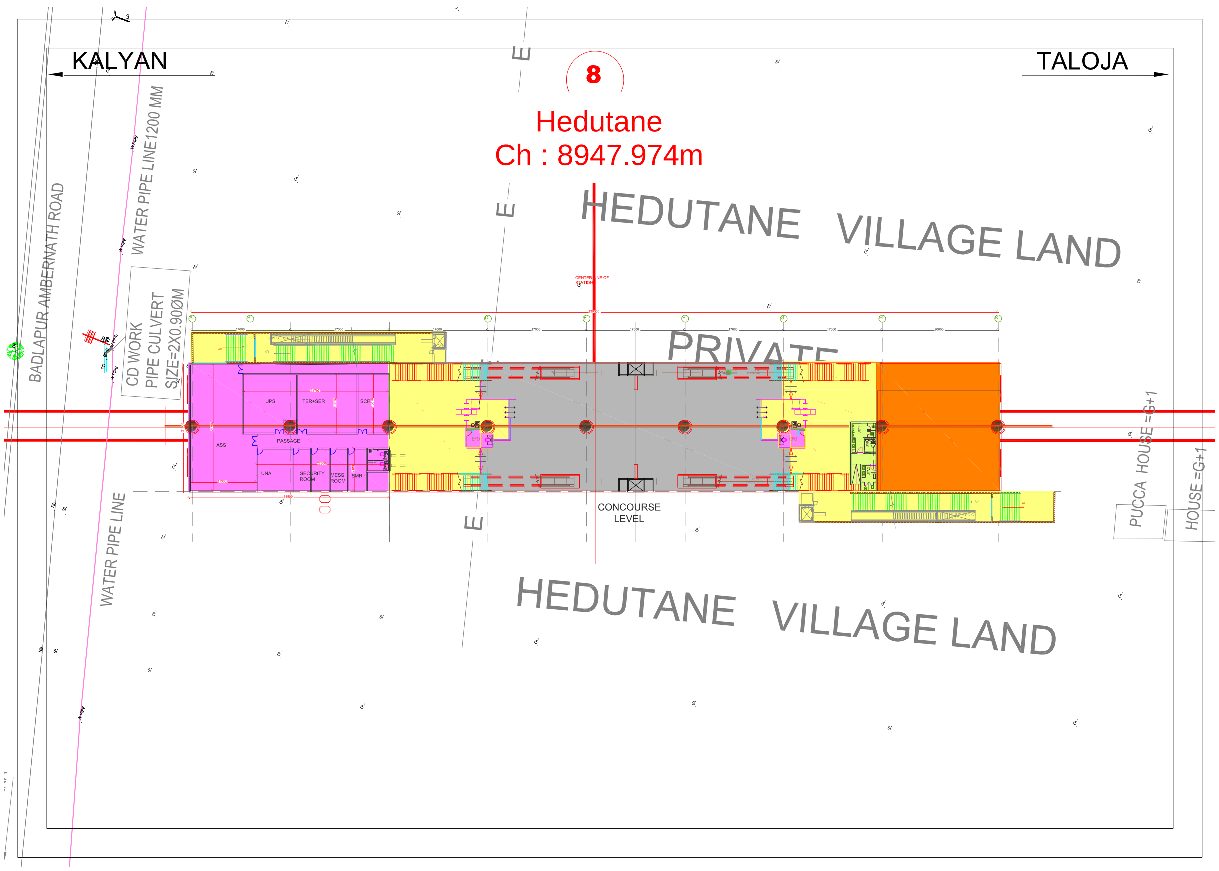


Figure 5.8: Site Conditions - Manpada

8. Hedutane

Chainage	8947.974 m
Inter-Station Distance	1258.228 m
Rail Level	13.5 m
Platform Height from Ground	14.59 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Hedutane residential areas which will be the main source of passengers to the station



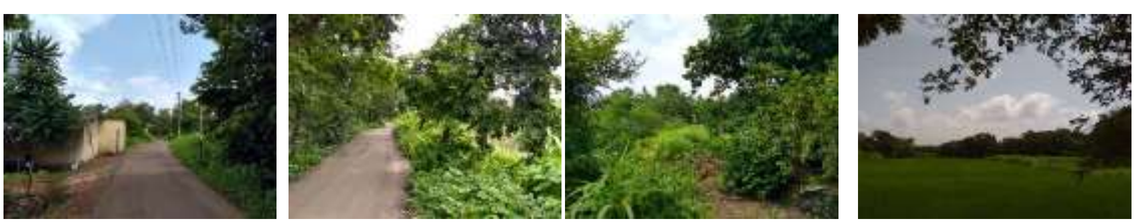


Figure 5.9: Site Conditions - Hedutane

9. Kolegaon

Chainage	9978.357 m
Inter-Station Distance	1030.383 m
Rail Level	13.6 m
Platform Height from Ground	14.69 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Kolegaon and upcoming development areas which will be the main source of passengers to the station

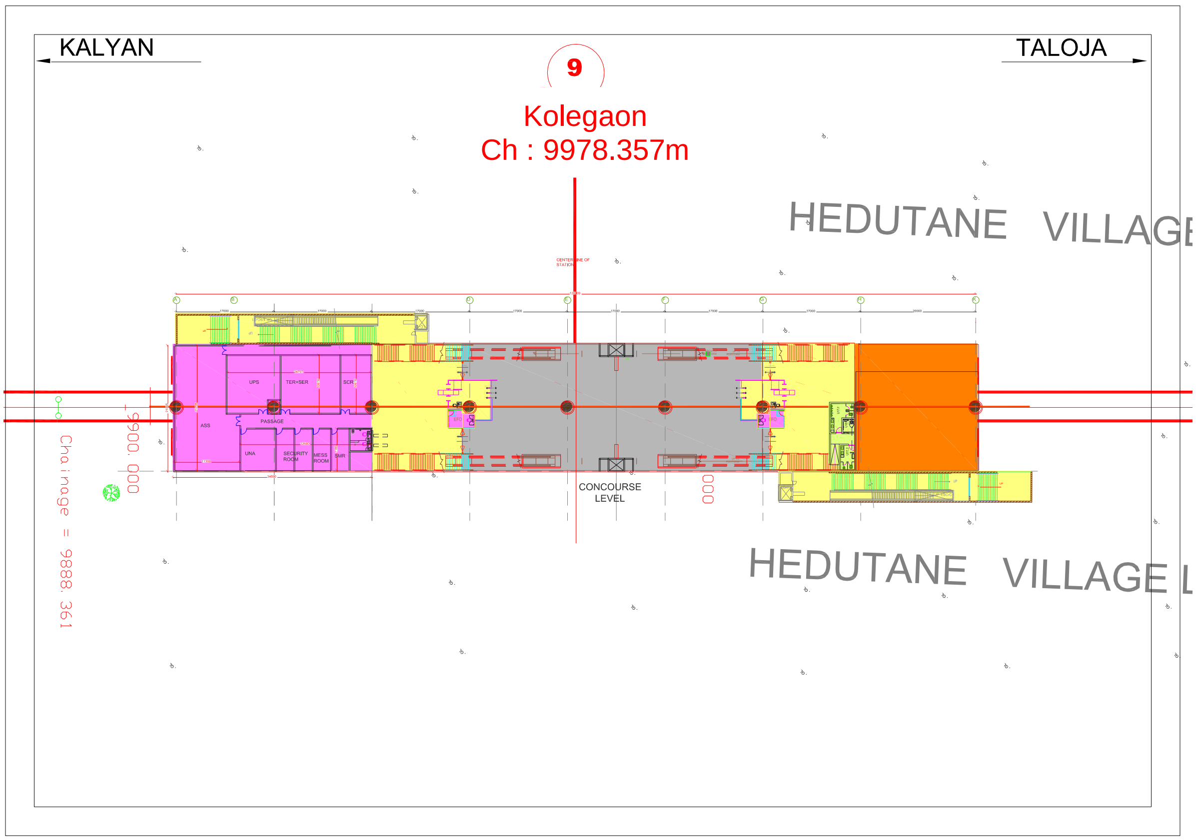


Figure 5.10: Site Conditions - Kolegaon

10. Nilje Gaon

Chainage	11093.376 m
Inter-Station Distance	1115.019 m
Rail Level	14.668 m
Platform Height from Ground	15.758 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Nilje Gaon and upcoming development areas which will be the main source of passengers to the station

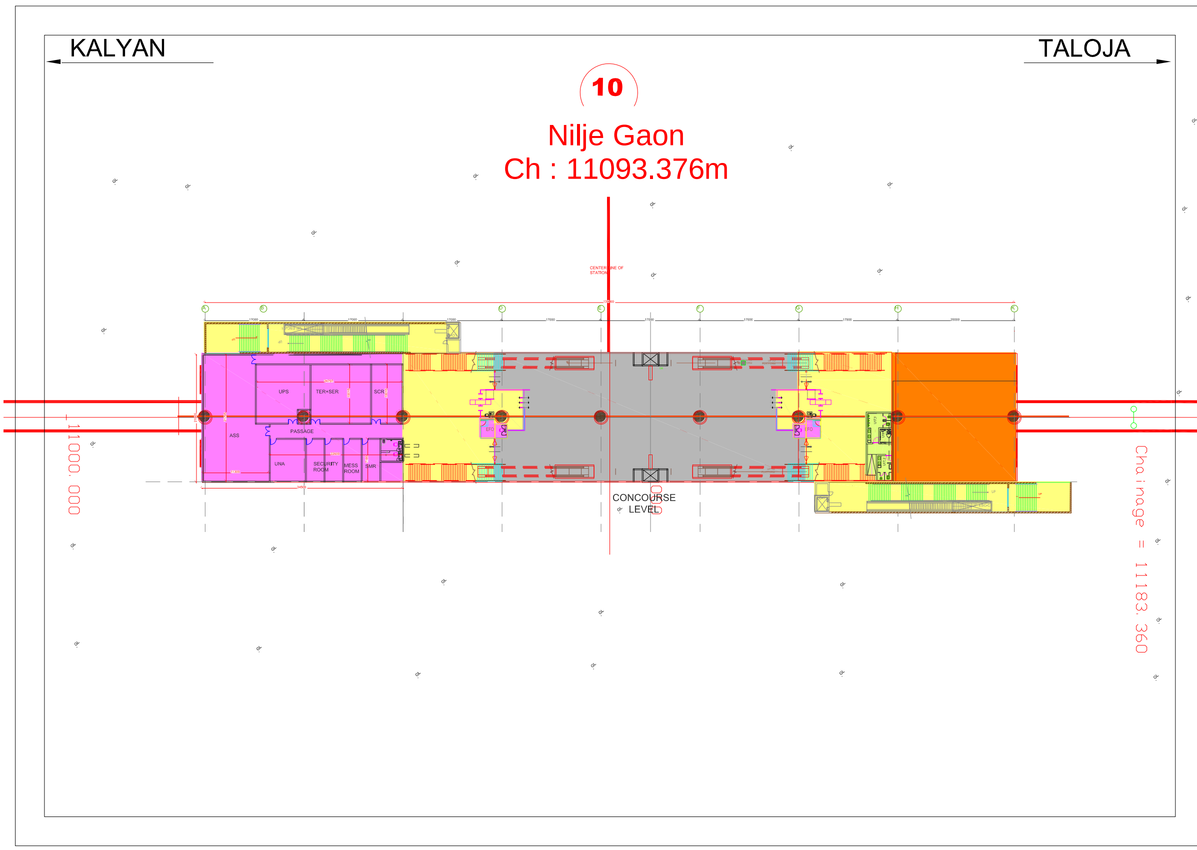


Figure 5.11: Site Conditions - Nilje Gaon

11. Vadavli (Khu.)

Chainage	12553.400 m
Inter-Station Distance	1460.024 m
Rail Level	15.965 m
Platform Height from Ground	17.055 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Vadavali Khurd and upcoming development areas which will be the main source of passengers to the station

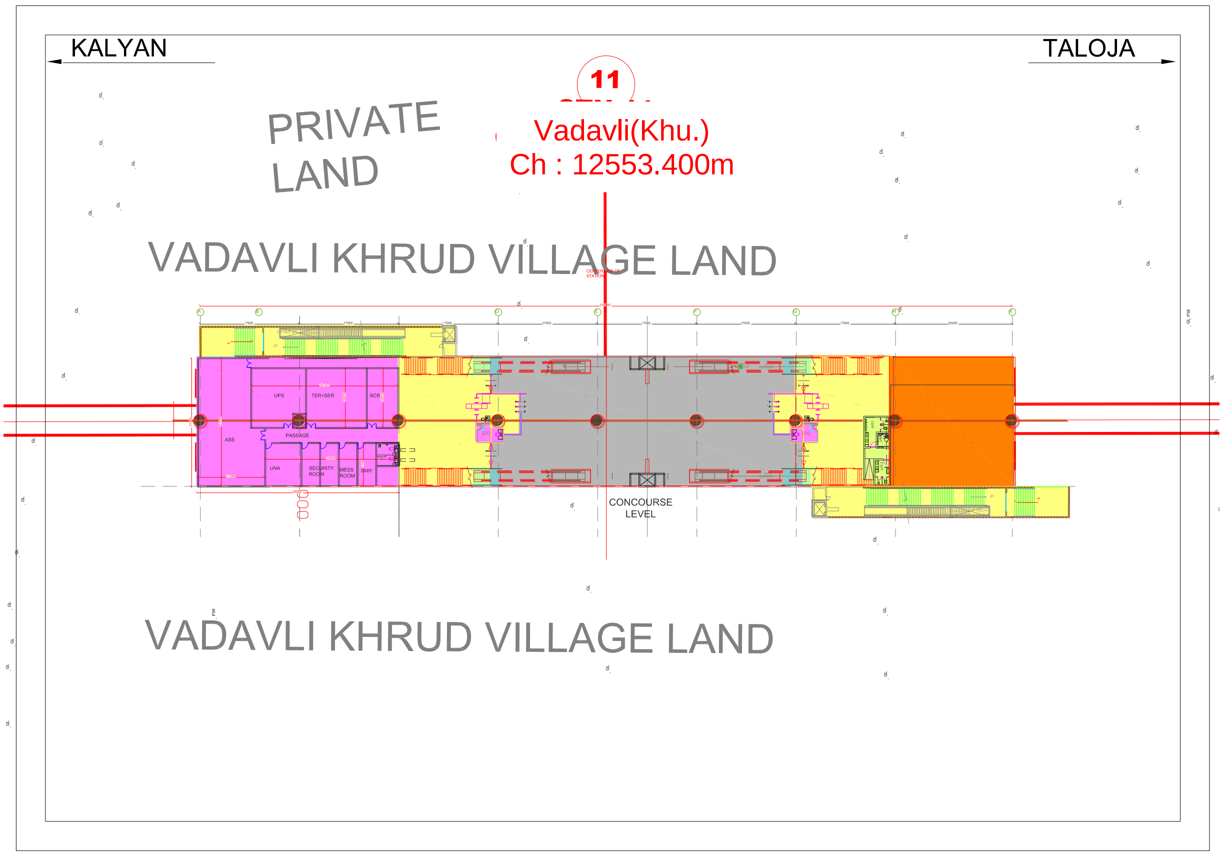


Figure 5.12: Site Conditions - Vadavli (Khu.)

12. Bale

Chainage	13974.564 m
Inter-Station Distance	1421.164 m
Rail Level	13.97 m
Platform Height from Ground	15.06 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Narivali, Bale and upcoming development areas which will be the main source of passengers to the station

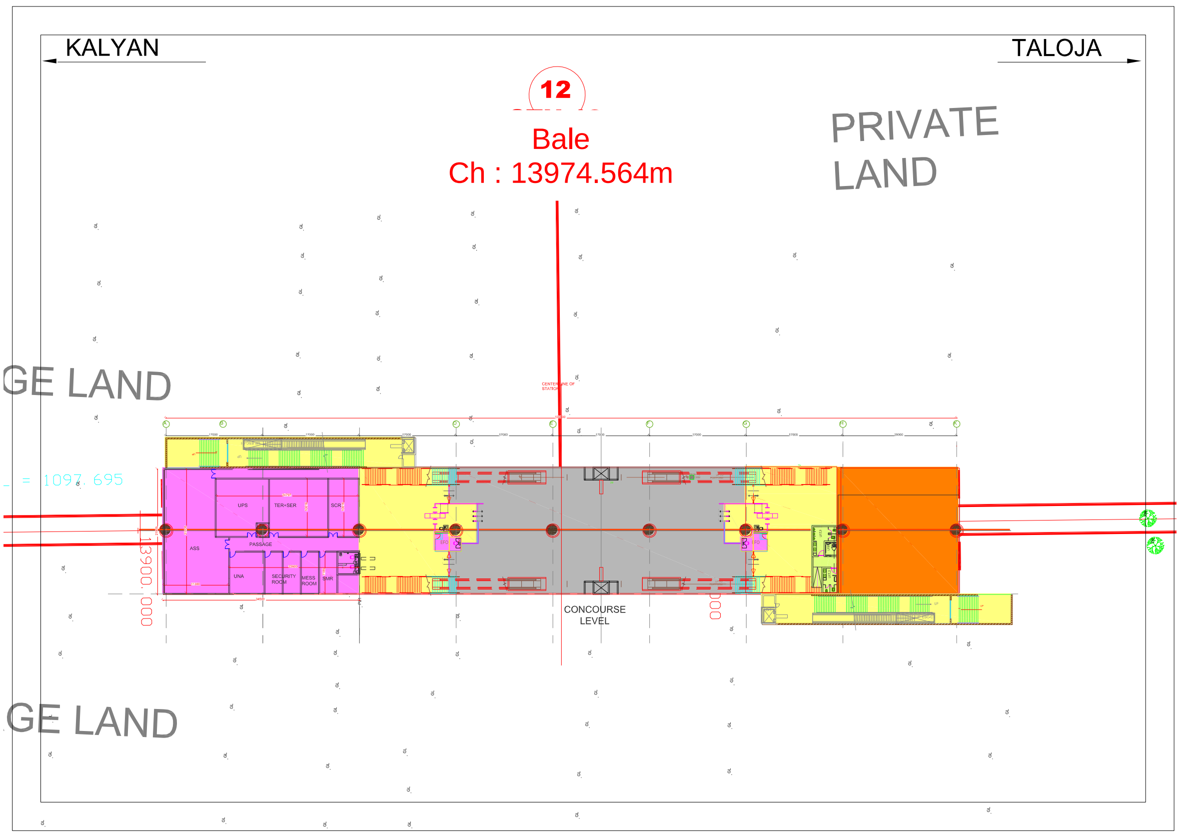


Figure 5.13: Site Conditions - Bale

13. Waklan

Chainage	15478.984 m
Inter-Station Distance	1504.420 m
Rail Level	13.5 m
Platform Height from Ground	14.59 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Waklan, Bamlli and upcoming development areas which will be the main source of passengers to the station

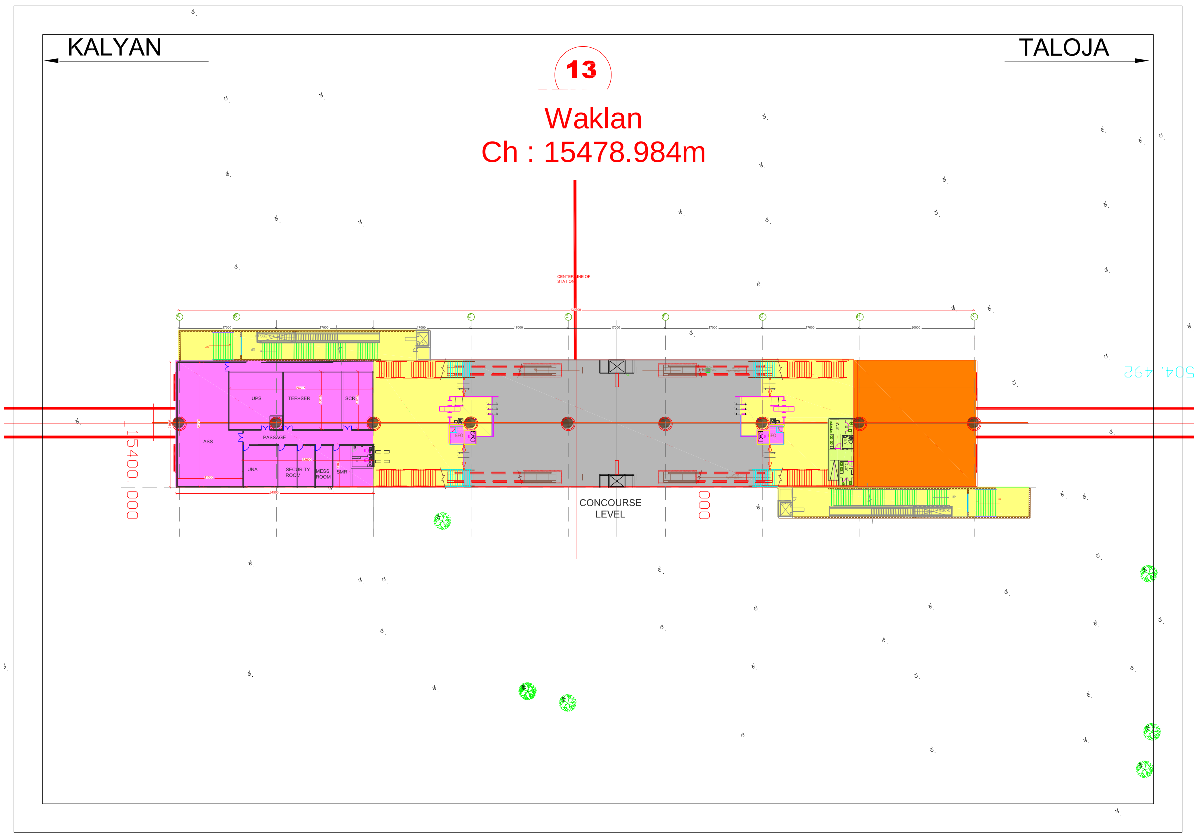


Figure 5.14: Site Conditions - Waklan

14. Turbhe

Chainage	16326.986 m
Inter-Station Distance	848.002 m
Rail Level	14.2 m
Platform Height from Ground	15.29 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at one side of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Turbhe and upcoming development areas which will be the main source of passengers to the station

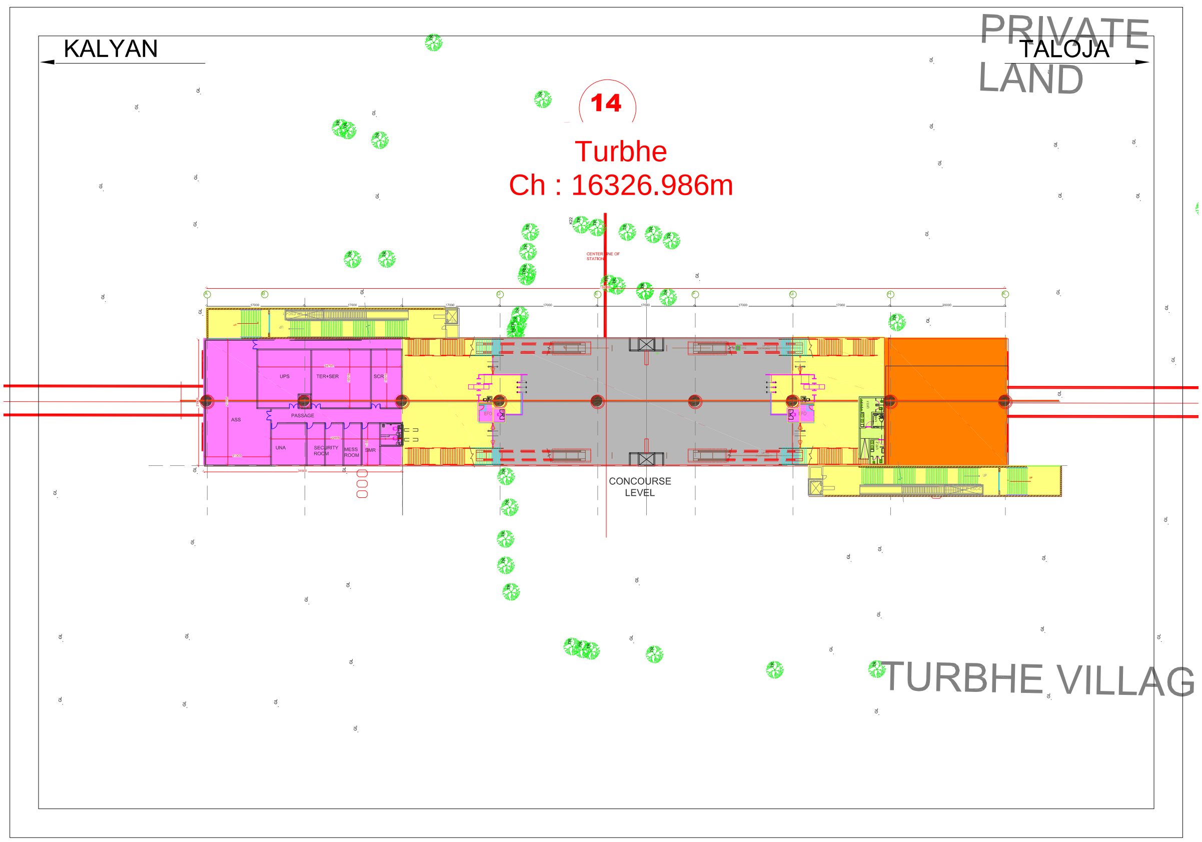


Figure 5.15: Site Conditions - Turbhe

15. Pisarve Depot

Chainage	17176.971 m
Inter-Station Distance	849.985 m
Rail Level	13.6 m
Platform Height from Ground	14.69 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at one side of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Shahpur, Dhansar and upcoming development areas which will be the main source of passengers to the station

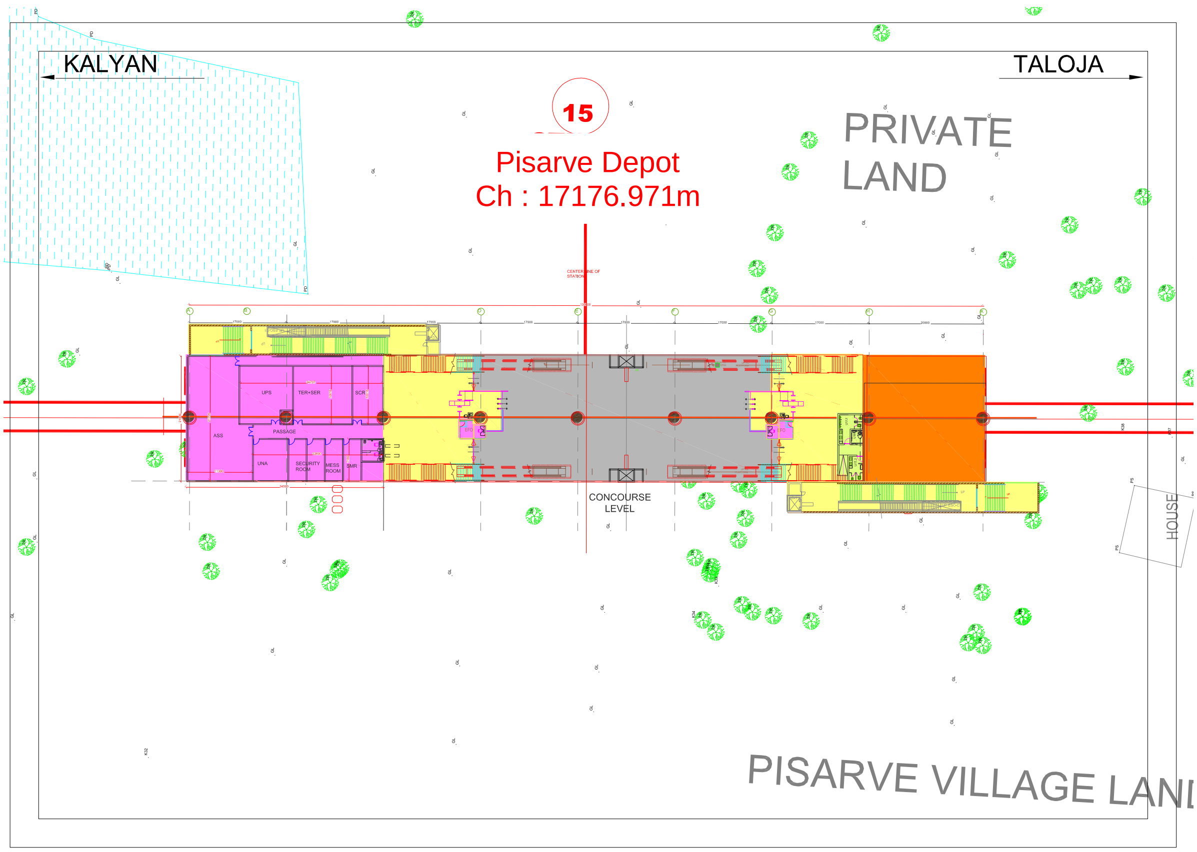


Figure 5.16: Site Conditions - Pisarve Depot

16. Pisarve

Chainage	18981.937 m
Inter-Station Distance	1804.966 m
Rail Level	15.6 m
Platform Height from Ground	16.69 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the station
Location	The station is located off Road
Catchment Area	The station is situated at off Road surrounded by Taloja and upcoming development areas which will be the main source of passengers to the station

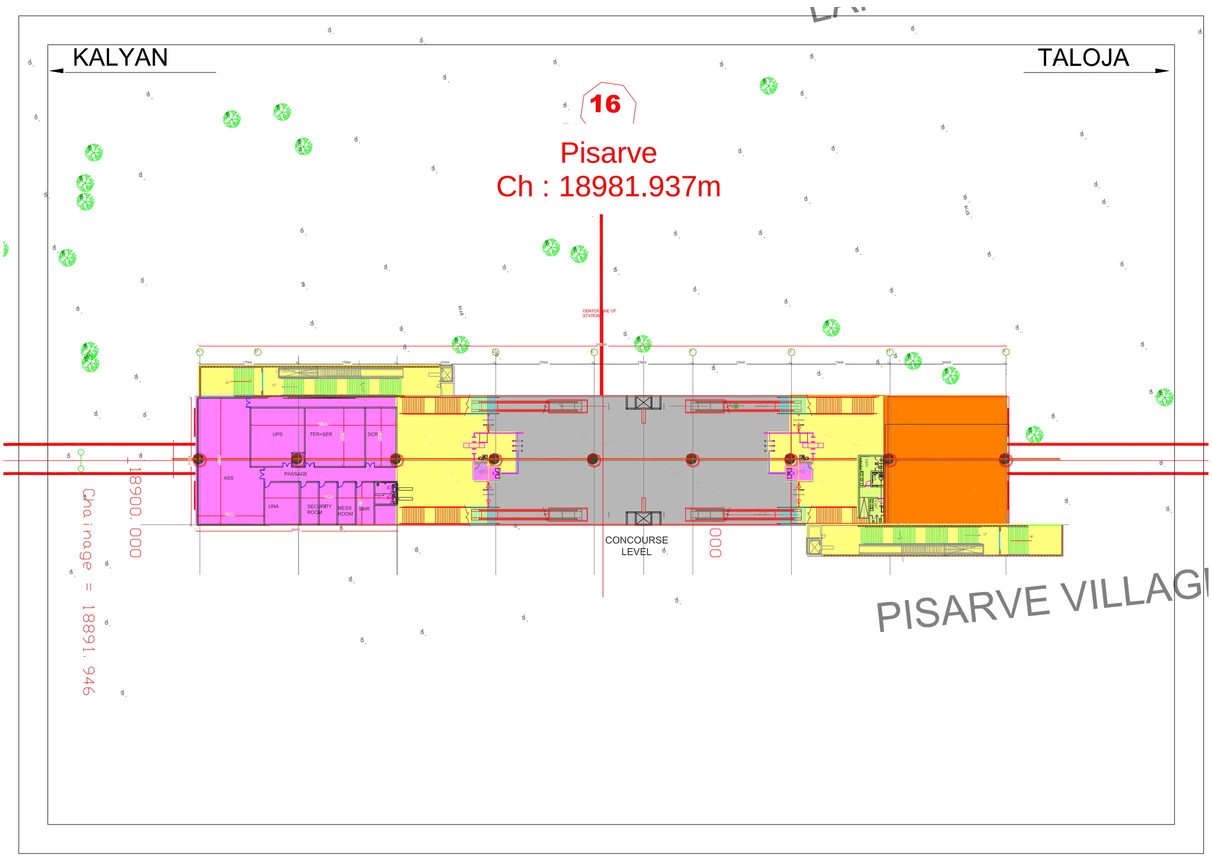


Figure 5.17: Site Conditions - Pisarve

17. Taloja

Chainage	20525.676 m
Inter-Station Distance	1543.739 m
Rail Level	15 m
Platform Height from Ground	16.09 m
Station Type	Elevated
Entry / Exit Stairs	Proposed at both sides of the Road
Location	The station is located on Road
Catchment Area	The station is situated at off Road surrounded by Taloja Panchnand, Sector-11 and Sector-38 residential areas which will be the main source of passengers to the station

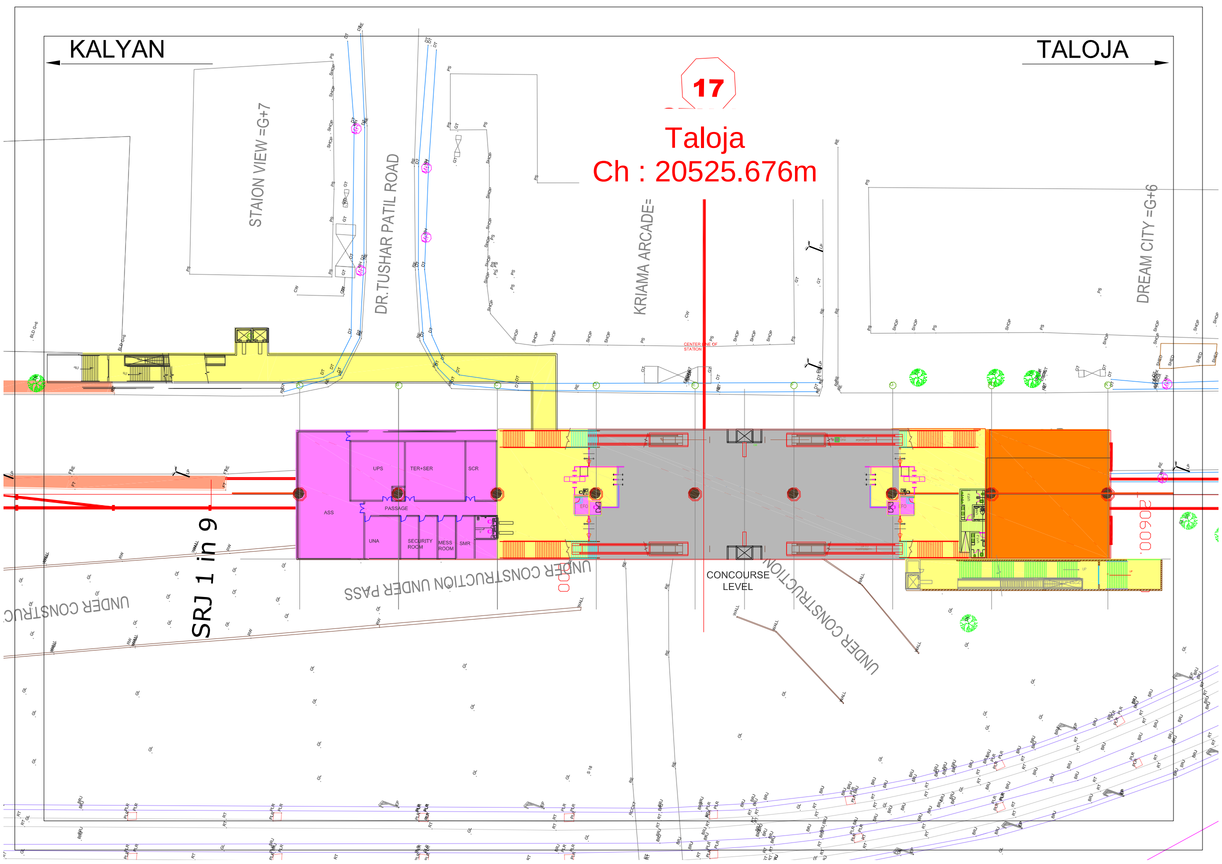


Figure 5.18: Site Conditions - Taloja

PASENGER AMINITY REQUIREMENTS IN THE STATION

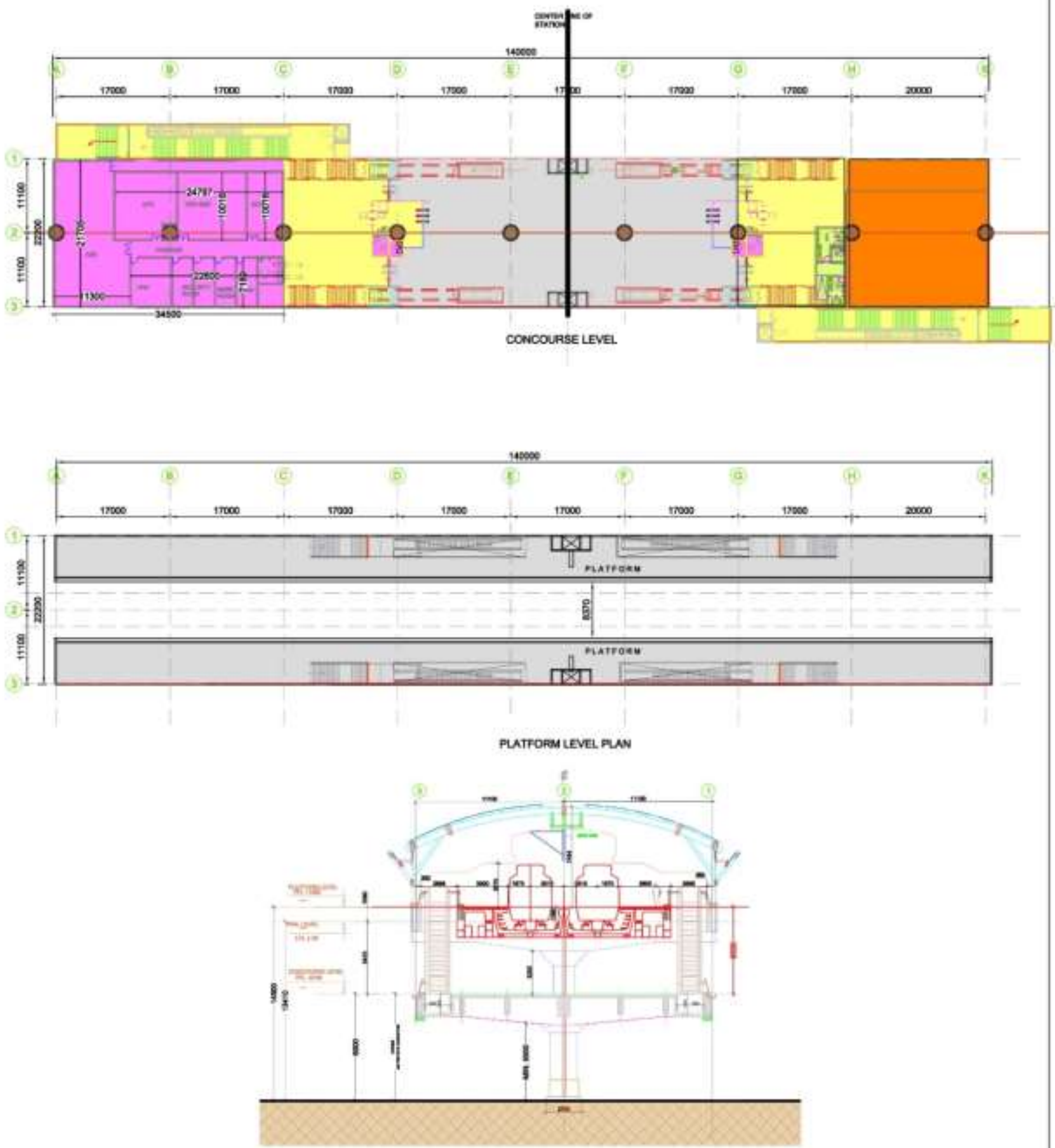
PASSENGER AMENITY REQUIREMENTS IN STATION Kalyan - Taloja Corridor (Horizon Year 2031)									
Daily Ridership									
MORNING PEAK									
S.No.	Station	Peak hour Boarding	Peak hour Alighting	Peak Hour Sectional Load	Peak Minute Boarding	Peak Minute Alighting	TOM Required	Head way in min.	Platform Width Required
1	Ganesh Nagar	186	18	1,427	4	0	2	2	3
2	Pisavali Gaon	36	27	1,436	1	1	2	2	3
3	Golavli	46	0	1,482	1	0	2	2	3
4	Dombivli MIDC	60	46	1,496	1	1	2	2	3
5	Sagaon	144	37	1,604	3	1	2	2	3
6	Sonarpada	34	23	1,615	1	0	2	2	3
7	Manpada	69	82	1,603	1	2	2	2	3
8	Hedutane	0	56	1,547	0	1	2	2	3
9	Kolegaon	148	60	1,635	3	1	2	2	3
10	Nilje Gaon	36	140	1,531	1	3	2	2	3
11	Vadavli (Khu.)	0	244	1,287	0	5	2	2	3
12	Bale	281	0	1,567	6	0	2	2	3
13	Waklan	0	0	1,567	0	0	2	2	3
14	Turbhe	44	2	1,609	1	0	2	2	3
15	Pisarve Depot	0	0	1,609	0	0	2	2	3
16	Pisarve	13	290	1,331	0	6	2	2	3
17	Taloja	0	1,331	0	0	27	2	2	3

PASSENGER AMENITY REQUIREMENTS IN STATION Kalyan - Taloja Corridor (Horizon Year 2031)									
Daily Ridership									
EVENING PEAK									
S.No.	Station	Peak hour Boarding	Peak hour Alighting	Peak Hour Sectional Load	Peak Minute Boarding	Peak Minute Alighting	TOM Required	Head way in min.	Platform Width Required
1	Ganesh Nagar	18	63	596	0	1	2	2	3
2	Pisavali Gaon	0	53	641	0	1	2	2	3
3	Golavli	1	14	694	0	0	2	2	3
4	Dombivli MIDC	0	46	707	0	1	2	2	3
5	Sagaon	74	43	753	1	1	2	2	3
6	Sonarpada	28	13	722	1	0	2	2	3
7	Manpada	30	72	697	1	1	2	2	3
8	Hedutane	26	15	740	1	0	2	2	3
9	Kolegaon	104	61	729	2	1	2	2	3
10	Nilje Gaon	35	25	686	1	1	2	2	3
11	Vadavli (Khu.)	0	0	677	0	0	2	2	3
12	Bale	0	0	677	0	0	2	2	3
13	Waklan	12	0	677	0	0	2	2	3
14	Turbhe	20	184	666	0	4	2	2	3
15	Pisarve Depot	0	41	829	0	1	2	2	3
16	Pisarve	43	13	870	1	0	2	2	3
17	Taloja	840	0	840	17	0	3	2	3

AFC GATES REQUIREMENTS IN THE STATION

S.No.	Station	AFC Gates required		
		Gates in	Gates out	Reversible
1	Ganesh Nagar	1	1	1
2	Pisavali Gaon	1	1	1
3	Golavli	1	1	1
4	Dombivli MIDC	1	1	1
5	Sagaon	1	1	1
6	Sonarpada	1	1	1
7	Manpada	1	1	1
8	Hedutane	1	1	1
9	Kolegaon	1	1	1
10	Nilje Gaon	1	1	1
11	Vadavli (Khu.)	1	1	1
12	Bale	1	1	1
13	Waklan	1	1	1
14	Turbhe	1	1	1
15	Pisarve Depot	1	1	1
16	Pisarve	1	1	1
17	Taloja	1	1	1

TYPICAL ELEVATED STATION (TYPE I)



LEGEND	
	PAID AREA
	UNPAID AREA
	PD AREA

Pisarve Depot
Ch : 17176.971m

CHAPTER - 6

TRAIN OPERATION PLAN

6.1 OPERATION PHILOSOPHY

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

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- Optimization of train's reliability for achieving best possible availability on line.
- A train consists of 3 coaches which will be augmented to 6 coaches in future.
- Multi-tasking of train operation and maintenance staff.

6.2 STATIONS

List of stations for the Mumbai Metro Line-12 (Kalyan to Taloja) is given below:

Table - 6.1: Stations

Kalyan to Taloja					
S. No	**Name of Station**	**Chainage (in m)**	**Inter – Station Distance (in m)**	**Station Type**	**Remarks**
0.	APMC Market Kalyan	-110.313			
1.	Ganesh Nagar	843.771	954.084	Elevated	
2.	Pisavali Gaon	2320.000	1476.229	Elevated	
3.	Golavli	3400.000	1080.000	Elevated	
4.	Dombivli MIDC	4567.083	1167.083	Elevated	
5.	Sagaon	5573.311	1006.228	Elevated	
6.	Sonarpada	6700.000	1126.689	Elevated	
7.	Manpada	7689.746	989.746	Elevated	
8.	Hedutane	8947.974	1258.228	Elevated	
9.	Kolegaon	9978.357	1030.383	Elevated	
10.	Nilje Gaon	11093.376	1115.019	Elevated	
11.	Vadavli (Khu.)	12553.400	1460.024	Elevated	
12.	Bale	13974.564	1421.164	Elevated	
13.	Waklan	15478.984	1504.420	Elevated	
14.	Turbhe	16326.986	848.002	Elevated	
15.	Pisarve Depot	17176.971	849.985	Elevated	
16.	Pisarve	18981.937	1804.966	Elevated	
17.	Taloja	20525.676	1543.739	Elevated	
18.	**Dead End**	20645.675	119.999		

6.3 TRAIN OPERATION PLAN: SALIENT FEATURES

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

6.4 TRAFFIC DEMAND

Peak hour peak direction traffic demands (PHPDT) for the Mumbai Metro 'Line-12: Kalyan to Taloja' in the year 2021 & 2031 for the purpose of planning are indicated in Attachment I/A & I/B respectively.

6.5 TRAIN FORMATION

To meet the above projected traffic demand, the possibility of running trains with composition of 3 and 6 cars with different headway has been examined.

Composition

DMC : Driving Motor Car
TC : Trailer Car
MC : Motor Car
3 Car Train Configuration: DMC-TC-DMC
6 Car Train Configuration: DMC-TC-MC-MC-TC-DMC

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

Driving Motor Car (DMC)	-282 (42 seated + 240 standing)
Trailer Car (TC)	-298 (50 seated + 248 standing)
Motor Car (MC)	-298 (50 seated + 248 standing)
3 Car Train	-862 (134 seated + 728 standing)
6 Car Train	-1756 (284 seated + 1472 standing)

6.6 TRAIN OPERATION PLAN

Based on the projected PHPDT demand, Train operation plan with train carrying capacity @ 6 persons per square meter of standee area for the Mumbai Metro 'Line-12: Kalyan to Taloja' for the year 2021 and 2031 is given below:

<u>**Mumbai Metro Line-12: Kalyan to Taloja**</u>

Train Operation Plan for 'Mumbai Metro Line-12: Kalyan to Taloja' has been planned in such a way that there is end to end train operation from APMC-Kalyan to Taloja.

i) Year 2021: End to end train operation is planned to meet the PHPDT demand for Kalyan to Taloja corridor. Train on 6 minutes headway will run from APMC-Kalyan to Taloja

- 6 minutes Headway with 3-car train configuration.

- Available Peak Hour Peak Direction Capacity of 8620@ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 11000@ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 8322 is in the Section between Ganesh Nagar to Pisavali Gaon and demand in the remaining sections is in the range of 2519 to 8159 only. The planned capacity is more than the PHPDT Demand in the corridor.

Traffic demand and train capacity for 'Mumbai Metro Line-12: Kalyan to Taloja' in the year 2021 is tabulated and represented on chart enclosed as Attachment I/A.

ii) Year 2031: End to end train operation is planned to meet the PHPDT demand for Kalyan to Taloja corridor. Train on 6.25 minutes headway will run from APMC-Kalyan to Taloja.

- 6.25 minutes Headway with 6-car train configuration.
- Available Peak Hour Peak Direction Capacity of 16858@ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 21504@ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 16342 is in the Section between Kolegaon to Nilje Gaon and demand in the remaining sections is in the range of 12579 to 16148 only. The planned capacity is more than the PHPDT Demand in the corridor.

Traffic demand and train capacity for 'Mumbai Metro Line-12: Kalyan to Taloja' in the year 2031 is tabulated and represented on chart enclosed as Attachment I/B.

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

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

Table - 6.2: Capacity Provided for Mumbai Metro Line-12: Kalyan to Taloja

Sections	Year	Head-way (min)	Total No. of Rakes	Rake Consist	Total No. of Cars**	Max. PHPDT Demand	PHPDT Capacity Available
Kalyan to Taloja	2021	6.00	15	3-car	45	8322	8620 (11000*)
Kalyan to Taloja	2031	6.25	15	6-car	90	16342	16858 (21504*)

* @ 8 persons per square meter of standee area

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

6.7 TRAIN FREQUENCY

Table - 6.3: Train Frequency Mumbai Metro Line-12: Kalyan To Taloja

Section	2021		2031	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
Kalyan to Taloja	6.00 min	10 to 24 min	6.25 min	10 to 24 min

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

6.8 HOURLY TRAIN OPERATION PLAN

The hourly distribution of daily transport capacity is presented in **Table 1.1 & 1.2** for ‘Mumbai Metro Line-12: Kalyan to Taloja’ Section for the years 2021 and 2031 enclosed as **Attachment II.**

The directional split for Mumbai Metro Line-12: Kalyan to Taloja is presented in **Table 2** enclosed as **Attachment III**.

6.9 VEHICLE KILOMETER

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Mumbai Metro Line-12: Kalyan to Taloja is given in **Table 3** enclosed as **Attachment IV**.

6.10 YEAR WISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, rake requirement has been calculated and enclosed as **Attachment V.**

Requirements of coaches is calculated based on following assumptions-

Assumptions –

(i) Train Composition planned as under

3 car Train Composition with 66.67% Powering	:DMC +TC + DMC
6 car Train Composition (in year 2031) with 66.7 % Powering	:DMC +TC +MC +MC+TC+DMC

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

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

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

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

(vi) Schedule speed is taken as: 35kmph

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

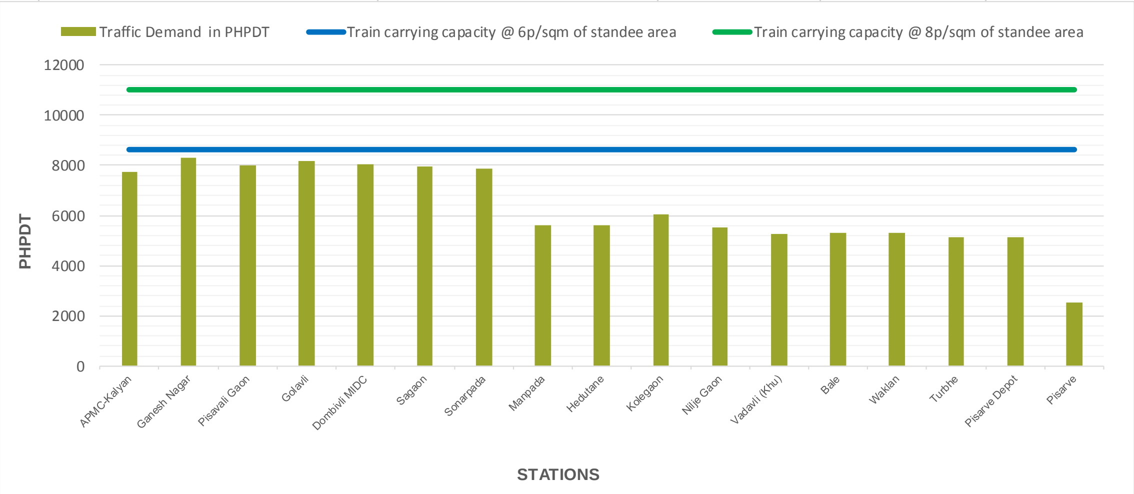
Attachment - I/A

PHPDT Demand and Capacity Chart

Mumbai Metro Line-12 (Kalyan to Taloja Corridor)

Year:	2021
No. of cars per train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	862
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	1100
Headway (min.)	6.00

S.No.	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	APMC-Kalyan	Ganesh Nagar	7748	8,620	11,000
2	Ganesh Nagar	Pisavali Gaon	**8322**	8,620	11,000
3	Pisavali Gaon	Golavli	8010	8,620	11,000
4	Golavli	Dombivli MIDC	8159	8,620	11,000
5	Dombivli MIDC	Sagaon	8055	8,620	11,000
6	Sagaon	Sonarpada	7970	8,620	11,000
7	Sonarpada	Manpada	7876	8,620	11,000
8	Manpada	Hedutane	5630	8,620	11,000
9	Hedutane	Kolegaon	5598	8,620	11,000
10	Kolegaon	Nilje Gaon	6030	8,620	11,000
11	Nilje Gaon	Vadavli (Khu)	5526	8,620	11,000
12	Vadavli (Khu)	Bale	5262	8,620	11,000
13	Bale	Waklan	5296	8,620	11,000
14	Waklan	Turbhe	5296	8,620	11,000
15	Turbhe	Pisarve Depot	5122	8,620	11,000
16	Pisarve Depot	Pisarve	5122	8,620	11,000
17	Pisarve	Taloja	2519	8,620	11,000



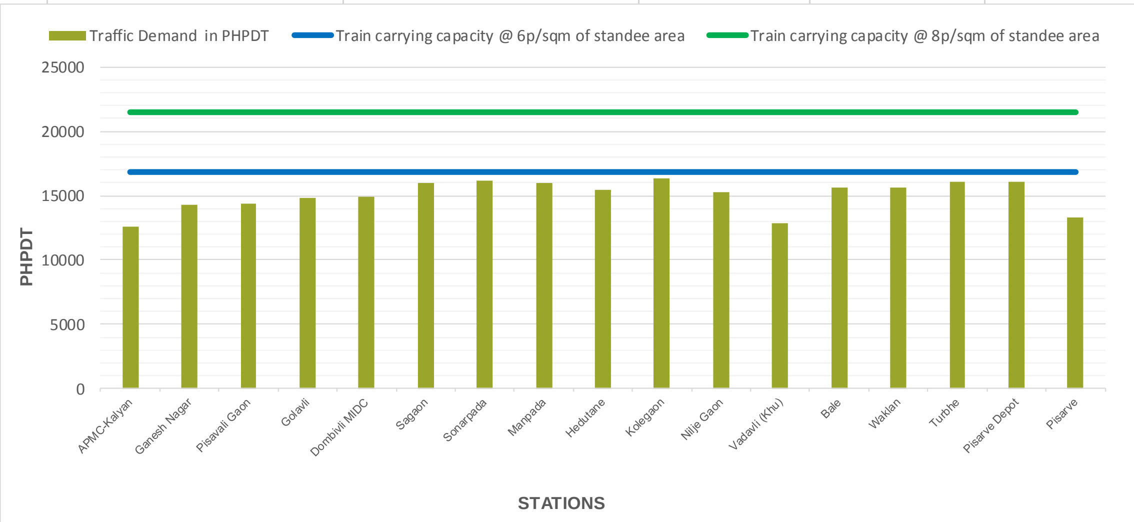
Attachment - I/B

PHPDT Demand and Capacity Chart

Mumbai Metro Line-12 (Kalyan to Taloja 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:	2240
Headway (min.)	6.25

S.No.	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	APMC-Kalyan	Ganesh Nagar	12579	16,858	21,504
2	Ganesh Nagar	Pisavali Gaon	14264	16,858	21,504
3	Pisavali Gaon	Golavli	14360	16,858	21,504
4	Golavli	Dombivli MIDC	14819	16,858	21,504
5	Dombivli MIDC	Sagaon	14956	16,858	21,504
6	Sagaon	Sonarpada	16032	16,858	21,504
7	Sonarpada	Manpada	16148	16,858	21,504
8	Manpada	Hedutane	16021	16,858	21,504
9	Hedutane	Kolegaon	15463	16,858	21,504
10	Kolegaon	Nilje Gaon	**16342**	16,858	21,504
11	Nilje Gaon	Vadavli (Khu)	15301	16,858	21,504
12	Vadavli (Khu)	Bale	12861	16,858	21,504
13	Bale	Waklan	15670	16,858	21,504
14	Waklan	Turbhe	15670	16,858	21,504
15	Turbhe	Pisarve Depot	16084	16,858	21,504
16	Pisarve Depot	Pisarve	16084	16,858	21,504
17	Pisarve	Taloja	13306	16,858	21,504



Attachment- II

TABLE 1.1

Hourly Train Operation Plan
Mumbai Metro Line-12 (Kalyan to Taloja Corridor)

Year- 2021

6 - Headway (min)

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6.00**	**10**	**10**
9 to 10	**6.00**	**10**	**10**
10 to 11	**6.00**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6.00**	**10**	**10**
18 to 19	**6.00**	**10**	**10**
19 to 20	**6.00**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**108**	**108**

TABLE 1.2

Hourly Train Operation Plan

Mumbai Metro Line-12 (Kalyan to Taloja Corridor)

Year- 2031

6.25 - Headway (min)

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6.25**	**10**	**9**
9 to 10	**6.25**	**10**	**9**
10 to 11	**6.25**	**10**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6.25**	**9**	**10**
18 to 19	**6.25**	**9**	**10**
19 to 20	**6.25**	**9**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**105**	**105**

Attachment III

TABLE 2

Mumbai Metro Line-12 (Kalyan to Taloja Corridor)

PHPDT for the year 2021

S.No	From Station	To Station	Peak hour Load	Directional Split to Kalyan	Directional Split to Taloja
1	APMC-Kalyan	Ganesh Nagar	7748	50%	50%
2	Ganesh Nagar	Pisavali Gaon	**8322**	50%	50%
3	Pisavali Gaon	Golavli	8010	50%	50%
4	Golavli	Dombivli MIDC	8159	50%	50%
5	Dombivli MIDC	Sagaon	8055	50%	50%
6	Sagaon	Sonarpada	7970	50%	50%
7	Sonarpada	Manpada	7876	50%	50%
8	Manpada	Hedutane	5630	50%	50%
9	Hedutane	Kolegaon	5598	50%	50%
10	Kolegaon	Nilje Gaon	6030	50%	50%
11	Nilje Gaon	Vadavli (Khu)	5526	50%	50%
12	Vadavli (Khu)	Bale	5262	50%	50%
13	Bale	Waklan	5296	50%	50%
14	Waklan	Turbhe	5296	50%	50%
15	Turbhe	Pisarve Depot	5122	50%	50%
16	Pisarve Depot	Pisarve	5122	50%	50%
17	Pisarve	Taloja	2519	50%	50%

Attachment IV

TABLE 3

Mumbai Metro Line-12 (Kalyan to Taloja Corridor)
Vehicle Kilometer

Year	2021	2031
	Kalyan to Taloja	Kalyan to Taloja
Section Length	20.60	20.60
No of cars per train	3	6
No of working Days in a year	340	340
Number of Trains per day each Way	108	105
Daily Train -KM	4450	4326
Annual Train - KM (10^5)	15.13	14.71
Annual Vehicle - KM (10^5)	45.39	88.25

Attachment-V

TABLE 4
Mumbai Metro Line-12 (Kalyan to Taloja Corridor)
RAKE REQUIREMENT

Year-2021

S. No.	Section		Length (km)	Gauge	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement					
	From	To											Bare	Bare (round-up)	Traffic Reserve	R&M	Total No. Of Rakes (3-car configuration)*	Total no. of cars
1	Kalyan	Taloja	20.60	SG	35	2021	6.00	35.31	3	0	6	76.62	12.77	13	1	1	**15**	**45**
																TOTAL	**15**	**45**

Year-2031

S. No.	Section		Length (km)	Gauge	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement					
	From	To											Bare	Bare (round-up)	Traffic Reserve	R&M	Total No. Of Rakes (6-car configuration)**	Total no. of cars
1	Kalyan	Taloja	20.60	SG	35	2031	6.25	35.31	3	0	6	76.62	12.26	13	1	1	**15**	**90**
																TOTAL	**15**	**90**

*	**Passenger capacity @ 6p/sqm for a train of 3 car configuration**	**862**
**	**Passenger capacity @ 6p/sqm for a train of 6 car configuration**	**1756**

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

CHAPTER - 7

MAINTENANCE DEPOT

7.1 **CORRIDOR:** Line-12 (Kalyan to Taloja) corridor of Mumbai Metro Rail Network, comprises as below:

Corridor	Route Length (km)
Kalyan to Taloja	20.756

7.2 DEPOT- CUM- WORKSHOP

7.2.1 It is proposed to establish one depot-cum-workshop near Taloja 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 train 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 (preferably as close to depot as possible) to cater to the required stability facilities.
(v) In case of space constraint for depot two storeyed Stabling lines can also be planned.

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

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

7.3 MAINTENANCE PHILOSOPHY

- Monitoring of the performance of all key Rolling Stock equipment by suitable advanced condition monitoring techniques available. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, "A" checks, "B" type checks, "IOH" and "POH".
- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Increase in the periodic maintenance intervals with predictive maintenance based on condition monitoring.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Periodic review of maintenance practices to update replacement cycle of critical components based on experience.
- Energy conservation is given due attention.

7.4 ROLLING STOCK MAINTENANCE NEEDS

7.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 337.5 kms running per train per day, taking in consideration the passenger load of 2021, 2031 respectively.

Table - 7.1

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 km (approx. 15 days)	Detailed inspection and testing of sub -systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 km (approx. 45 days)	Detailed Inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 km, (3 and half Years approx.) whichever is earlier	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition.	Workshop

Type of Schedule	Interval	Work Content	Locations
		Replacement of parts and rectification, trial run.	
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, wheel set/axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

7.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

Table - 7.2

S.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 &intensive cleaning shed.

7.5 Year-wise planning of maintenance facility setup at depot cum workshop based on planned Rolling Stock requirement in TOP is tabulated below:

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

(i) Planned rakes as per TOP:

Table - 7.3

Year	No. of Coaches	No. of Rakes	Total No. of coaches
2021	3-Coach	15	45
2031	6-Coach	15	90

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

Table - 7.4: Stabling and Inspection Lines

Year	No. of Rakes	SBLs	IBLs
2021	15	7 lines x two trains of 3-car	One bay of 3 lines each with two trains of 3-cars will be required from year 2021 onwards which will cater requirement upto year 2031.
2031	15	15 lines x two trains of 3-car	

Table - 7.5: Workshop Lines

Year	No. of Rakes	WSLs
2021	15	One bay of 2 lines each with two trains of 3-cars will be required from year 2021 onwards
2031	15	Two bays of 2 lines each with two trains of 3-cars will be required from year 2031 onwards. Additional one bay of 2 lines each with two trains of 3-cars will be required in this year.

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

Table - 7.6

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2021 - Maximum no. of rake holding is (15 TS x 3 = 45 Cars)		
'A' Checks (5000 km) approx. 15 days	(15X3) Cars = 45 Cars	1 Line x Two trains of 3 - Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(15X3) Cars = 45 Cars	1 Line x Two trains of 3-Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x Two trains of 3-Cars (with Sunken Floor)
Requirement		One bay of 3 lines each with two trains of 3-cars.

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
ii) Year 2031 -Maximum no. of rake holding is (15 TS x 6 = 90Cars)		
'A' Checks (5000 km) approx. 15 days	(15 X 6) Cars = 90 Cars	1 Line x Two trains of 3 -Cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days.	(15 X 6) Cars = 90 Cars	1 Line x Two trains of 3-Cars (with Sunken Floor)
Unscheduled line & adjustment lines		1 Line x Two trains of 3-Cars (with Sunken Floor)
Requirement		No additional requirement. Available one bay of 3 lines each with two trains of 3-car length will cater requirement from year 2031 onwards.

7.7 INSPECTION REQUIREMENTS AT DEPOT

Facilities for carrying out inspection activities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules and other pneumatic systems.
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks and "B" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off peak and night. Since "B" checks take longer time, these cannot be completed in the off-peak times. Certain inspection lines will be nominated for "A" checks. For "B" checks, separate line will be nominated where the rakes may be kept for long time.

7.8 Design of Depot-cum-Workshop Facilities

7.8.1 Stabling Lines at Depot:

As per advised dimensions of the Rolling Stock, the length of 3 - Car train would be approx. 69 mtrs. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximate dimensions have been taken in consideration, however final dimensions shall be decided based on actual site conditions/ area available at the time of design finalization of depot:

(i) Length of one 3 - Car rake= 69 m
(ii) Pathway in the entry side=10m
(iii) Free length at outer ends of two trains of 3 - Car rake (for cross pathway, Signal and Friction buffers) = 10m
(iv) Total length of Stabling lines = (ii) + (i) + (iii) = 10+69+10+69+10= 168m (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 3 - Car rake= 69m
(ii) Embedded track in the entry side =10 m
(iii) Pit length of IBL = 73 m
(iv) Embedded track length at outer ends of IBL = 12 m
(v) Free length at outer ends of two trains of 3- Car rakes (for cross pathway, Signal and Friction buffers) = 10m
(vi) Total length of Inspection lines = (ii) + (iii) + (iv) = 10+73+10+73+12= 178 m (approx.)

The width of the Inspection bay in computed as below:
(i) Centre - to - Centre spacing between the lines= 6.25 m
(ii) Centre line of outer lines to column of Shed= 4.25 m
(iii) Width of a 3 line Inspection Bay= (ii)+(i)+(i)+(ii) = 4.25+6.25+6.25+4.25 = 21 m

a) There shall be one inspection bay of 178 m X 21 m size with provision of accommodating three inspection lines each having sunken floor and overhead roof inspection platforms in two lines adjacent to I-Girder. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 6.25m.

b) Roof Inspection platforms of 1.2m width and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under-frame inspection. Ramps of 1:10 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. Both lines of inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment on retractable OHE.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have the arrangement close by for cleaning of HVAC filter under high pressure water jet.

7.8.3 Workshop Shed at Depot:

Requirement of workshop lines is planned as under:

Table- 7.7

Year	IOH & POH	Major Overhauling	Unscheduled repairs /lifting	Total	Remarks
2021	1	1 line x two 3-Car train and free space of 3-car train length for storage of other equipment.	1 line x1 train of 3-Car length.	One bay of 2 lines each with two trains of 3-Cars is to be required for the year 2021 onwards.	The size of workshop shall be 178 m X 21 m for one working bay comprising of two lines each capable of accommodating two 3-Car rake with Bogie turn table facility.
2031	1	2 lines x two 3-Car train and free space of 3-car length for storage of other equipment.	1 line x1 train of 3-Car length.	Two bays of 2 lines each with two trains of 3-Cars is to be required for the year 2031 onwards.	Additional one bay of 2 lines each with two trains of 3-car length capable of accommodating two 3-Car rake with Bogie turn table facility will be required from year 2031 onwards.

(a) Each bay shall be comprising of two lines (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 178m x 21m. The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the two 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 AW0 (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 178 m x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(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 50m long. The unloading bay should be of 50 m X 30 m and the bearing capacity of the floor should be 15-20 MT/m2. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers and minimum turning radius for the trailer movement should be 20-23 m. in case of space limitation a point lifting jack system can be installed.

7.10 OPERATIONAL FEATURES

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the main line train operation is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

7.11 INFRASTRUCTURE FACILITIES

I. Inspection and Workshop facilities:

As indicated in 7.8.2 & 7.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 7.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Table 7.8.

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting ‘On’ duty or going ‘Off’ duty can obtain updates regarding ‘Special Notices’, ‘Safety Circulars’ and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mtrs. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a8- Car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop, Inspection and intensive cleaning sheds. Thus, the pneumatic pipeline shall run within the workshop, inspection and intensive cleaning bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under-ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.
   - i) Close to the depot entry.
   - ii) Close to the stabling lines.

iii) Close to the Workshop/IBL.

b) Space for parking of road cum rail vehicle equipped with re-railing and rescue item: Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of road cum rail vehicle equipped with re-railing and rescue item will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated at Para 7.12.1. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL) of 50 m X 16 m approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given at Para 7.12.1 & 7.12.2.

7.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac rigid/ retractable OHE in such a way that, the cranes become operational only when the rigid/ retractable OHE is isolated and grounded.

b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is ‘Live’.

c) Multi-level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.

d) Pillars in the inspection bay & workshop should have provision for power sockets.

e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.

f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.

g) Control Centre, PPIO & store depot must be close to Workshop.

h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.

i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior, workshop and inspection shed for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

7.12 LIST OF BUILDINGS AND LIST OF PLANTS & EQUIPMENTS AT DEPOT-CUM-WORKSHOP:

7.12.1 List of Buildings at Depot-cum-workshop:

Table- 7.8

S.No.	Name of Building	Size	Remarks
1.	Inspection Shed	178m x 21m for each bay.	Servicing of Cars for 15 days & 45 days inspection.
	Workshop Shed	178 x 21m for each bay.	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs. Space for future provision to be kept beyond year 2031.
	Associated Sections	178m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed (Covered Stabling)	168m x28 m (for initial provision of 5 SBL lines)	Provision for total area (covered & uncovered SBL) as per requirement of stabling of 15 rakes of two 3-Car train length during year 2021 is to be made which will cater to the requirement of year 2031 also.
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	80m x 30m (partly	Stabling and routine maintenance of

S.No.	Name of Building	Size	Remarks
	depot and E&M repair shop	double storey)	shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	60m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
	Auto coach washing platform	20m X 10m	
7.	Washing apron for Interior Cleaning	184m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	Blowdown plant	30m X 5m (additional to intensive cleaning)	Heavy cleaning of underframe and roof through compressed air at 30 days interval.
9.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
10.	ETU Building	30m X 15m	For parking of CMV and OHE machinery.
11.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
12.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
13.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
14.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
15.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
16.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
17.	a) Traction 25kV/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
18.	Waste Collection Bin	10m x 10m	Garbage dumping

S.No.	Name of Building	Size	Remarks
19.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
20.	Work shop Manager Office	30m x 20m	Office of Depot in charge
21.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
22.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
23.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
24.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies' toilets shall be completely insulated from gent's toilet.

7.12.2 List of Plants & Equipments at Depot-cum-Workshop *:

Table - 7.9

S. No.	Description	Approx. Unit Price (INR Lakh)	Mumbai Metro Line-12: Kalyan to Taloja Depot IBL-3 Lines WSL-2 Lines	
			Qty.(set)	**Approx. Cost Provision (INR Lakh)**
1	Under floor Pit Wheel lathe	621.0	**1**	621.0
2	RRM for wheel lathe	184.0	**1**	184.0
3	Pit Jacks-for 3 car unit	521.0	**1**	521
4	Automatic Train Washing Plant	268.0	**1**	268.0
5	Battery Shunting Loco	300.0	**1**	300.0
6	Electric Tractors (RRM)	199.0	**1**	199.0
7	Bogie Test Stand	388.0	**1**	388.0
8	CNC Wheel press	425.0	**1**	425.0

S. No.	Description	Approx. Unit Price (INR Lakh)	Mumbai Metro Line-12: Kalyan to Taloja Depot	
			IBL-3 Lines	
			WSL-2 Lines	
			Qty.(set)	**Approx. Cost Provision (INR Lakh)**
9	CNC Vertical turret lathe	150.0	**1**	150.0
10	Blow Down Plant	110.0	**1**	110.0
11	Mobile Jacks for Lifting cars (15 T capacity (12 nos.) for 3 car)	93	**1**	93
12	Mobile Cranes(1T)	2.8	**2**	5.6
13	Mobile Lifting Table(1T for Insp)	2.8	**2**	5.6
14	Mobile Lifting Trolley / Tables (01 ton)	1.0	**2**	2
15	Mobile Lifting Table(3T for WS)	3.6	**2**	7.2
16	Work Lift Platform (Scissor lift)	19.0	**2**	38.0
17	Bogie Turn table (25T roll over capacity)	25.0	**2**	50.0
18	High Pressure Wash Pumps	6.5	**1**	6.5
19	AC Filter cleaning machine	22.0	**1**	22.0
20	Mobile Compressor(10 bar)	4.2	**1**	4.2
21	Industrial Vacuum Cleaner(heavy duty + dry/wet)	4.8	**1**	4.8
22	Small part cleaner	1.0	**LS**	1.0
23	Polyster Web Sling +B51+B51:B70:BB51:B70	1.0	**LS**	1.0
24	Compressor(17 bar)	4.2	**1**	4.2
25	EMU Battery Charger	5.6	**2**	11.2
26	Re-railling & rescue equipment (set)	83.4	**1**	83.4
27	Road cum rail vehicles for rerailing equipment(RRV)	43	**1**	43
28	Container for rerailing equipment	4.0	**1**	4.0
29	Battery Operated Platform Truck for Workshop & DCOS	6.3	**2**	12.7

S. No.	Description	Approx. Unit Price (INR Lakh)	Mumbai Metro Line-12: Kalyan to Taloja Depot IBL-3 Lines WSL-2 Lines	
			Qty.(set)	**Approx. Cost Provision (INR Lakh)**
30	Gas Cutting Equipments	1.4	**1**	1.4
31	Work / Test Benches	80.0	**LS**	80.0
32	Vertical Carousal storage system	19.5	**LS**	19.5
33	Storage racks for Workshop & Tool Room	32.0	**LS**	32.0
34	Weighing scales	1.5	**LS**	1.5
35	Storage Bins	4.2	**LS**	4.2
36	Hand Pallet Trucks	0.3	**3**	0.9
37	Fork Lift Truck-3T(Elect)	9.7	**2**	19.4
38	Stackers(1T for DCOS)	8.7	**1**	8.7
39	Mobile Safety Steps (MS+AL)	0.3	**3**	0.9
40	Set of Pallets	10.00	**LS**	10.00
41	Storage racks (Workshop & DCOS stores)	50.00	**LS**	50.00
42	Electric and Pneumatic Tools	40.00	**LS**	40.00
43	Measuring and calibration equipment Instruments	40.00	**LS**	40.00
44	Special Jigs and Fixtures, stand and trolleys	30.00	**LS**	30.00
45	Industrial Furniture	60.00	**LS**	60.00
46	Miscellaneous	50.00	**LS**	50.00
47	Pantograph checking fixture	30	**1**	30
48	Impulse tester for TMs(Surge Comparison Tester)	18	**1**	18
49	Minor diagnostic equipment/ Electronic equipment	20	**LS**	20

S. No.	Description	Approx. Unit Price (INR Lakh)	Mumbai Metro Line-12: Kalyan to Taloja Depot IBL-3 Lines WSL-2 Lines	
			Qty.(set)	Approx. Cost Provision (INR Lakh)
50	Induction heater	8.4	**1**	8.4
51	Bearing puller	9.6	**1**	9.6
52	Training equipment/ diagnostic software/computer equipment/laptop etc.	20	**LS**	20
53	Lifting jacks for ACS/Bogies(Two post lift)	12	**1**	12
54	Auto wheel profile meter	18	**1**	18
55	High capacity vacuum cleaner	9	**2**	18
56	TM cleaning equipment	3	**1**	3
57	Video diagnostic equipment for TM	17	**2**	34
58	Bearing monitoring equipment for TM , Gearbox etc.	20	**1**	20
59	Wooden Blocks	0.77	**1**	0.77
60	Auxiliary Truck	1.82	**1**	1.82
61	Wheel Gauges/Templates	3.8	**LS**	3.8
62	Ultrasonic Flow detector	2.18	**1**	2.18
63	Industrial Video scope	10.13	**2**	20.26
64	Memory recorder/Chart recorder	10	**1**	10
65	Coupler Backlog Gauge	8.15	**1**	8.15
66	25 Ton Hydraulic Frame Press	7.44	**1**	7.44
67	Hydraulic work bench for Gear box	16	**1**	16
68	Hydraulic work bench for couplers	7.6	**1**	7.6
69	Special tools for couplers	17.5	**LS**	17.5
70	Other tools/equipments as per RS contractor	50	**LS**	50

S. No.	Description	Approx. Unit Price (INR Lakh)	Mumbai Metro Line-12: Kalyan to Taloja Depot IBL-3 Lines WSL-2 Lines	
			Qty.(set)	**Approx. Cost Provision (INR Lakh)**
71	Damper Testing Machine	52.98	**1**	52.98
72	Spring Testing Machine	166.1	**1**	166.1
73	Rail fed Bogie Wash Plant	188.1	**1**	188.1
74	Heating Oven for TM	5.88	**1**	5.88
75	High voltage Test set	2	**1**	2
76	SS cage for HV Test Set	3.2	**1**	3.2
Total (INR Lakh)				**4788.68**

7.13 UN-ATTENDED TRAIN OPERATION (UTO)

(i) Proper segregation for UTO and non-UTO zone shall be earmarked while finalizing of depot layout.
(ii) Train Operator (TO) platform of 10m X 12m (L X B) shall be provided in each overlap zone of UTO and non-UTO.
(iii) Bulb fencing of depot tracks shall be done up to 1.5 m height from T.O.R. (Top of the Rail) level.
(iv) Gates should be provided in some interval with locking facility.
(v) All crossing roads which crosses the track should have gates with locking facilities.
(vi) All stabling lines should have SPK (Staff Protection Key) to avoid unauthorized entry.

CHAPTER - 8

POWER SUPPLY ARRANGEMENTS

Power supply is the lifeline of Metro System

8.1 POWER REQUIREMENTS

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting, ventilation fan & air-conditioning etc) and workshops in depots & other maintenance infrastructure within premises of metro system. The power requirements of Kalyan to Taloja 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 parameters: -

(i) Specific energy consumption of rolling stock at Pantograph/ Current Collector – 50 kWh/1000 GTKM for 25 kV ac system as per MOUD guideline.
(ii) Elevated/at –grade station load – initially 250 kW, which will increase to 300 kW in the year 2031.
(iii) Depot auxiliary load - initially 2000 kW, which will increase to 2200 kW in the year 2031.

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

Table 8.1 - Power Demand Estimation (MVA)

Corridor	Load	Year	
		2021	2031
Kalyan to Taloja (17 Elevated, 20.75 km)	Traction	5.68 MVA	10.50 MVA
	Auxiliary	7.72 MVA	9.02 MVA
	Total	**13.40 MVA**	**19.52 MVA**

The detailed calculations of power demand estimation are attached at annexure 8.1 and 8.2

8.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed section Kalyan to Taloja of Mumbai metro system is being designed to handle about 16,342 passengers per direction during peak hours when trains are expected to run at **6.25** minutes' intervals in the year 2031. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that there must be two sources of supply and both the sources of Supply & their connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220, 110 or 100 kV from stable grid sub-stations and further transmission & distribution will be done by the Metro Authority itself.

8.3 SOURCES OF POWER SUPPLY

The high voltage power supply network of Mumbai Metropolitan Region was studied in brief. The city has 220, 110 and 100 kV network to cater to various types of demand in vicinity of this section/ corridor.

The Mumbai Metro Corridor from Kalyan to Taloja has 20.75km length with 17 elevated stations. Keeping in view of requirement of power supply two Receiving Sub-stations are proposed to be set up at the following locations:

a) At depot near Pisarve Depot Station
b) Near Sagaon.

Power supply for this corridor will be taken care by these two RSS. In the event of failure of one of the two RSS, the power supply will be extended from the other RSS and vice versa. This is an economical solution without compromising reliability. Therefore, to avail power supply for traction as well as auxiliary services, the brief details of grid sub-stations of M/s MSETCL from which power will be taken at 220, 110 & 100 kV voltage through cable feeder are hereunder:

Table 8.2 - Sources of Power Supply

S. No.	Corridor	Grid sub-station (GSS) (Input voltage)	Location of RSS of Metro Authority	Approx. length b/w GSS & RSS
1	Kalyan to Taloja	100kV Sonarpada Sub-Station	Near Sagaon	1.5km
2		220kV MIDC Taloja Sub-Station	At depot near Pisarve Depot Station	4 km

*Note:
DMRC has done a joint survey/ meeting with M/s MMRDA and M/s MSETCL on 11.10.2018 & 12.10.2018 for this section for feasibility of Power Supply (Annexure-8.3). Accordingly, availability of power supply has been planned and tabulated above. Projected Power demand is calculated on each RSS and furnished below –

Table 8.3 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand** – Emergency (MVA)	
		Year (2021)	Year (2031)	Year (2021)	Year (2031)
Kalyan to Taloja	RSS Near Sagaon				
	Traction	2.31	4.46	5.68	10.50
	Auxiliary	2.68	3.22	7.72	9.02
	Sub-total (A)	4.99	7.68	13.40	19.52
	RSS at depot near Pisarve Depot Station				
	Traction	3.37	6.04	5.68	10.50
	Auxiliary	5.04	5.80	7.72	9.02
	Sub-total (B)	8.41	11.84	13.40	19.52

**Incase of failure of other source of power supply.

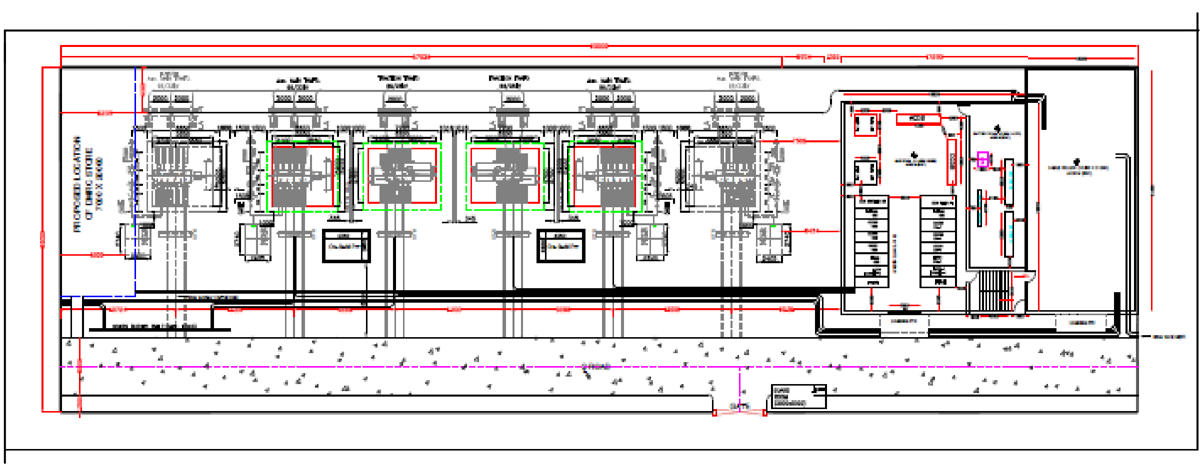
The 220 and 100 kV power supply will be stepped down to 3 Φ 33 kV and 1 Φ 25 kV level at the RSS located near Pisarve Depot Station & Sagaon respectively. The 1 Φ 25 kV will be fed to the OHE to cater to traction load and the 33 kV power will be distributed along the alignment through 33 kV Ring main cable network for feeding auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of this RSS of this section owing to fault or input supply failure, train services can be maintained from other RSS. 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 these DG Sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well, except for the train running.

Typical High Voltage Receiving Sub-station

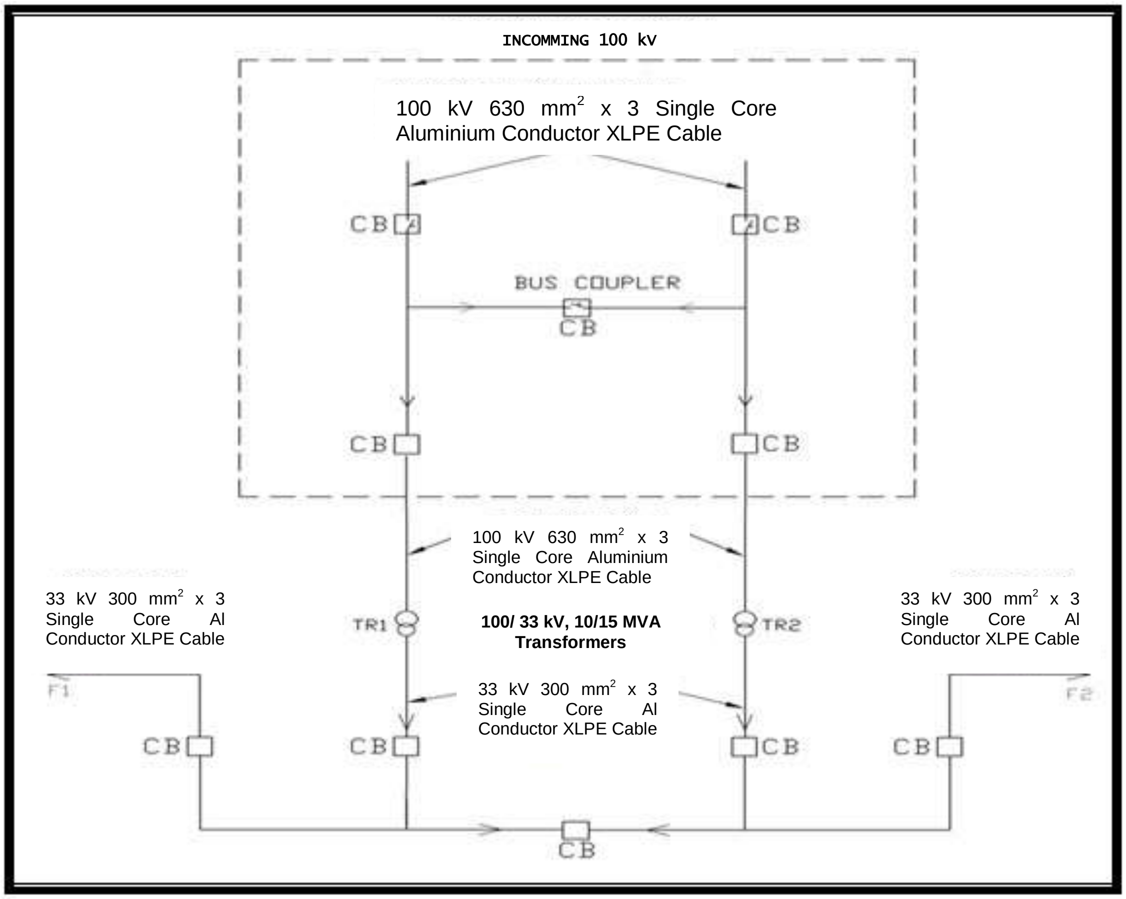
Typical High Voltage Gas Insulated Sub-Station (GIS)

The 220 and 100 kV cables will be laid through public pathways from the Sub-stations of Supply Authority to RSS of Metro Authority. The RSS at depot near Pisarve Depot Station shall be provided with 2 Nos. (One as standby) 220/25 kV 21.6/30 MVA (ONAN/ ONAF) Traction Transformers for feeding Traction load and 2 Nos. (one as standby) 220/33 kV, 10/15 MVA (ONAN/ ONAF) three phase Transformers for feeding auxiliary load. The RSS near Sagaon shall be provided with 2 Nos. (One as standby) 100/25 kV, 21.6/30 MVA (ONAN/ ONAF) Traction Transformers for feeding Traction load and 2 Nos (one as standby) 100/33 kV 10/15 MVA (ONAN/ ONAF) three phase Transformers for feeding auxiliary load. The capacity of transformers may be reviewed considering the load requirement/distribution of extension this section at the time of detailed design.



Typical Layout of GIS RSS

Gas Insulated Switchgear (GIS) type Switchgear is planned on account of less space availability in Mumbai and reduction in maintenance. 220 kV GIS substation land requirement will be approx. 80 X 50 m (4000 sq. m). For 110 kV GIS substation, land requirement will be approx. 60 X 50 m (3000 sq. m).



TYPICAL 100/33kV RSS LAYOUT

8.4 VARIOUS OPTIONS OF TRACTION SYSTEM

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

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

A sub- committee set up by "Ministry of Urban Development" on Traction system for metro railway has studies various aspects of merits and demerits of various traction system. The following are the highlights of Report-:

Merits and Demerits of various traction systems

a) **25 kV AC with OCS (Flexible/rigid):- Merits**

- **Reduced cost** – Unlike dc traction this system, does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in cost. Cost of 25 kV AC traction systems is about 15% less as compared to 750V DC 3rd rail traction system for the estimated level of traffic.

- **Energy regeneration & line losses-** Energy regeneration is more than 30% in 25 kV AC traction system as compared to 18% in 750V DC 3rd rail traction system. In 25 kV AC traction system line losses are 12% less as compared to 750V DC 3rd rail traction system.
- **Cost of rolling stock-** The cost of rolling stock & maintenance cost of traction system are comparable.
- **Capacity** – In future, the system can cater to traffic needs even in excess of 75000 PHPDT, which, however, is restricted on account of other constraints.
- **Easy of capacity enhancement** – Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation.
- **Higher efficiency of operation** – The efficiency of regeneration is substantially more than DC systems and line losses are very less of the order of 5%. 100% recovery of regenerated energy is possible in the case of 25 kV AC traction compared to a figure of 75% in the case of 1500 V DC systems and 60% in the case of 750 V DC systems.
- **Less Fire hazards**-AC system poses lesser fire hazards as current levels are much lower than DC system.
- **Stray current** - There are no problem of stray currents and hence nearby metallic structures are not affected by corrosion. However, there are problems of EMC / EMI which can be controlled by using return conductor & screened cables in signaling applications & fiber optic cable in telecommunication system without using booster transformer as per recent developments. This also helps in avoiding use of booster transformer which causes 2%-line loss and excessive voltage drops besides involving maintenance & reliability issues.
- Traction equipments in 25 kV AC system are standardized & mostly indigenously available. In DC traction system it is mostly imported.
- Though in underground section higher side tunnel diameter is required.

b) **750-850 V DC third rail traction system:-Demerits**

- **High operating currents and High voltage drops necessitating reduction in spacing of sub-station-** This leads to larger voltage drops along the Third Rail distribution system, which necessitates closer spacing of sub- stations at an interval of almost every 2 Km, leading to higher costs of construction.
- **Low levels of regeneration-** The regeneration is 18%, because 60% of re-generated energy in a 750 V dc system is possible to be retrieved.
- **Safety hazards with use of high voltage at ground level-** Due to existence of the “live” third rail at ground level, this system can be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.
- **Line losses-** Line losses are more due to higher current. Transmission line losses on 750 V DC traction system are around 21% as against 5% of 25 kV AC traction system.

- **Phenomenon of stray current-** In a third rail system, where the running rails are used as a return path, a part of the return current leaks into track structure. This current is called stray current. It is necessary to manage the stray current to ensure minimal corrosion effect and consequent damages to metallic components in the track structure as well as metallic reinforcement and metal pipes of building of metro and public areas adjacent to the Metro alignment.
- **Higher Consumption of Specific Energy:** As per MOUD guideline specific energy consumption in 750 V dc system is 60 kWh/GTKM and in 25 KV ac system is 50 kWh/GTKM. The specific energy consumption in 750 V dc system is higher as compared to 25 kV ac system. Hence operating cost will increase in 750 V dc system (copy enclosed).

c) 1500 V dc system with Overhead Catenary System:-Demerits

- Higher maintenance requirement and costs as compared to 750V DC third rail system.
- Theoretical traffic capacity with 1500 V traction system is less as compared to 25 kV AC system.
- Line losses are more due to higher current as compared to 25 kV AC. It may be in the range of 10 to 12% as against 5% of 25 kV AC system.

d) 2x25 kV ac single phase Traction System

The following are the benefit of 2x25 kV ac traction system used for this corridor are:

- The electromagnetic interference in of 2x25 kV systems is very less and hence no BT/RC system is required which has its own maintenance and reliability issues. However, additional space for autotransformer shall be required.
- The line loss in of 2x25 kV system is almost half as compared to 25 kV conventional system.
- In the event of 2 x 25 kV traction systems being adopted no of neutral section shall reduce.
- Load balancing will be better on all the three phase using Scott connected transformer.
- Since the OHE current is much lower in the of 2x25 kV systems; hence the OHE voltage profile will be better than conventional system. In fact, the voltage drop at the terminal end for the similar load will be almost half in of 2x25 kV system.
- Harmonics: since the fault currents are much higher in of 2x25 kV & 220/132 kV side, there are less harmonics on the system. Fifth harmonics on the system are in the range of 1% of less as compared to around 3% or higher, in case of conventional system. Due to fewer harmonic, the reliability of the Traction installation equipment and of electric rolling stock in expected to be better.
- Substation spacing: The inter-spacing between sub-station is almost double in of 2x25 kV system as compared to conventional system. Therefore, the number of substation almost reduces to half in the 2x25 kV AT system (with proper planning) as compared to the conventional system. This brings in substantial saving of costly space of around 2000 sq. m. in Mumbai metro area, besides saving due to use of lesser high voltage cable.

- 2x25 kV system is highly suitable for high dense load, as the voltage fed to the system at 25 kV as system due to better voltages and thus improved efficiency of the rolling stock.
- Arcing problems are encountered at BT overlap in 25 kV system and there have been melting cases of contact wire at the BT overlap location when bridging by stationary pantograph. No such problem will be encountered in 2x25 kV system.
- With the use of 2x25 kV system return conductor shall be replaced be feeder wire and the design shall be finalized accordingly.

In view of above techno-economic considerations, 25 kV AC traction system is suggested for this corridor.

8.5 ELECTROMAGNETIC INTERFERENCE (EMI) AND ELECTROMAGNETIC COMPATIBILITY (EMC)

25 kV AC traction current produces alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors–Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated via duct and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25 kV OHE and the elevated viaduct.
Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/EMC plan will be required to be developed during project implementation stage.

8.6 AUXILIARY SUPPLY ARRANGEMENTS FOR ELEVATED STATIONS

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 300 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415 kV) of 315 kVA capacity are proposed to be installed at the elevated/ at grade stations (one transformer as standby).

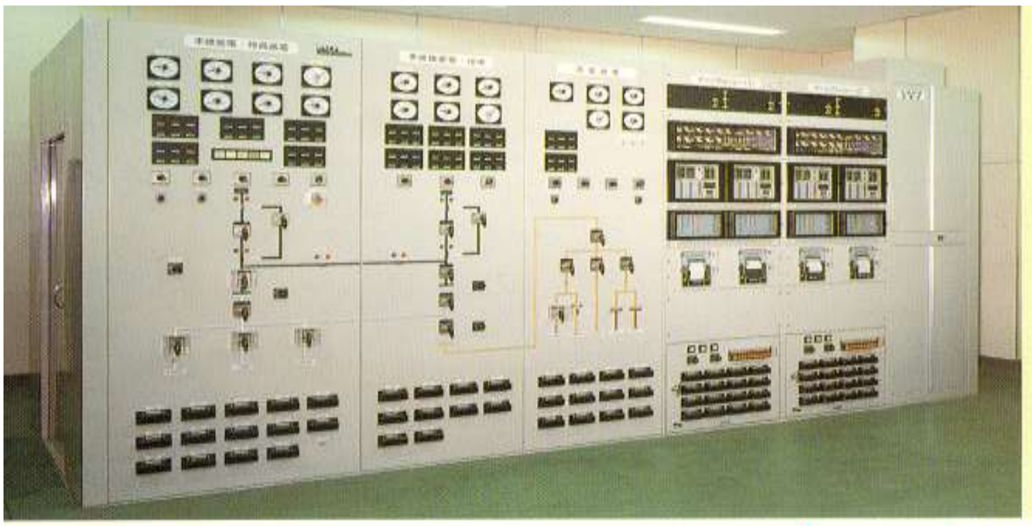
8.7 AUXILIARY SUPPLY ARRANGEMENTS FOR DEPOT

The Following major plant and machinery are to be provided in Depot-:

- RRV for carrying re railing equipments
- Road vehicles (pick up van/ truck)
- Flat wagon for carrying material.

- Diesel/Electric battery powered locomotive with traction battery charger.
- Under floor Pit wheel lathe, chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe.
- Travelling O/H crane workshop 15T/3T,1.5T capacity (IBL), ETU shed 5T crane
- Mobile Jib crane

A separate ASS is required at the depot. The Depot ASSs will be provided with 33kV/415V, 2x2500 kVA auxiliary transformers.



Typical Indoor Auxiliary Sub-station

8.8 25 KV AC FLEXIBLE OVERHEAD EQUIPMENT (OHE) SYSTEM

25 kV AC flexible OHE system shall comprise 150 sq.mm silver copper contact wire and 65 sq.mm Magnesium Copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be Aluminium Conductor Steel Reinforced (ACSR) 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. Final sizing of Catenary may be decided at the time of Detailed Design Stage as per Simulation Study.

8.9 RATING OF MAJOR EQUIPMENT

Based on emergency demand expected at the RSSs of this section as shown in Table 8.3, shall be provided with 2 Nos. (One as standby) 220/25 kV 21.6/30 MVA (ONAN/ ONAF) Traction Transformers for feeding Traction load & 2 Nos. (one as standby) 220/33 kV 10/15 MVA (ONAN/ONAF) three phase Transformers for feeding auxiliary loads at depot RSS near Pisarve Depot Station and 2 Nos. (One as standby) 100/25 kV 21.6 MVA (ONAN/ ONAF) Traction Transformers for feeding Traction load & 2 Nos. (one as standby) 100/33 kV 10/15 MVA (ONAN/ONAF) three phase Transformers for feeding auxiliary loads at RSS near Sagaon. The incoming cable shall be 3-phase single core XLPE insulated with 800 mm^2

Aluminum conductors for fault level of the 220 kV and 630 mm^2 Aluminum conductors for fault level of 100 kV supply to meet the normal & emergency loading requirements.

33 kV and 25 kV switchgear shall be rated for 1250 A and 2000 A respectively 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 Al 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 feeding Post. 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
- Lightning protection system
- Earthing system.

Panels shall be front operated front access cubical type indoor duty floor mounted totally enclosed dust and vermin proof with neoprene gaskets fabricated from CRCA sheet with powder coated finish suitable for 415 V 3 Phase 4 wire 50 Hz system.

8.11 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 160 kVA capacity at the elevated stations.

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.UPS Supply is to also be considered for following emergency services:

- Emergency Lighting
- Fire Detection & Fire Alarm system.

- Station Control Room
- Control Supply
- Signaling & telecommunications
- Lift operation
- Fare collection system

8.12 SOLAR PHOTO VOLTAIC (PV) POWER SYSTEM

In DMRC solar PV power system are installed at various sites in RESCO (Renewable Energy Service Company) model. In DMRC Stations and Depots 21 MWp solar PV power system has been installed in RESCO model.

Solar PV Power panel

“RESCO Model” means where the developers intend to provide solar power system on rooftop/sites owned by DMRC on mutually agreed terms and conditions from DMRC and enters into the PPA (Power purchase agreement) with DMRC for supply of Solar power for 25 years from the date of Commissioning of project.

In elevated stations about 50 kWp to 150 kWp capacity of Solar PV power system can be provided depending upon type of roof availability, shadow free roof area, orientation of stations. In DMRC receiving sub-station 20 kWp to 50 kWp capacity Solar PV systems are generally provided. In DMRC Depot area, approx.1000 kWp to 1500 kWp of solar capacity has been provided. Solar PV system in station parking area can also be planned as per availability of area.

8.13 SEWAGE TREATMENT SYSTEM USING INTEGRATED CONSTRUCTED WETLANDS (ICW)

Following are the objectives for providing Sewage Treatment System using Integrated Constructed Wetlands (ICW): -

1) To establish an effective option for treatment of wastewater that is generated from campus.

2) Establish an onsite treatment solution which is effective and cost effective option without producing any by products.
3) To establish a sustainable and environmental friendly solution with minimal maintenance.
4) The treated water can be reused for various non-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 35-40% (approx.) of total traction energy will be regenerated. Some of the regenerated energy rolling stock is consumed by auxiliary application itself and remaining energy is fed back to 25kV ac OHE to be consumed by nearby trains

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-room less type lifts with re-generative braking feature 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 resulting saving of electrical energy.

(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 MAJOR EHV/HT LINE CROSSING THE ALIGNMENT

(i) At two locations 400 kV EHV lines single circuit double conductors are crossing the corridor between Kolegaon & Nilje Gaon.

(ii) One HT line of 220 KV double circuit double conductors is crossing between Pisarve Depot & Pisarve Station and at two locations between Sonarpada & Manpada Station.

(iii) At three locations 220 kV HT line double circuit is crossing between Kolegaon & Nilje Gaon Station.

(iv) At Four locations, 11/33 KV HT line is crossing the alignment between Ganesh Nagar & Pisavali Gaon.

(v) There is HT line of 11/22 kV running both side and along the road from Manpada to Sagaon and ay infringe at Metro Stations.

Detailed survey / estimation etc will be done after finalization and approval of DPR.

8.17 ELECTRIC POWER TARIFF

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 30-38% of total annual operating cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 34.53 million units in initial years 2021, which will be about 53.21 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 220 & 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 M/s MSETCL for FY 2018 – 19 demand charges Rs 350/ kVA per month and energy charges Rs 7.00/ kWh. It is proposed that Government of Maharashtra takes necessary steps to fix power tariff for Mumbai Metro at "No Profit No Loss" basis. Similar approach has been adopted for Delhi Metro.

MUMBAI METRO			Annexure 8.1	
Line-12: Kalyan to Taloja				
POWER (Traction & Auxiliary)				
S.No.	**Particulars**	**Unit**	**2021**	**2031**
A	**Traction Power Requirement**	1	2	3
1	No. of cars	(2DMC+2TC+2MC) (DMC+TC+DMC)	3	6
2	Passenger Weight	T	71.5	145.6
3	Train Tare Weight	T	127.0	254.0
4	Total Train Weight	T	198.5	399.6
5	Section Length	km	20.86	20.86
6	Headway	mts	6.00	6.25
7	SEC at Pantograph/ current Collector (As per MOUD guideline)	KWhr/ 1000 GTKM	50	50
8	No. of Trains/hr in both directions	Nos.	20	19
9	Peak Traction Power Requirement	MW	4.14	8.00
11	Depot Power Requirements	MW	1.00	1.50
12	No. of Depot	No	1	1
13	Total Traction Power Requirement	MW	5.14	9.50
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**5.68**	**10.50**
B	**Aux. Power Requirement**			
1	Elevated/at-grade Station Power Consumption	MW	0.25	0.30
2	Underground station Power Consumption	MW	2.20	2.50
3	Mid Shaft	MW	0.30	0.30
4	No. of Elevated/at-grade Stations	Nos.	17	17
5	No. of Underground stations	Nos.	0	0
6	No. of Mid Shaft	Nos.	0	0
7	Total Station Aux Power Requirement	MW	4.3	5.1
8	Depot Aux Power Requirement	MW	2.0	2.2
9	No. of Depot	No.	1	1
10	Total Aux Power Requirement	MW	6.25	7.30
	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for aux loads	**MVA**	**7.72**	**9.02**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**13.40**	**19.52**

Note:
1. The requirement of PD load is not considered in Power calculation.

MUMBAI METRO			Annexure 8.2	
Line-12: Kalyan to Taloja				
ENERGY CONSUMPTION				
S.No.	Particulars	Unit	2021	2031
A	Traction Energy	1	2	3
1	Section Length	KM	20.86	20.86
2	No. of Trains per direction in a day	Nos.	108	105
3	Weight of Train & Passenger	T	198.5	399.6
4	SEC at Pantograph/ current Collector (As per MOUD guideline)	KWH/ 1000 GTKM	50	50
	Yearly Traction Energy consumption with 365 days working	**million units**	**16.32**	**31.95**
B	Auxiliary Energy			
1	Elevated/at-grade Station	MW	0.25	0.30
2	Underground Station	MW	2.20	2.50
3	Mid Shaft	MW	0.30	0.30
4	No. of Elevated/at-grade Stations	Nos.	17	17
5	No. of Underground Stations	Nos.	0	0
6	No. of Mid Shaft	Nos.	0	0
7	Total Station Aux. Power Requirement	MW	4.25	5.10
8	Depot Aux power requirement	MW	2.00	2.20
9	No. of Depot	No	1	1
10	Total Aux. Power Requirement	MW	6.25	7.30
11	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	**MVA**	**7.72**	**9.02**
12	Diversity Factor of Aux. loads		0.40	0.40
	Yearly Aux. Energy Consumption 19 hrs/day and 365 days working (million units)	**million units**	**18.20**	**21.26**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**34.53**	**53.21**

Note:
1. The requirement of PD load is not considered in energy calculation.

Annexure-8.3

CIN No. U74899DL 1995G0I068150

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दिल्ली मेट्रो रेल कॉर्पोरेशन लि०
DELHI METRO RAIL CORPORATION LTD.
(भारत सरकार एंव दिल्ली सरकार का संयुक्त उपक्रम)
(A JOINT VENTURE OF GOVERNMENT OF INDIA AND GOVT. OF DELHI)

AID-MEMOIRE OF THE MEETING/JOINT SURVEY DONE WITH MSETCL AND MSEDCL

Date: 11.10.2018 & 12.10.2018 Place: Mumbai

Present:-

	MSETCL & MSEDCL		DMRC
1	Mr. S. N. Bhople, CEE (MSETCL)	1	Mr. Arbind Kumar Singh, Dy.CEE-II / Mumbai
2	Mr. S. V. Gahawar, Chief Engineer (Vashi Incharge), MSEDCL	2	Mr. A.K. Sinha, AM/Electrical/Mumbai
3	Mr. Amit Naik, Executive Engineer	3	Mr. Ravi Jadhav, Surveyor

A meeting was held on 11.10.2018 with the officers of MSEDCL, MSETCL & DMRC/Mumbai Officers and a joint survey done with DMRC/Surveyor on 12.10.2018 for the proposed Mumbai Metro Corridor Line- 12 from Taloja to Kalyan accordingly following conclusions were made on proposed corridor of Mumbai Metro Rail (20.75 km):-

1) DMRC explained the route alignment of proposed Mumbai Metro Rail Corridor and requirement of a power source of 66 kV and above with approx. Tentative load of 25 MVA for each RSS near STN- 5 Station and STN- 15 at depot. Each RSS requires two bays from the respective nearby grid Sub-station.
2) MSETCL has confirmed that they shall provide two no. 100 kV bays from their 100 kV Sonarpada Sub-station Kalyan, distance of Sonarpada Substation is approximately 1.5 KM from proposed STN- 5 Station.
3) MSETCL has confirmed that they shall provide and give the supply with LILO connection from 220 kV transmission line that is passing from STN- 15 at depot approximately distance is 1.0 km or 2 bays supply shall be provided from MIDC Taloja 220 kV substation and it is approximately 4 kms away from the proposed station.

4) HT Crossing-

I. One HT Line of 220 kV double circuit double conductor crossing between STN- 15-16 station.

II. Three locations HT Line of 100 kV double circuit and Two EHV lines of 400 kV single circuit double conductors are crossing between STN- 9-10 station.

III. Two locations HT line of 220 kV double circuit crossing the alignment between STN- 6-7 Station.

IV. Four locations HT Line of 11/33 kV crossing the alignment between STN- 1-2 Station.

V. There are HT lines of 11/22 kV running both side and along the road from STN- 7 to STN 5 and may infringe at Metro Stations.

(A.K. Singh)
Executive Director/electrical-II
Telefax: 011-23417920

CC:

1. Mr. M.S. Devaru, Addl. Chief (M, MO & U), Transport & Communication Division, Mumbai Metropolitan Region Development Authority, Bandra-Kurla Complex, Bandra (E), Mumbai-400051
   Tel: 2659 0001/ 4000, Fax: 2659 1264, Email: mruthunjaya.devaru@mailmmrda.maharashtra.gov.in

2. **DBD/DMRC**:- for kind information please

3. Copy to all present.

CHAPTER – 9

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

9.1 LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

The need for a well-developed legal mechanism to conserve resources, protect the environment and ensures the health and well being of the people in India is more than ever before. Keeping pace with international laws, the Ministry of Environment and Forest enacted Environmental Protection Act in 1986. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. The available national and state level legal Acts and Legislation referred during the study are:

- Constitutional provisions of Government of India on Environment;
- The Environment (Protection) Act, 1986;
- EIA Notification, 1994 and EIA Notification in 2006;
- Forest (Conservation) Act, 1980 - as amended in 1988;
- The Indian Forest Act, 1927;
- Wildlife Protection Act, 1972;
- The Forest (Conservation) Rules, 1981;
- Water (Prevention and Control of Pollution) Act, 1974 - as amended in 1978 &1988;
- Air (Prevention and Control of Pollution) Act, 1981;
- The Motor Vehicles Act, 1988;
- Hazardous Wastes (Management & Handling) Rules, 1989 as amended in 2008;
- C& D waste management Rules, 2016;
- Solid Waste management rules 2016;
- Plastic waste management rules 2016;
- Fly ash notification 2016
- Directions of National Green Tribunal (NGT) etc
- CRZ Regulations.

9.2 VARIOUS ENVIRONMENT PERMISSIONS REQUIRED

As per EIA notification, Railway Projects are not covered to seek prior Environmental Clearance from MoEFCC/SEIAA. Various permissions related to environment required for the project during Preconstruction, Construction and Operation phase of the project. The key permissions required for the project are listed in **Table 9.1**.

Table 9.1 - Key Environmental Clearances Required

Permission/ Clearance /Permit	Acts/Rules	Concerned Agency	Stage
Consent to establish and consent to operate batching plant/casting yard	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988 and The Air (Prevention and Control of Pollution) Act 1981, amended 1987	Maharashtra State Pollution Control Board	Pre-Construction
Consent to establish and operate STP and ETP	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988	Maharashtra State Pollution Control Board	Operation
Generation, handling, storage and transportation of hazardous waste	Hazardous and other wastes (management & transboundary movement) rules, 2016	Maharashtra State Pollution Control Board	Construction and Operation
Permission for extraction of ground water	Environment (Protection) Act, 1986	CGWA	Pre-constrcution (as the case may be) / and for operation
Permission for felling trees	Tree Preservation Act	Forest Department / Tree Authority	Pre-construction
C&D Waste Management Plan	C&D Waste Management rules, 2016	Local Authority	Pre-construction
CRZ Permission	CRZ Regulations	MCZMA	Pre-construction

Following Table 9.2 gives summary of relevant environmental laws applicable to the project

Table 9.2 - Environmental laws applicable to the project

SI. No.	Act/Regulation	Objectives	Implementing /Responsible Agency
01.	Air (Prevention and Control of Pollution) Act, 1981	To control and monitor air pollution as per prescribed limits set by	Maharashtra State Pollution Control Board
02.	The Water (Prevention and Control of Pollution) Act, 1977	To control and monitor water pollution as per prescribed limits	Maharashtra State Pollution Control Board
03.	The Forest Conservation Act, 1980	To check deforestation by restricting conversion of forested areas into non-forested areas	• Forest Department, Govt. of Maharashtra • Regional Chief Conservator of Forest - 5 - 20 Ha. • MoEFCC - Above 20 Ha and more than 40 % canopy closure)

Sl. No.	Act/Regulation	Objectives	Implementing /Responsible Agency
04.	National Forest Policy, 1988	To preserve and restore biological diversity	Forest Department, GoI and Government of Maharashtra.
05.	Wildlife (Protection) Act, 1972	To protect wildlife through creation of Wildlife Sanctuaries and National Parks	Chief Conservator of Wildlife, or Chief Wildlife Warden, Wildlife Wing, State Forest Department, National Wild Life Board, MoEFCC
06.	Environment Protection Act, 1986	To protect and improve the overall environment	Ministry of Environment, Forest and Climate Change
07.	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Rules for acquisition of land by Government	project Authority/District Collector
08.	National Environmental Appellate Authority Act, 1997	For grievance redressal	Ministry of Environment and Forests and Climate Change
09.	Notification on roadside trees (February, 1998)	For maintenance and preservation of roadside trees	State Forest Department
10.	Hazardous Materials storage and handling Rules	Liability for damages due to any accident while handling hazardous substances	Chairman, National Environmental Tribunal
11	CRZ Regulations	Regulating construction activities in Coastal Regulation Zone are to protent sensitive coastal ecology	MCZMA

9.3 CLEARANCES

For the proposed project, required clearances/permissions related to environment have been summarized below in Table 9.3:

Table 9.3: Permissions/Clearances Required for the Project

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980) Procedural Guidelines developed by the Department of Environment, GoM; Tree removal will be guided as per state government rules.	District Forest Office/State Forest Department/ District Collector	MMRDA
2	CRZ Clearance	The Ministry of Environment and Forests had issued the Coastal Regulation Zone (**CRZ**) Notification on 19.2.1991 under the Environment (Protection) Act, 1986, with the aim to provide comprehensive measures for the protection and conservation of our coastal environment.	MCZMA	MMRDA
B. Implementation Stage				
3	Consent to operate hot mix plant, crushers, batching plant	Air (Prevention and Control of Pollution) Act 1981	Maharashtra State Pollution Control Board	Contractor
4	Permission for withdrawal of groundwater	Environment (Protection) Act, 1986	Central Ground Water Authority	Contractor
5	Permission for sand mining from river	Environment (Protection) Act, 1986	Mining Department/ MoEF	Contractor
6	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 1989	Maharashtra State Pollution Control Board	Contractor
7	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 1989	Local civic body to use local solid waste disposal site	Contractor
8	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	Maharashtra State Pollution Control Board	Contractor
9	Pollution Under Control Certificate	Central Motor and Vehicle Act 1988	Department of Transport, Govt. of Maharashtra authorised testing centres	Contractor
10	Roof Top Rain Water Harvesting (RWH)	Central Groundwater Authority (CGWA) Guidelines	Central Ground Water Authority	Contractor

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
11	Permission for groundwater extraction for drinking purpoes	Environment (Protection) Act, 1986	CGWA	Contractor
12	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employmentv and Conditions of Service) Act, 1996	District Labour Commissioner	Contractor

9.4 OBJECTIVE AND SCOPE OF THE STUDY

The objective of the study is to facilitate the Mumbai Metropolitan Region Development Authority (MMRDA) evaluate the environmental impacts of its proposed activity. MMRDA proposes to apply for loan to seek financial support from multilateral fundinng agencies. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of Kalyan- Taloja Metro corridor at Mumbai. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles. The MoEF, Government of India, Notification of 14th September 2006 and its amendment dated 1st December 2009 enlist projects in Schedule that require environmental clearance. However, as per the said notification Railway/ Metro projects do not require environmental clearance from MoEF.

9.5 APPROACH AND METHODOLOGY

The MMRDA has considered different alternative corridors. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are minimum private land acquisition, least disturbance to properties, minimum disturbance to ecology/biodiversity. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the alignment proposed by MMRDA. The impacts are assessed for various phases of project cycle namely:

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

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

The standard methodology for the data collection, impact assessment and formulation of management plans is adopted. The national acts, legislation and laws along with guidelines were consulted with a view to ensuring compliance with various requirements. Environmental baseline data for environmental attributes from primary and secondary sources were collected and compiled. The primary sources include site visits, visual inspection, field studies, monitoring and analysis.

9.5.1 Data Collection

The existing land-use pattern of the area has been identified mainly as urban human settlements, roads, Trees and water bodies.

Water Resources in the project were considered in terms of precipitation, surface run off; quantity and quality of water.

Air and Noise quality is an important consideration during construction and operation phases. Ambient air quality and noise levels were monitored in project area to develop present baseline levels in the area. Terrestrial **Ecology** was also studied.

9.5.2 Environmental Impact Assessment

The objective of the study is to assess the impacts as a result of construction of the proposed metro corridor. The changes likely to occur in different components of the environment were studied and analyzed. Based on project particulars and the existing environmental conditions, potential impacts were identified that are expected to be affected as a result of the proposed project and wherever possible, these are quantified. Both positive and negative impacts are evaluated to get an idea about resultant impacts. The environmental impact of the project includes changes in land use, soil, erosion, water quality, air quality and noise levels etc. The impact on soil due to disposal of waste water and erosion during construction were predicted. On the other hand, the project may provide higher living standard, better quality of life, less travel time, better connectivity and transport facilities.

9.5.3 Environmental Management Plan

The management plans are essential to ensure that stress/ loads on the systems are within carrying capacity. The management plan aims at maintaining the environmental quality of project area with respect to pre-project stage. An environmental management strategy/ plan is developed to mitigate the adverse impacts. Efforts are made to enhance the quality of environmental attributes.

9.5.4 Environmental Monitoring

Monitoring would indicate any environmental problem, which has come up due to an ongoing activity. This will facilitate to assess the effectiveness of management / mitigation measures.

9.6 PROJECT DESCRIPTION

9.6.1 Project Area

The metro project in Mumbai is proposed between Kalyan and Taloja. The proposed alignment would serve the city by ultimately providing connectivity between Kalyan and Taloja. This line is also known as line 12 of Mumbai Metro.

9.6.2 Proposed Metro Corridor

Metro corridor is proposed in Mumbai to cater the requirement of the city between suburban area of Kalyan and Taloja for a length of about 21 km. The part of the alignment passes through green field area. The total corridor will be elevated. The Metro corridor will have standard Guage alignment.

9.6.3 Route Alignment

The proposed route alignment of metro corridor between Kalyan and Taloja. The alignment has 17 stations.

9.6.4 Route Length and Stations

Elevated option has been adopted throughout the proposed corridor between Kalyan and Taloja to minimize the adverse effects on the existing properties and the road network. At places, the alignment steers off the road. The details of stations have been given in respective chapter**.**

9.6.5 Boarding and Alighting

Traffic projections for different horizon years have been worked out in traffic chapter.

9.7 SYSTEM REQUIREMENT

The entire corridor will be elevated. 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. On the viaducts, it is proposed to adopt plinth type ballastless track structure with RCC derailment guards integrated with the plinths. Train Operation Plan has following Salient Features

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

The headway will be 6.00 min in 2021 and 6.25 min in 2031 with 15 rakes.

9.8 CONSTRUCTION METHODOLOGY

The segmental construction has been proposed. The superstructure of a large part of the viaduct comprises of simply supported spans. It is proposed to provide Double U girders as superstructure for the viaduct.

9.9 MAINTENANCE DEPOT

It is proposed to develop Depot for this corridor at Taloja in the vicinity of existing Taloja Depot developed by SIDCO. The Depot will be developed in 20 ha land.

9.10 POWER REQUIREMENT

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting & air-conditioning etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Keeping in view of the train operation plan and demand of traction and power, power requirements projected for the year 2021 and 2031 are summarized in table 9.4 below:

Table 9.4 - Power Demand Estimation (MVA)

Corridor	Load	Year	
		2021	2031
Line-12 Kalyan Taloja corridor (17 Elevated Stations, 20.75 km)	Traction	5.68 MVA	10.50 MVA
	Auxiliary	7.72 MVA	9.02 MVA
	Total	**13.40 MVA**	**19.52 MVA**

9.11 ENVIRONMENTAL BASELINE DATA

9.11.1 Environmental Scoping

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

The information presented in this chapter has been acquired from various sources. Data on land environment has been collected and compiled from various reports and field surveys. The data on water, air, noise quality, and biodiversity were collected through field studies, sampling and monitoring during March 2018. Climatological data was collected from Indian meteorological Department. Efforts have been made to compile the available data from literature, books, maps and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental Attributes and Frequency of Baseline Survey is presented in **Table 9.5**.

Table 9.5 - Environmental Attributes and Frequency of Monitoring

S. No	Attribute	Parameter	No. of Samples	Source
LAND ENVIRONMENT				
1	Geology	Geological Status	---	Literature review
2	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
3	Ground Water	Physical, Chemical and Biological parameters	5	Sampling/ Monitoring locations
	Surface Water	Physical, Chemical and Biological parameters	4	Sampling/ Monitoring locations
AIR, NOISE AND METEOROLOGY				
4	Ambient Air Quality	PM_{10},$PM_{2.5}$, SO_2, NO_x	22	Sampling/ Monitoring locations

S. No	Attribute	Parameter	No. of Samples	Source
5	Noise	Noise levels in dB (A) Leq, Lmax, Lmin, L_{10}, L_{50}, L_{90}	22	Sampling/ Monitoring locations
6	Soil Quality	Physico-chemical parameters	5	Sampling/ Monitoring locations
SOCIO-ECONOMIC				
7	Socio-economic aspects	Socio-economic profile	Once	Field Studies, Literature review.
ECOLOGY				
8	Trees	Number	Once	Filed Studies

The sampling/ monitoring sites have been depicted in **Fig. 9.1**.

Fig. 9.1 Sampling/ Monitoring locations

9.12 LAND ENVIRONMENT

The Project area is situated in Mumbai. The elevation of the project area is ranging between 6m to 18 m above the mean sea level (a-MSL). Parameters involved in land environment are, physiography, geology and soils, and seismicity. These are discussed in the following paragraphs.

9.12.1 Geography, Geology and Soil

The total area of Mumbai is 437.71 km^2. Of this, the island city spans 67.71 km^2, while the suburban area spans 370 km^2, together accounting for 437.71 km^2 under the administration of Municipal Corporation of Greater Mumbai (MCGM). Mumbai lies at the mouth of the Ulhas River on the western coast of India, in the coastal region known as the Konkan. It sits on Salsette Island (Sashti Island), which it partially shares with the Thane district. Mumbai is bounded by the Arabian Sea to the west. Many parts of the city lie just above sea level, with elevations ranging from 10 m to 15 ; the city has an average elevation of 14 m. Northern Mumbai (Salsette) is hilly, and the highest point in the city is 450 m at Salsette in the Powai–Kanheri ranges. Soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy. The underlying rock of the region is composed of black Deccan basalt flows, and their acidic and basic variants dating back to the late Cretaceousand early Eocene eras.

9.12.2 Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. Mumbai sits on a seismically active zone owing to the presence of 23 fault lines in the vicinity. Mumbai falls in zone III according to IS 1893: 2002 which means an earthquake upto magnitude 6.5 on Richer scale may be expected. (**Figure 9.2).**

Project Area

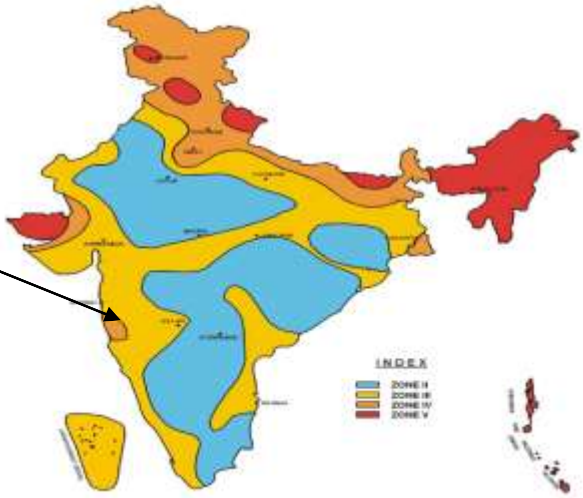


Figure 9.2 Seismic Zoning Map of India

9.13 WATER ENVIRONMENT

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

9.13.1 Water Resources

Under colonial rule, tanks were the only source of water in Mumbai, with many localities having been named after them. The MCGM supplies potable water to the city from six lakes, most of which comes from the Tulsi and Vihar lakes. About 700 million litres of water, out of a daily supply of 3500 million litres, is lost by way of water thefts, illegal connections and leakages, per day in Mumbai.

9.13.2 Hydrogeology and Ground Water

The entire Mumbai district is underlain by basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow Alluvium formation of Recent age also occur as narrow stretch along the major river flowing in the area. The data of Central Ground Water Board (CGWB) from the year 1998 to 2007 shows decline in ground water levels in major parts of Mumbai.

9.13.3 Water Quality

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality are related to drinking water, safety of human contact, and for health of ecosystems. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for our use. Water sampling Sites have been shown in **Fig.9.1.** Ground and surface water samples were collected in September 2018**.** Water quality has been given in **Table 9.6.** Groundwater quality is quite good. However total dissolved solids are a little higher than the desirable limits but within permissible limits. All other parameters are well within the desirable limits.

Table 9.6 - Ground Water Quality at Project Site

S. No.	PARAMETER	Near APMC	Nr. Tata Power	Nr Golavli	Nr. Toll Plaza	Taloja Depot	UNIT	IS : 10500:2012 (Limits)	
								Acceptable	Permissible
Sampling Date: 15.9.2018									
1	Colour	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	Hazen	5	15
2	pH	6.90	6.90	7.16	7.15	7.14	–	6.5-8.5	No relaxation
3	Total Hardness (as $CaCO_3$)	296.0	276.0	317.0	318.0	311.0	–	200	600
4	Calcium Hardness (as $CaCO_3$)	192.0	190.0	163.0	155.0	169.0	NTU	75	200
5	Iron (as Fe)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	–	0.3	No relaxation
6	Chloride (as Cl)	99.8	96.8	56.4	66.4	85.4	mg/L	250	1000
7	Residual Free Chlorine	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	mg/L	0.2	1
8	Fluoride (as F)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	mg/L	1	1.5
9	Total Dissolved Solids	645.0	650.0	638.0	628.0	643.0	mg/L	500	2000
10	Magnesium Hardness (as $CaCO_3$)	80.0	78.0	134.0	142.0	131.0	mg/L	30	100
11	Copper (as Cu)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	mg/L	0.05	1.5
12	Manganese (as Mn)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	mg/L	0.1	0.3
13	Sulphate (as SO_4)	40.6	40.1	44.2	49.8	39.2	mg/L	200	400
14	Nitrate (as NO_3)	1.15	1.16	1.56	1.67	1.06	mg/L	45	No relaxation

S. No.	PARAMETER	Near APMC	Nr. Tata Power	Nr Golavli	Nr. Toll Plaza	Taloja Depot	UNIT	IS : 10500:2012 (Limits)	
								Acceptable	Permissible
15	Phenolic Compounds	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	mg/L	0.001	0.002
16	Mercury (as Hg)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	mg/L	0.001	No relaxation
17	Selenium (as Se)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	mg/L	0.01	No relaxation
18	Arsenic (as As)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	mg/L	0.01	0.05
19	Cyanide (as CN)	Absent	Absent	Absent	Absent	Absent	mg/L	0.05	No relaxation
20	Lead (as Pb)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	mg/L	0.01	No relaxation
21	Zinc (as Zn)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	mg/L	5	15
22	Total Chromium (as Cr)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	mg/L	0.05	No relaxation
23	Nickel (as Ni)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	mg/L	0.02	No relaxation
24	Aluminium (as Al)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	mg/L	0.03	0.2
25	Boron (as B)	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	mg/L	0.5	1
26	Cadmium (as Cd)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	mg/L	0.003	No relaxation
27	Total Suspended Solids	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	mg/L	-	-
28	Biological oxygen demand	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	mg/L	-	–
29	Chemical oxygen demand	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	mg/L	-	–
30	Oil & Grease	ND	ND	ND	ND	ND	mg/L	-	-
31	Pesticides	ND	ND	ND	ND	ND	mg/L	0.1	No relaxation
32	Total Phosphate	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	mg/L	-	-
33	Total Kjheldal Nitrogen	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	mg/L	100	-
34	Dissolved Oxygen	4.1	4.4	5.3	5.6	5.8	mg/L	-	-
35	Poly Aromatic Hydrocarbon	ND	ND	ND	ND	ND	mg/L	0.0001	No relaxation
36	Total Coliform	Absent	Absent	Absent	Absent	Absent	MPN/100 ml	Shall be undetectable in 100ml	-

Table 9.7 Surface Water Quality at Project Site

S. No.	PARAMETER Sampling Date: 15-9-2018	Nilaje Lake	River	UNIT
1	Colour	30	30	Hazen
2	pH	7.12	7.12	–

S. No.	PARAMETER Sampling Date: 15-9-2018	Nilaje Lake	River	UNIT
3	Total Hardness (as $CaCO_3$)	74.0	54.0	mg/L
4	Calcium Hardness (as $CaCO_3$)	33.0	31.0	mg/L
5	Iron (as Fe)	< 0.1	< 0.1	mg/L
6	Chloride (as Cl)	32.9	32.9	mg/L
7	Residual Free Chlorine	< 0.2	< 0.2	mg/L
8	Fluoride (as F)	< 1.0	< 1.0	mg/L
9	Total Dissolved Solids	197.0	201.0	mg/L
10	Magnesium Hardness (as $CaCO_3$)	36.0	31.0	mg/L
11	Copper (as Cu)	< 0.01	< 0.01	mg/L
12	Manganese (as Mn)	< 0.1	< 0.1	mg/L
13	Sulphate (as SO_4)	29.3	25.3	mg/L
14	Nitrate (as NO_3)	9.18	9.58	mg/L
15	Phenolic Compounds	< 0.001	< 0.001	mg/L
16	Mercury (as Hg)	< 0.001	< 0.001	mg/L
17	Selenium (as Se)	< 0.005	< 0.005	mg/L
18	Arsenic (as As)	< 0.005	< 0.005	mg/L
19	Cyanide (as CN)	Absent	Absent	mg/L
20	Lead (as Pb)	< 0.005	< 0.005	mg/L
21	Zinc (as Zn)	0.16	0.11	mg/L
22	Total Chromium (as Cr)	< 0.01	< 0.01	mg/L
23	Nickel (as Ni)	<0.01	<0.01	mg/L
24	Aluminium (as Al)	< 0.01	< 0.01	mg/L
25	Boron (as B)	< 0.25	< 0.25	mg/L
26	Cadmium (as Cd)	< 0.001	< 0.001	mg/L
27	Total Suspended Solids	157.0	133.0	mg/L
28	Biological oxygen demand	9.9	10.5	mg/L
29	Chemical oxygen demand	41.9	38.6	mg/L
30	Oil & Grease	ND	ND	mg/L
31	Pesticides	ND	ND	mg/L
32	Total Phosphate	< 0.3	< 0.3	mg/L
33	Total Kjheldal Nitrogen	1.59	1.52	mg/L
34	Dissolved Oxygen	5.9	5.2	mg/L
35	Poly Aromatic Hydrocarbon	ND	ND	mg/L
36	Total Coliform	Absent	Absent	MPN/100 ml
ND - Not Detected				

9.14 METEOROLOGY

9.14.1 General

Mumbai has a tropical climate, specifically a tropical wet and dry climate (Aw) under the Köppen climate classification, with seven months of dryness and peak of rains in July. The cooler season from December to February is followed by the summer season from March to June. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season.

Between June and September, the south west monsoon rains lash the city. Pre-monsoon showers are received in May. Occasionally, north-east monsoon showers occur in October and November. The maximum annual rainfall ever recorded was 3,452 mm for 1954. The highest rainfall recorded in a single day was 944 mm on 26 July 2005. The average total annual rainfall is 2,146.6 mm for the Island City, and 2,457 mm for the suburbs.

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

9.14.2 Temperature

The temperature data for Mumbai has been taken. The month-wise minimum & maximum temperatures have been given in **Table 9.8.**

Table 9.8 - Normal Temperature at Mumbai

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

Source: India Meteorological Department, Govt. of India.

9.14.3 Rainfall

The detail of rainfall at the Mumbai (Santacruz) is given in **Table 9.9.**

Table 9.9 – Month wise Rainfall at Mumbai

S. No.	Month	Rainfall	Peak Rainfall
1	January	0.6	
2	February	1.3	

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

Source: India Meteorological Department, Govt. of India.

9.15 AIR ENVIRONMENT

The atmospheric concentrations of air pollutants were monitored at 2 locations near the proposed alignment during the month of September 2018. Locations of air monitoring station are shown in **Figure 9.1.** Air Monitoring was carried out for PM_{10}, NOx, SO_2 and CO. Results of the air quality monitoring are presented in **Table 9.10.**

Table 9.10 - Ambient Air Quality Results

S.No.	PARAMETER	Particulate Matter (PM_{10})	Particulate Matter ($PM_{2.5}$)	Sulphur dioxide (as SO_2)	Nitrogen dioxide (as NO_2)	Carbon monoxide (as CO)
	UNIT	**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**	**mg/m^3**
	15-09-2018					
1	Ganesh Nagar	211.6	65.3	9.98	23.3	1.21
2	Pisavali Gaon	215.6	84.5	9.61	24.9	1.73
3	Golavli	191.2	76.5	8.81	21.6	1.67
4	Dombivli MIDC	192.1	72.9	9.23	25.1	1.56
5	Sagaon	234.7	73.2	8.99	21.8	1.48
6	Sonarpada	224.3	89.1	8.89	22.4	1.51
7	Manpada	189.2	74.4	8.29	21.5	1.81
8	Hedutane	166.6	71.6	9.11	20.7	1.67
9	Kolegaon	138.3	52.1	9.27	19.9	1.51
10	Nilje Gaon	129.1	51.9	9.12	20.3	1.34
11	Vadavli (Khu.)	128.2	55.2	8.92	19.7	1.21
12	Bale	132.1	57.3	9.71	21.9	1.32
13	Waklan	125.3	55.9	8.93	21.8	1.25
14	Turbhe	131.1	58.3	9.11	20.9	1.19
15	Pisarve Depot	133.2	57.4	9.28	21.6	1.32
16	Pisarve	131.9	59.1	8.99	22.9	1.18
17	Taloja	129.8	55.9	9.38	21.6	1.11
	Limits as per EPA Act	**100.0**	**60.0**	**80.0**	**80.0**	**4.0**

The results show that the concentration of all parameters is within permissible limits except suspended particulates PM_{10} as well as $PM_{2.5}$ at locations along the National Highway.

9.16 NOISE ENVIRONMENT

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

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

Noise level survey was conducted along the alignment with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise levels were measured at nine locations on 15-16 September 2018 for 24 hours. The locations of Noise level monitoring has been shown in **Fig.9.1**. The noise levels so obtained are summarized in **Table 9.11.**

Table 9.11 - Noise Levels [Values in dB(A)]

S.No.	Location\ Parameter	Day/Night	Leq	Lmax	Lmin	L90	L50	L10
1	Ganesh Nagar	L Day	64.5	73.5	46.2	61.4	64.4	67.7
		L Night	51.4	68.6	41.3	47.5	51.2	54.3
2	Pisavali Gaon	L Day	63.5	74.7	52.6	48.8	68.7	69.7
		L Night	53.6	64.9	44.5	46.6	54.5	59.4
3	Golavli	L Day	63.5	76.3	62.5	55.1	66.4	70.6
		L Night	58.6	59.4	47.8	45.4	54.2	58.6
4	Dombivli MIDC	L Day	63.7	72.6	62.2	54.1	63.2	69.2
		L Night	57.8	64.4	48.1	46.5	57.2	59.8
5	Sagaon	L Day	64.4	75.5	47.3	60.5	63.9	66.4
		L Night	52.2	67.0	44.5	48.5	52.8	53.6
6	Sonarpada	L Day	63.1	76.3	62.5	56.1	66.6	70.6
		L Night	58.6	59.7	47.8	45.4	54.2	58.6
7	Manpada	L Day	54.4	63.6	42.2	51.4	59.4	61.7
		L Night	46.6	59.5	41.2	42.5	48.3	54.3
8	Hedutane	L Day	59.5	64.7	48.6	48.8	62.9	63.7
		L Night	50.6	58.8	42.8	43.6	51.5	56.4
9	Kolegaon	L Day	63.1	74.4	47.8	58.7	63.7	65.5
		L Night	54.8	68.3	44.6	47.6	48.6	54.6
10	Nilje Gaon	L Day	60.9	69.6	53.3	54.1	65.2	68.5
		L Night	57.2	64.8	48.1	46.5	57.2	59.8
11	Vadavli (Khu.)	L Day	61.4	71.5	45.3	48.5	56.9	66.4
		L Night	52.3	70.0	44.5	48.3	52.8	53.4
12	Bale	L Day	63.8	75.3	62.5	55.1	66.2	70.5
		L Night	57.6	58.1	47.5	45.4	54.2	58.6

S.No.	Location\ Parameter	Day/Night	Leq	Lmax	Lmin	L90	L50	L10
13	Waklan	L Day	63.4	73.2	44.2	61.7	64.4	67.7
		L Night	51.8	67.5	41.2	47.5	52.3	54.3
14	Turbhe	L Day	62.5	71.7	51.6	48.8	68.7	69.7
		L Night	51.6	63.8	44.8	46.6	54.5	59.4
15	Pisarve Depot	L Day	62.1	74.2	47.7	58.7	61.7	65.5
		L Night	51.8	67.3	44.3	47.6	48.6	54.6
16	Pisarve	L Day	62.5	71.6	62.3	54.1	65.2	69.5
		L Night	54.8	62.8	47.1	46.5	57.2	59.8
17	Taloja	L Day	61.4	70.5	47.3	56.5	61.9	66.4
		L Night	47.3	59.0	44.5	45.3	48.8	53.4

Allowable Noise Levels dB (A):

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

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

The observed noise level is higher than the permissibble limits which may be due to heavy traffic movement on the western express highway.

9.17 SOIL QUALITY

Soil quality in project area has been worked out by sampling at one location and the test results are given in **Table 9.12**

Table 9.12 - Soil Sample Analysis Sampling Date:- 15.09.2018

S. No.	PARAMETER	1	2	3	4	5	UNIT
1	pH	7.02	7.51	7.15	7.16	6.58	-
2	Conductivity	594					µs/cm
3	Calcium as Ca	1228.4	541	632	648	451	mg/kg
4	Sodium as Na	137.5	39	36	33	39	mg/kg
5	Potassium as K	129.7	87	111	110	88	mg/kg
6	Organic Matter	0.82	1.59	1.07	0.79	0.58	mg/kg
7	Magnesium as Mg	328.8	183	566	556	263	% by mass
8	Texture	Sandy Clay	Silty Clay	Sandy Clay	Sandy Clay	Sandy loam	mg/kg
9	Sand	56.9	19	51	51	49	% by mass
10	Slit	15.7	44	13	14	32	% by mass
11	Clay	27.4	37	36	35	19	% by mass

S. No.	PARAMETER	1	2	3	4	5	UNIT
12	Nitrogen Available	657.3	196	82.5	89.5	74	mg/kg
13	Phosphorus	65.9	9.2	10.3	10.5	8.7	mg/kg

9.18 TREES

Tree survey has been carried out along the proposed alignment. Tree with Girth at Breast Height (GBH) is 30 cm have been counted. The alignment does not pass through any forest area. About 112 trees are likely to be felled due to the project allignment between kalyan and Taloja including station areas. No rare or endangered species of trees have been noticed during field survey.

9.19 SOCIO- ECONOMIC CONDITIONS

Socially and culturally this area is cosmopolitan in nature. According to the 2011 census, the population of Mumbai was 12,479,608. The population density is estimated to be about 20,482 persons per square kilometre. The living space is 4.5sq metre per person. As Per 2011 census, Greater Mumbai, the area under the administration of theMCGM, has a literacy rate of 94.7%, higher than the national average of 86.7%.

The sex ratio was 838 (females per 1,000 males) in the island city, 857 in the suburbs, and 848 as a whole in Greater Mumbai, all numbers lower than the national average of 914 females per 1,000 males. The low sex ratio is partly because of the large number of male migrants who come to the city to work. Mumbai has a large polyglot population like any other metropolitan city of India. Sixteen major languages of India are also spoken in Mumbai, most common being Marathi, Hindi, Gujarati and English. English is extensively spoken and is the principal language of the city's white collar workforce. A colloquial form of Hindi, known as Bambaiya – a blend of Marathi, Hindi, Gujarati, Konkani, Urdu, Indian English and some invented words – is spoken on the streets. Mumbai suffers from the same major urbanisation problems seen in many fast growing cities in developing countries: widespread poverty and unemployment, poor public health and poor civic and educational standards for a large section of the population. With available land at a premium, Mumbai residents often reside in cramped, relatively expensive housing, usually far from workplaces, and therefore requiring long commutes on crowded mass transit, or clogged roadways. Many of them live in close proximity to bus or train stations although suburban residents spend significant time travelling southward to the main commercial district. With a literacy rate of 69%, the slums in Mumbai are the most literate in India.

9.20 SOCIO-ECONOMIC SURVEY

A socio-economic survey was undertaken in September 2018 for the proposed corridors to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed metro alignment on their conditions. The survey has been undertaken on the corridor using structured questinnaire. It was found that there are about 12 Shops and 2 houses are likely to be affected due to the project.

9.21 ARCHAEOLOGICAL SITES

There are many heritage sites in Mumbai which are very much far off from the corridor alignment.

9.22 ENVIRONMENTAL IMPACTS ASSESSMENT

9.22.1 General

The primary function of an environmental impact assessment study is to predict and quantify the magnitude of impacts, evaluate and assess the importance of the identified changes and formulate plans to monitor and mitigate the actual changes. Environmental impacts could be positive or negative, direct or indirect, local, regional or global, reversible or irreversible. The main aim of the project is to decongest the road traffic. The project is designed keeping in view population growth, future traffic demands and environmental protection aspects.

Negative impacts likely to result from the proposed development have been listed under the following headings:

- Impacts due to Project Location;
- Impacts due to Project Design;
- Impacts due to Construction; and
- Impacts due to Project Operation.

For each of these headings, potential impacts have been considered.

9.22.2 Environmental Impacts

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

- Land Environment
- Water Environment
- Air Environment
- Noise Environment
- Biological Environment
- Socio-Economic Environment

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

A. Impacts Due to Project Location

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

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;

- Utility/Drainage Problems,
- Socio-economic impacts;
- Impact on Historical and Cultural Monuments;

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

- **Change of Land Use**
  The details of land required (permenant and temporary) and change in land use are presented in **Table 9.13**. The required land (permenant & temporary) for the construction of the proposed alignment is both government as well as private land which shall be allotted by Mumbai Metropolital Regional Development Authority. Private land will be acquired as per the provisions of The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013 (Act 30 of 2013) and Resettlement and Rehabilitation Policy for Mumbai Urban Transport Project (MUTP) notified in March 1997 and amended in December 2000.

Table 9.13 - Change in Land Use (m^2)

S.No.	Permanent Land Requirement	Pvt. (Agricultural)	Private	Total
1.	Stations	21600	10800	**32400**
2.	Running Section	249506.2	0	**249506.2**
3.	Depot	200000	0	**200000**
4.	Staff Quarters	10000	0	**10000**
5.	Office Complex and OCC	5000	0	**5000**
6.	RSS	11200	0	**11200**
	Total	**497306.2**	**10800**	**508106.2**
	Temporary Land Requirement			
1.	Office/ Site Office	6000	2000	8000
2.	Segment Casting Yards	60000	20000	80000
	Total	**66000**	**22000**	**88000**

Source: Chapter-4

- **Loss of Forests/ Trees**
  The proposed metro lines are in urban/ city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. However, trees do exist in patches in the corridor selected for the project. There are about 112 trees which are likely to be felled during construction. These include trees in alignment, station area and Depot area. Trees are assets in purification of urban air, which by utilizing CO_2 from atmosphere, release oxygen into the air. Trees help carbon sequestration acting as a carbon sink. By removing the carbon and storing it as cellulose, trees release oxygen back into the air.

- **Utility/ Drainage Problems**
  Metro lines are mostly planned to run through the urban area. The alignment will cross many properties, canals/ drains/ nalas, large number of sub-surface, surface

and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, roads, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance.

- **Socio-Economic Impact on PAPs**

  As such 12 shops and 2 houses have been found to be affected due to land acquisition for the proposed Mumbai metro project. Almost all the establishments are being affected due to ROW of the alignment and Station areas. It is also found that 156 employees are also working in the affected commercial establishments mostly shops. These are also getting affected and shall be compensataed as per Act 30 of 2013 and for resettlement and rehabilitation policy for Mumbai Urban Transport Project (MUTP). There would be an effort to restore their socio-economic status by resettling and rehabilitating the affected owners of commercial properties and their employees.

- **Impact on Archaeological Sites**

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

B. Impacts Due to Project Design

Considered impacts, due to project designs are:

- Lighting,
- Risk Due to Earthquake.

- **Lighting**

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

- **Risk Due to Earthquake**

  The project area lies in Zone III of Bureau of Indian Standards (BIS) Seismic Zoning Map (**Fig. 9.2**). Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures.

C. Impacts Due to Project Construction

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

- Top Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk to existing building,

- Excavated soil disposal problems,
- Dust Generation,
- Increased water demand,
- Impact due to Supply of Construction Material,
- Disposal of Construction and Demolition Waste,
- Impacts due to batching plant and casting yard,
- Noise Pollution

- **Soil Erosion, Pollution and Health Risk at Construction Site**

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

- **Traffic Diversions and Risk to Existing Buildings**

  During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the part of western express highway and service road. Advance traffic updates/ information on communication systems will be an advantage to users of affected roads. The rail corridor does not pose any serious risk to existing buildings since there is safe distance between buildings and proposed corridor except at a few shops the alignment is passing over the shops. Here special care has to be taken for safety of the structures during construction when they will be shifted.

- **Problems of Excavated Soil and Bentonite Disposal**

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

- **Dust Generation**

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

Movement of trucks and other heavy equipments at construction site would generate dust during construction phase.

- **Increased Water Demand**

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

- **Impact due to Supply of Construction Material**

  Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of metro corridor. These shall be sourced from the nearest source. Quarry operations are independently regulated activities and outside the purview of the project proponent. The construction material shall be sourced only from legalized and approved quarries.

- **Generation of Construction and Demolition Waste**

  Construction and demolition (C&D) debris is defined as that part of the solid waste stream that results from land clearing and excavation, and the construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste includes concrete, stones and dirt generated during excavation (sometimes collectively referred to as "fill material" or rubble). C& D Waste may be generated from Pile caps, residual cement bags, residual steel scrap, excess construction material stacked at site etc. It is a waste stream that is separate and distinct from residential and commercial waste, commonly called municipal solid waste (msw). The C& D waste would be handled and disposed off to C&D waste processing facility or for back filling of low lying areas, leaving no significant impact on environment.

- **Impacts due to Casting Yard and Batching Plant**

  During construction phase there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by MMRDA away from habitation. There would be requirement to get NOC (Consent to establish) and Consent to operate under water and air Acts from Maharashtra Pollution Control Board. Simultaneously, there would be requirement to get the authorization for storage and handling of hazardous chemicals to store and handle used oils and other such materials. The Application forms for seeking Consent to establish, Consent to Operate and Authorization for storage of Hazardous chemicals are available from the office of Maharashtra Pollution Control Board at Mumbai.

- **Noise Pollution**

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

- **Loss of Historical and Cultural Monuments**

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

D. Impacts Due to Project Operation

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

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

- **Noise Pollution**

  During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures. The noise level at 2 m distance from the rail alignment is about 73 dB(A). The noise level reduces with distance logarithmically.

- **Water Supply and Sanitation at Stations**

  Public facilities such as water supply, sanitation and wash rooms are very much needed at the stations. The water requirement for stations would be for drinking, toilets, cleaning and also for other purpose like AC. Water Demand as per existing norms in working metros is about 23 kld for each elevated station. It is assumed that there would be similar water requirements in Mumbai Metro as well. Raw water should be treated and brought to national drinking water standards, before used for consumption. In addition, water will be required for contractor's camps during construction. The water requirement for the stations will be met through the public water supply system or purpose built tubewells after taking necessary approvals from CGWA. However, as an environmental conservation measure, rainwater harvesting structure will also be constructed at stations and along the via-duct.

  There would be total water requirement of 391 KLD in 17 elevated stations @ 23 KLD for each station. However, arrangement of water will have to be made at each station separately.

- **Station Refuse**

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

- Garbage,
- Rubbish, and
- Floor Sweepings.

As per the available data from Delhi Metro Phase I and II, the solid waste generation is about 0.8 – 1.2 cum/day at elevated stations. Thus, about 14 to 21 cum of solid waste will be generated from seventeen stations of this corridor of Mumbai metro. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is the responsibility of the project authorities. The storage containers for this purpose need to be designed. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals

- **Visual Impacts**

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

E Impacts Due to Depot

Water Supply

Water supply will be required for different purposes in the depot. Total water requirement of Depot is likely to be 250 KLD. This will be sourced by extracting ground water after taking necessary permissions from CGWA.

Hazardous Waste

Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock is very common.

Noise Pollution

The main source of noise from depot is the operation of workshop. The vibration of concrete structures also radiates noise. Since the activities are restricted well within the depot boundary, no impact on the ambient noise is anticipated. However, to protect the work force against occupational noise PPE should be provided.

Solid Waste

Solid waste will be generated from the Depot site which will be taken by the cleaning contractor weekly and disposed to the Municipal waste disposal sites.

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

Oil and grease will be produced from Depot which will be disposed off through approved re-cyclers.

Iron turning for the wheel profiling will also be generated from the Depot. Authorized recyclers shall be engaged for disposal of hazardous wastes.

E Wastes

E-waste generated from the operation and maintenance activities shall be disposed through authorized e-waste recyclers/collectors. E-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste.

F. Positive Environmental Impacts

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

Various positive impacts have been listed under the following headings:

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

- **Employment Opportunities**

  The project is likely to be completed in a period of about 4 years. During this period manpower will be needed to take part in various activities. About 3000 to 4000 persons are likely to work during peak period of activity. In operation phase of the project about 35 persons per kilo meter length of the corridor, ie (approx. 700 persons) may be employed for operation and maintenance of the proposed system in shifts. Thus the project would provide substantial direct employment. Besides, more people would be indirectly employed in allied activities and trades.

- **Enhancement of Economy**

  The proposed transport facility of MMRDA will facilitate sub-urban population to move quickly. With the development of Line 12 between Kalyan and Taloja corridor, it is likely that more people will be involved in trade, commerce and allied services. MMRDA will, however, make it convenient for more people to move in the present suburban areas. This will reduce population pressure on urban area and will be a boom to rural economy.

- **Mobility Safety and Reduced Accidents**

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

- **Traffic Congestion Reduction**

  To meet the forecast transport demand in the year 2026, it is estimated that the number of buses will have to be more. During this period personalised vehicles may also grow. Together, they will compound the existing problems of congestion and delay. The proposed development will reduce journey time and hence congestion and delay.

- **Reduced Fuel Consumption**

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

- **Carbon Credits**

  Due to savings in fuel and reduction in airpollution etc carbon credit would be generated during operation of the metro rail similar to the experience with Delhi Metro Rail Corporation Ltd. However, at this stage calculation of carbon credits is not feasible.

- **Improvement of Quality of Life**

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

G. Checklist of Impacts

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

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

Each of the methods is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented. Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. A typical checklist identifying anticipated environmental impacts is shown in **Table 9.14**.

Table 9.14 - Checklist of Impacts

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
A.	**Impacts due to Project Location**			
i.	Displacement of People	*		
ii.	Change of Land use and Ecology	*		
iii.	Loss of Cultural and Religious Structures		*	
iv.	Socio-economic Impacts	*		

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

9.23 ANALYSIS OF ALTERNATIVES & PUBLIC CONSULTATION & INFORMATION DISCLOSURE

9.23.1 Analysis of Alternatives

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

- To serve areas of population and employment concentration not served hereto.

- To ensure regional linkages and connectivity to rail system proposed in adjoining regions like Thane and Navi Mumbai.
- Maximum inter-modal integration with existing and committed suburban rail network.
- Easy connectivity to depot sites.
- Feasibility of the minimum values for system parameters in terms of vertical curves, horizontal curves and gradients.

All the above reports have been submitted to MMRDA.

An SPV named as Mumbai Metro rail Corporation Ltd. (MMRC) is incorporated and implementation of Line -3 between Colaba- BKC-Aarey is being done by the SPV. Line no 1 viz. Versova - Andheri - Ghatkopar has been implemented and commissioned on 8th June 2014 The work was done on Public Private Partnership (PPP) mode by a Special Purpose Vehicle, Mumbai Metro one, comprising of Government of Maharashtra, Reliance Infrastructure and VOELIA of France. A special purpose vehicle (SPV) was formed for line no 2, viz. Charkop - Bandra - Mankhurd corridor. SPV comprises of Government of Maharashtra, Reliance Infrastructure and SNC Lavalin of Canada. However, the implementation of this Line did not take off.

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

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

All the above reports were submitted to MMRDA.An SPV named as Mumbai Metro rail Corporation Ltd. (MMRC) is incorporated and implementation of several corridors is being done by the SPV and MMRDA. MMRDA now intends to implement other corridors by itself.

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

Need to Increase Public Transport Share

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

9.23.2 Public Consultation and Disclosure

Public consultation and participation is a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and unwanted political propaganda against the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly. Public consultations with the people of different sections of the society along the project alignment, shopkeepers, and influential persons of the project area will be made. Attention shall be given to potential vulnerable people like, squatters, encroachers, schedule caste, and other backward section (OBC) of society shall be consulted to make them aware and identify adverse impacts of the project.

A. Consultation with Stakeholders

Consultations were conducted at the early stage of EIA preparation, mostly involving local communities and organizations. Successive consultations shall be conducted by the MMRDA after the initial drafting of this report that includes representatives of local communities and entities tasked with the regulation of the road development and environmental protection.

B. Compliance with Regulatory and Funding Agency Requirement

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

9.24 ENVIRONMENTAL MANAGEMENT PLAN

9.24.1 Management Plans

The Mumbai Metro Project will provide employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand. The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components. For optimal integration of EMP into the project, there should be investment links for:

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

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

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

9.25 MITIGATION MEASURES

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

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

b) Compensatory Afforestation

The objective of the afforestation program should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. According to the results of the present study, it is found that about 112 trees are likely to be lost due to the project. Three saplings are to be planted for felling a single tree. Hence 336 trees need to be planted. Plantation program will be finalized in consultation with Forest Department and project proponent would provide the funds for compensatory afforestation as per government policy. The cost of plantation and maintenance for 3 years for 336 saplings would be Rs. 6.72 Lakhs.

c) Construction Material Management – Storage and procurement

The major construction material to be used for construction of the proposed corridor are coarse aggregates, cement, coarse sand, reinforcement steel, structural steel, water supply, drainage and sanitary fittings etc. The material will be loaded and unloaded by engaging labour at both the locations by the contractor. The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the MMRDA Officer and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. Care shall be taken to avoid spillage of material during construction. Procurement of material would be from environment friendly source. The materials shall be procured from nearest available source and shall be transported in coverd trucks. All the material would be stored in a manner to avoid multiple handling for use in construction activities.

d) Labour Camp

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

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

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

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

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

e) Energy Management

The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon MMRDA request. The contractor shall design site offices maximum daylight and minimum heat gain. The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be explored.

f) Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file a 'Request for Authorization' with Maharashtra State Pollution Control Board along with a map showing the location of storage area. Outside the storage area, the contractor shall place a 'display board', which will display quantity and nature of hazardous waste, on date, Hazardous Waste needs to be stored in a secure place. The contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the MMRDA.

g) Environmental Sanitation

Environmental sanitation also referred to as Housekeeping, is the act of keeping the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries.

The contractor shall employ a special group of environmental sanitation personnel to carry out following activities:

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

- Flammable chemicals / compressed gas cylinders shall be safely stored.
- Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified location(s).
- Empty cement bags and other packaging material shall be properly stacked and removed.

h) Utility Plan

The proposed Metro alignment runs along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. A number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. already exist 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. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro alignment, the following guidelines could be adopted:

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

i) Air Pollution Control Measures

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

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

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

j) Construction and Demolition Waste

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

The source of C & D waste are pile caps, excess RMC and demolition material. An effort shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. The contractor shall store C&D waste separately at the site and sent to recycling facility periodically. There shall be no disposal of any waste along storm water drains, canals and/ or any other water body or depression. Rather C & D waste shall be collected and sent to any authorized waste recycling facility.

k) Noise Control Measures

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

- Job rotation,
- Automation,
- Construction of permanent and temporary noise barriers,
- Use electric instead of diesel powered equipment,
- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
- Scheduling and staggering truck loading, unloading and hauling operation,
- Schedule and stagger work to avoid simultaneous activities which generate high noise levels,
- Anti drumming floor and noise absorption material,
- Low speed compressor, blower and air conditioner,
- Mounting of under frame equipments on anti-vibration pad,
- Smooth and gradual control of door,
- Provision of sound absorbing material in the supply duct and return grill of air conditioner,
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes, and
- Sound proof compartments control rooms etc.

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

l) Traffic Diversion/ Management

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

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

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

m) Soil Erosion Control

Prior to the start of the relevant construction, the Contractor shall submit to the MMRDA for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works are as applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and/ or other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the project authority.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures. Temporary erosion/sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage or associated with permanent control features on the Project. Under no conditions shall a large surface area of credible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the project authority.

Temporary erosion is sometimes caused due to the Contractor's negligence, care-lessness or failure to install permanent controls. Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the project authority, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the project authority.

n) Water Supply, Sanitation and Solid Waste Management

During Construction

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water should be treated before use up to national drinking water standards. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage solves the excreta disposal problems. The sewerage disposal systems should be adopted for sewage disposal. The water for domestic consumption shall be sourced from public water supply or alternatively designated borewells may be installed with due permission from statuatory authority prior to installation of borewell. For Construction activity, there is a restriction to utilize groundwater all over the nation as per order of National Green Tribunal (NGT). Thus, construction water shall be sourced from Mumbai Municipal Corporation which is responsible for sewage disposal in Mumbai area. Alternatively, contractor shall arrange tie up for surface water supply or tanker water supply for construction activity. Best option is to use treated STP water for construction activity. Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed off through covered trucks to land fill site designated and authorized by MMRDA.

During Operations

Practically, public facilities at stations have to be operated by regular staff or may be designated to any NGO working in the area in the field of sanitation as per policy of MMRDA. Requirement of drinking water supply at an elevated station is about 6 KL/day. The water consumption for an elevated station to meet the requirements of its activities is 17 KLD. The water shall be provided from Mumbai authority sources.

Solid waste will be generated at station is about 0.8 – 1.2 m^3/Day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authority. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. This should be collected and transported to local municipal bins for onward disposal to disposal site by municipality. During operation, as mitigation measures rainwater harvesting will be carried out at stations and along the viaduct.

o) Rain water harvesting

To conserve and augment the storage of groundwater, it is suggested to construct rainwater harvesting structures of suitable capacity along the alignment and at stations. The stations shall be provided with the facility of rainwater harvesting and artifirical recharge. The total length of the proposed elevated alignment is about 20.5 km and there would be 17 stations. The estimated cost of rain water harvesting for elevated corridor is about 15 lakhs per km and 10.0 lakhs per station. The total cost of rainwater harvesting would be Rs. 477.5 Lakh (Rs. 307.5 Lakh for 20.5 Km viaduct + Rs. 170.0 Lakhs for 17 stations) for elevated section of the corridor.

p) Tree Protection

There is requirement of felling 112 trees during construction of Metro corridors in Mumbai. An attempt shall be made to minimize the tree felling. As remediation of tree felling it is suggested to plant 3 trees for each tree felled. Moreover, MMRDA would chalk out the plantation program in close coordination with DFO Mumbai or will get plantation done through Forest Department by making the payment for plantation work including after care for three years. An attempt should be made to minimize the felling of trees to the bare minimum while working and undertaking construction work. The left out trees shall be protected by providing metal or brick tree guard around the tree at a distance of one metre surrounding the tree. Scope of transplantation of trees would also be explored with discussion with the DFO. The cost of compensatory afforestation would be Rs.6.72 Lakh @ Rs 2000/- per tree for 336 trees.

q) Management Plan for Depot

Water supply: Water will be required for operation and functioning of depot which could be either collected from tube well. The ground water will need treatment depending upon its use. For Domestic and some of the industrial application, a reverse Osmosis (RO) plant will be appropriate.

Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. Such tanks usually employ compressed air to coagulate the oil and grease and cause it to rise promptly to the surface. Compressed air may be applied through porous plates located in bottom of the tank. The tank may be designed for a detention period of 5 to 15 minutes.

Sewage/Effluent Pollution Control: Sewage will be generated from depot which could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream. Similarly effluent is likely to be generated from Depots. This will have oil, grease and, detergent as main pollutants. This has to be treated as per requirement of Statutaory bodies.

Surface Drainage: The area should have proper drainage. The Storm water of the depot will be collected through the drains. Rain water harvesting pits shall be provided at different locations in the drains and for surplus storm water, the drainage system should be connected to a nearby disposal site.

Green belt development: The greenbelt development/ plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical structures of proposed buildings with surrounding environment but also acts as pollution sink noise barrier. In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance.

Rain water harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the proposed depot. Most of the area in depot will be open to sky and approximately 10% area will be covered. Rainwater harvesting potential of depots is calculated as app. 30000 cum per year.

Recycling of treated waste water: Waste Water streams generated at depot are proposed to be carried through separate lines for treatment at ETP & STP and the treated waste water will be recycled for horticulture work of the depot.

r) Disaster Management

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should identify sources of repair equipments, materials, labour and expertise for use during emergency.

Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details.

The Engineer-in-Chief should notify the officer for the following information:

- Exit points for the public,
- Safety areas in the tunnel/overhead rail, and
- Nearest medical facility

Communication System

An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and fool proof communication system.

Emergency Action Committee

To ensure coordinates action, an Emergency Action Committee should be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

- Station Manager concerned,
- Police Officer of the area,
- Mumbai Transport Corporation Representative,
- Home Guard representative,
- Fire Brigade representative,
- Health Department representative,
- Department of Information and Publicity, and
- Non-Governmental Organization of the area

Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

- Demarcation of the areas to be evacuated with priorities,
- Safe route to be used, adequacy of transport for evacuation, and traffic control,
- Safe area and shelters,
- Security of property left behind in the evacuated areas,
- Functions and responsibilities of various members of evacuation teams, and

- Setting up of joint control room

All personnel involved in the Emergency Action Plan should be thoroughly familiar with all the elements of the plan and their responsibilities. They should be trained through drills for the Emergency Action Plan. The staff at the site should be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan must be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.

It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

9.25.1 Summary of Environmental Management Plan (EMP)

The environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures. Adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A set of preliminary EMP is presented in **Table 9.15,** which defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts. The major concern during the construction stage is that the contractors, due to lack of enforcement, would not practice good environmental sanitation (housekeeping) may intend to get unauthorized use of the easily available natural resources and other available infrastructure like roads and water resources. This would result in degradation of ambient air quality, water resources and land environment around the construction sites and workers camp. Improper management of earthwork and bridge construction activities would disrupt the natural drainage and increase soil erosion. Improper management may result in spillage of explosives into the hands of unsocial elements. Finally, the implementation of the mitigation actions requires that the project implementation unit would record an end-of-construction mitigation checklist, before releasing the final payment of any work contract. Additionally, project authority should prepare and established Environmental and Health Policy and Procedures as per earlier Phases and that should become an integral part of contract document.

Operational phase mitigation would involve good environmental sanitation (housekeeping) practice at metro establishments including effective solid waste collection and disposal, wastewater disposal, upbringing of plantations and green area. Protection of earth slopes in landslide prone area would be a very important task. During the operation period, the metro operating unit will be required to confirm receipt of the construction period mitigation report through the MMRDA and prepare a follow on timetable of actions.

TABLE 9.15 - ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMP)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimise the land disturbance to avoid areas sensitive environmentally.	During Design	DPR and design consultant	MMRDA
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	MMRDA
Flood	Bridges shall be well designed	During Design	DPR and design consultant	MMRDA
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	MMRDA
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water for construction purpose etc shall be planned and shall be arranged from available and authorized sources in order to avoid digging of Tube wells.	Pre construction stage	Contractor	MMRDA/EMP implementing agency
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact on receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	MMRDA/EMP implementing agency
Batching Plant and Casting Yard	These facilities to be located away from habitation. Consent to Establish and Consent to Operate to be taken from MSPCB and to comply with all stipulations.	During Pre-construction Stage	Contractor	MMRDA/EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	MMRDA/EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	MMRDA/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that	Beginning with and	Contractor	MMRDA/EMP implementing

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	emissions conform to National and State AAQ Standards. No vehicle without valid PUC certificate would be allowed at Construction Sites.	continuing throughout construction period		agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet acceptable standards for emissions and will be maintained and operated in a manner that ensures that relevant air, noise, and discharge regulations are met.	During construction	Contractor	MMRDA/EMP implementing agency
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery to be provided noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	MMRDA/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak velocity as given in Environmental Manual	Beginning and through construction	Contractor	MMRDA/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into any rivers, drainage and irrigation system	Throughout construction period	Contractor	MMRDA/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	MMRDA/EMP implementing agency
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters.	Through out construction period	Contractor	MMRDA/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian	Before and during building of construction camps	Contractor	MMRDA/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	National Standards. Garbage will be collected in a tank and disposed off daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.			
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only. All environmental mitigation measures shall be enforced at Quarry site also.	During construction	Contractor	MMRDA/EMP implementing agency
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory afforestation Policy under the Forest Conservation Act. Ten trees will be planted against every tree felled as per norms.	During and after completion of construction activities	Forest Department	Forest Department
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	MMRDA/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	MMRDA/ Traffic department
Safety with vehicles, people and livestock and signage	• Safety education and fines. • Allow for adequate traffic flow around construction areas • Provide adequate signage, barriers and flag persons for safety precautions. • Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions	During construction	Contractor	MMRDA/ Traffic department
Increase in disease Water-borne Insect-borne Communicable diseases	Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. Provide adequate sanitation and waste disposal at construction camps. Provide adequate health care for workers and locate camps away from vulnerable groups, if any	During construction At start-up Throughout construction	Contractor	MMRDA/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	MMRDA/EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	MMRDA/EMP implementing agency	MMRDA/EMP implementing agency
WATER				
Maintenance of Storm Water Drainage System	The urban drainage systems will be periodically checked and cleared so as to ensure adequate storm water flow.	Beginning and end of monsoon	MMRDA/ EMP implementing agency	MMRDA/EMP implementing agency

9.26 ENVIRONMENTAL MONITORING PLAN

9.26.1 Pre-Construction Phase

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. Generation of dust and noise are two main issues during any large construction activity. Degradation of water quality is another. The parameters are monitored in pre- construction, construction and operation phase and are based on the need to evaluate the deviation of environmental conditions from baseline environmental conditions due to construction and operation of the Metro. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored:

- Water Quality,
- Air Quality,
- Noise and Vibration,
- Environmental Sanitation and Waste Disposal
- Ecological Monitoring and Afforestation,
- Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. Pre-construction phase monitoring has been done for the proposed project for air, noise, water, soil quality and ecology.

9.26.2 Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels and water quality. Keeping a broad view of the sensitive receptors and also the past experience of Phase I and II and Mumbai Metro, an estimate of locations has been made and are summarized in **Table 9.16.** The number could be modified based on need when the construction actually commences.

Water Quality

Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL certified laboratory. Water quality should be analyzed following the procedures given in standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

Air Quality

Air quality should be monitored at the locations of baseline monitoring as reported in Chapter 3. The parameter recommended is Particulate Matter (PM_{10}). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of project authority.

Noise and Vibration

The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of project authority.

Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites and workers camp will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans. The monitoring Schedule for Water Air, noise and ecology are presented in **Table 9.16.**

TABLE 9.16 - CONSTRUCTION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Twice a month During entire civil construction stage or even later, if directed by MMRDA	17 locations
Water	Groundwater quality (IS 10500:1991)	Once in 6months During entire civil construction stage or even later, if directed by MMRDA	4 locations
Noise	Noise Level (Leq and Lmax)	24hours Once a week During entire civil construction stage or even later, if directed by MMRDA	17 locations
Ecology	Felled and planted trees	Once a year till all trees that were to be planted by Maharashtra Government on behalf of project authority, are planted	All the trees felled and newly planted

9.26.3 Operation Phase

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, water, waste water, solid waste and ecology during operation phase of the project. The parameters monitored during operation will be PM_{10} for air, heavy metals for solid waste, pH, TSS, BOD, COD, oil and grease for waste water. However, water quality parameters that will be monitored will be as per BIS 10500. The monitoring schedule is presented in **Table 9.17**. The monitoring program shall be conducted by an external agency certified by NABL under the supervision of MMRDA. Project proponent (MMRDA) is responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE 9.17 - OPERATION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Once a monthFor 3years	4 location
Water	Surface, Groundwater quality (IS 10500:1991)	Once a year For 3years	2+1 location
Noise	Noise Level (Leq)	24hours Once a year For 3years	4 locations (Sensitive Receptors)

The results of Air quality, water quality, waste water will be submitted to management quarterly during construction phase and half yearly during operation phase.

9.26.4 Establishment of an Environmental Division

MMRDA already has the setup for environmental Management and the proposed corridor is an extension of already existing operative line, additional set-up for environmental management is not recommended. Existing set up for environmental management can also handle this extension.

9.27 COST ESTIMATES

9.27.1 Summary of Costs

All costs involved in Environmental mitigation and management and monitoring to be put on the account of Mumbai Metro Project corridors**.** A summary of these is presented in **Table 9.18.**

Table 9.18 - Environmental Costs

S. No.	ITEM	COST Rs. lakh
1.	Rain Water Harvesting at stations and along alignment	477.50
2.	Air, Noise, vibration, Water, Waste Water, Solid waste, during construction and operation	20.00
3.	Ecological monitoring	10.00

S. No.	ITEM	COST Rs. lakh
4.	Tree Plantation 159 trees @ Rs.2000/- per tree	6.72
	Total	**514.22**

9.28 CONCLUSION

The proposed Metro line is proved to have significant positive effects to the development of Mumbai City. Benefits to the economy, traffic congestion reduction, quick and safety transport, employment opportunities, fuel consumption reduction, and air quality improvement are the obvious positive effects from this Metro line. Besides, the potential adverse environmental impacts on air quality (during construction phase), water environment, noise, solid waste, ecology, population resettlement are also taken into consideration. Based on these detailed potential adverse environmental impacts, appropriate mitigation measures have been developed for consideration. The EIA concluded that project impacts from both construction and operation will be minimal, and can be mitigated through the use of prevailing current practices and appropriate technologies. With the implementation of the EMP and the monitoring plan, the Project is not expected to have significant environmental impacts.

CHAPTER - 10

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

10.1 INTRODUCTION

This is extension of Mumbai Metro Line-5 (Thane – Bhiwandi – Kalyan). It is being extended from Kalyan to Taloja, length of this extension is 20.756 km and is named as Mumbai Metro Line-12. It is completely elevated. Total Seventeen stations have been proposed and all are elevated.

It will be augmented through enhanced flexibility of criss-cross interchanges to other metro corridors and other modes of public transport. It will reduce the travel time of commuters. While Metro is a high capacity mode of transport, the need for integration with other secondary/intermediate transport mode is getting highlighted more than ever to ensure a seamless journey. This concept is to provide first mile and last mile connectivity to the commuters with their places of stay. With top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Rail Systems. (Ref: MoUD (Urban Transport Wing) Advisory Circular No. K-14011/1/2007-UT-IV dated 30.08.2013).

The share of various modes of secondary/intermediary mode of travel is complex and debatable issue which is dependent on a large number of variables like available road width, penetration in the residential areas, Road condition, distance from the Metro Stations, availability of parking and lay out and availability of circulating areas at the Metro Rail Stations, Business centre or Market & existing traffic densities. These factors relate with each other and evolve with development of new model mix of transport, infrastructure and changes with the passage of time. Even though for a given urban transport scenario, optimal mode share may be determined from computer based models but actual **optimal mode share** is never achievable on the road due to dynamic nature of demand and supply of transport modes.

10.2 PRESENT CONDITION OF TRANSPORT ON CITY ROADS

At present the various modes coming to Metro Stations comprise of State Transport buses, Auto-rickshaws, Private cars, Two Wheelers and Bi-cycles. These can be classified in three groups of transport modes namely Public, IPT and Private.

In public transport group there are large buses of State Transport (50 Seaters) and Charted Buses hired by Schools and private offices. Generally the public transport in Mumbai comprises of the buses which are operated by the Transport Corporation.

Auto-rickshaws are also an important part of public transports at Mumbai. After bus, it is these auto rickshaws which are the most important modes of public transport in Mumbai even though they are little expensive. Auto rickshaws are Intermediate Public Transport (IPT) Modes. Another public transport at Mumbai which can be ranked third among all is the cabs or taxis that run on the streets of Mumbai.

In the personalised transport modes, there are Cars, Two Wheelers and Bicycles of all possible sizes.

A chaotic situation is observed when all the above mentioned transport vehicles are seen jostling to each other for space for moving forward. More pathetic conditions are seen at the Road Intersections.

The solution lies in the showcasing a workable arrangement of co-existence through identification of good points of each mode and then utilise the same to get the attention and embedding it in public psyche.

Because of high traffic and less capacity as well as length of the roads, average distance between two consecutive vehicles becomes very less. Such situation does not permit speed higher than 15-20 km/hr. This indicates that unless there is some solution to reduce this unmanageable mix of the vehicle fleet, real transport integration may not be possible. While no significant increase, the Road length on main & arterial Roads may be anticipated which may relieve the congestive/chaotic/slow moving road traffic, a divergent policy of linking commuters directly through E-Rickshaw using the service/inner road length to supplement the main road traffic will impact the congestion and provide relief to the Metro commuters in reaching out to Metro Stations.

10.3 IMPACT OF BUS/CLUSTERS IN MODE SHARE

Primary reason for using personal vehicle (for buying vehicle) is **to save travel time** during journey. On the other hand, Government has tried to increase number of public buses on the road in many different ways.

Government has tried hard to popularise public buses by subsidising the fare but could not bring higher (and middle) income group to use public bus simply because it is slow and uncomfortable. Therefore objective of achieving optimal mode share remained elusive than reality.

10.4 BALANCING ACT OF METRO

After introduction of Metro Rail System in the city, Traffic and Transportation scenario will significantly change. People will no longer be afraid to travel a much longer distance. With Metro in place, longer distances can be travelled in shortest time with relatively more ease and comfort.

10.5 WAY FORWARD

In view of above deliberations in back ground, along with planning for Metro System in any city, there is a need for providing a transportation system which is seamlessly integrated across all modes and provides first mile as well as last mile connectivity. It is also necessary that various public transportation modes including Inter-mediate Public Transport (IPT) and feeder buses etc. work together in order to facilitate increase in ridership to the Metro/Metro system and provide ease of using Metro system by the public at large.

Therefore, there is a need for doing more scientific study exclusively for this. To achieve this goal, Metro Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. Detailed Study is required to be done in this influenced zone of a Metro station for following aspects mainly:

i) Availability and review of existing public and IPT facilities, in terms of motorized and non-motorized 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 pedestrianization 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. 2.65 crores per station has been considered sufficient and included in the project cost of proposed Metro System. If at any stage more feeder services etc. will be required, same can be augmented by concerned City Transportation Authorities.

CHAPTER -11

FRIENDLY FEATURES FOR DIFFERENTLY ABLED

11.1 INTRODUCTION

The objective of making this chapter is to create a user-friendly mass transport system in India which can ensure accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems (e.g. a leg in plaster) and the elderly persons.

The design standards for universal access to Public Transport Infrastructure including related facilities and services, information, etc. would benefit people using public transport.

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Harmonised Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disabled and Elderly Persons", 2016 (by MoUD), and international best practices / standards.

Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around Metro stations.

11.2 CONTENT

1. Metro Rail Station
    - Way finding
    - Signage
    - Automated Kiosks
    - Public Dealing Counters
    - Audio-visual Displays
    - Public Telephones
    - Rest Areas/Seating
    - Tactile Paving - Guiding & Warning
    - Doors
    - Steps & Stairs
    - Handrails

- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

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

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

11.3 METRO RAIL STATION

1. General
   - Whether over-ground or underground, rail travels is a highly effective mode of transport.
   - Every train should contain fully accessible carriages.
   - Staff should be trained in methods of assistance and be at hand on request.
   - Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways
   - Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
   - All new railway stations should be designed to be fully accessible.
   - For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
   - For persons with visual impairments audio system announcing the station names and door location should be available.

2. Accessible Metro Rail Cars

   The railway cars should have the following features:
   - Railway car doors should be at least 900 mm wide;
   - The gap between the car doors and the platform should preferably be less than 12 mm;

- Identification signage should be provided on the doors of wheelchair accessible coach.
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

3. Wheel Chair Space
    - Space for a wheel chair should be available at the side of the door:-
    - The space should be indicated inside and outside the car by using the international symbol of access; and
    - Wheel stoppers and ring-strap or other appropriate safety grip should be provided for wheelchair users.

4. Seats
    - An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles
    - Aisles should be at least 900 mm wide.

11.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

11.5 METRO STATION AREA

1. LEVEL APPROACH
    - Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should have a ramp.
    - Walkway surfaces should be non-slip.
    - Approach walkway should have tactile pavements for persons with visual impairments.

2. STATION ENTRANCES AND EXITS
    - These should have a minimum width of 1800mm and is level or ramped.

3. RESERVATION AND INFORMATION COUNTERS
    - Should have clear floor space of at least 900 mm x 1200 mm in front of the counters;
    - There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
    - At least one of the counters should have an induction loop unit to aid people with hearing impairments; and

- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

4. TOILET FACILITIES
   - There should be at least one unisex accessible toilet
   - Ticket Gates

   At least one of the ticket gates should:
   - Be minimum 900 mm wide to allow a wheelchair user through; and
   - Have a continuous line of guiding paver for people with visual impairments.

5. PLATFORMS

   The Platforms should:
   - Have a row of warning paver installed 600mm before the track edge (Fig. 11.4);
   - Have non-slip and level flooring;
   - Have seating areas for people with ambulatory disabilities;
   - Be well illuminated lux level 35 to 40;
   - There should be no gap or difference in level between the train entry door and the platform.
   - All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING
   - Way finding references should be available at decision points.
   - Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
   - Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
   - Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
   - In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
   - Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
   - Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travellers.
   - Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

- Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille)

8. SIGN DESIGN SPECIFICATIONS

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.
- Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
- The colour of the text should be in a colour that contrasts with the sign board.
- The sign board should also contrast with the wall on which it is mounted.
- The surface of the sign should not be reflective.
- Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
- Illuminated signs should not use red text on a dark background.
- Signs should be supplemented by Braille where possible.

Fig. 11.1 - Way finding signage

Fig. 11.2 - International Symbol of Accessibility

9. AUTOMATED KIOSKS

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. PUBLIC DEALING COUNTERS
    - Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.
    - Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
    - It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.
    - Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
    - Staff manning the counters should know sign language.
    - Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
    - Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
    - Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
    - There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
    - One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep.

11. AUDIO-VISUAL DISPLAYS
    - Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
    - Enable captioning at all times on all televisions and other audio-visual displays that are capable of displaying captions and that are located in any portion of the terminal.
    - The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING
    - Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
    - Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
    - Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.

- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. TACTILE PAVING- GUIDING & WARNING

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. PLACES TO INSTALL WARNING PAVER

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

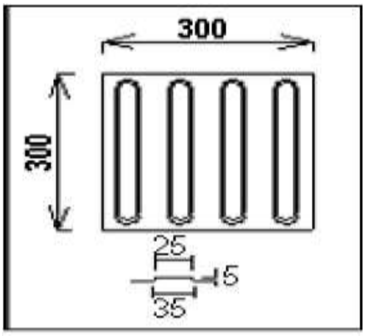


Fig. 11.3 - Guiding paver

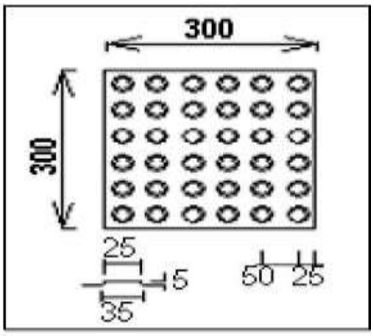


Fig. 11.4 - Warning paver

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 detectable.
- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

11.19.2 Car Park

(A) SIGNAGE

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be at a minimum height of 2100 mm.

(B) SYMBOL

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the centre of the lot; and
- The colour of the symbol should be white on a blue background.

(C) CAR PARK ENTRANCE

The car park entrance should have a height clearance of at least 2400 mm.

LOCATION

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.
- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) ACCESSIBLE CAR PARKING LOT

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm;
- Have a firm, level surface without aeration slabs;
- Wherever possible, be sheltered;
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings;
- Two accessible parking lots shall be provided for every 25 no of car spaces.

(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

CHAPTER-12

SECURITY MEASURES FOR A METRO RAIL SYSTEM

12.1 INTRODUCTION

Metro Rail System is emerging as the most favoured mode of urban transportation system. The inherent characteristics of Metro Rail System make it an ideal target for terrorists and miscreants. Metro Rail System is typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic importance, being the life line of city high news value, fear & panic and human casualties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

12.2 NECESSITY OF SECURITY

It is well known that public transportation is increasingly important for urban areas to prosper in the face of challenges such as reducing congestion and pollution. Therefore, security places an important role in helping public transport system to become the mode of choice. Therefore, excellence in security is a prerequisite for Metro Rail System for increasing its market share. Metro Rail System administration must ensure that security model must keep pace rapid expansion of the Metro Rail System and changing security scenario.

12.3 THREE PILLARS OF SECURITY

Security means protection of physical. Human and intellectual assets either from criminal interference, removal of destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. There are three important pillars of security as mentioned under:

(i) The human factor;
(ii) Procedures;
(iii) Technology

Staff engaging with the passengers creates a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective staff has to be qualified, trained, well equipped and motivated. They should be trained, drilled and tested. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed communicated and drilled in advance.

There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems are to differ i.e., making planning or execution of on attack too difficult, detect the planned evidence before it occurs deny the access after in plan of attack has been made and to mitigate i.e. lessen the impact severity as the attack by appropriate digits.

12.4 PHASES OF SECURITY

There are three phases of security as under:

(i) Prevention

These are the measures which can prevent a security incidence from taking place. These can be identified by conducting a risk assessment and gathering intelligence. Prevention begins with the daily operational security -problems.

Uncared for dirty, damaged property is a breeding ground for more serious crime.

(ii) Preparedness

Plans must be prepared to respond to incidents, mitigate the impact. Train staff accordingly and carry out exercises. The results of the risk assessment give a basis for such plans.

(iii) Recovery

Transport system must have laid down procedures/instructions for the quick recovery of normal service after an incident. Recovery is important for the financial health of the operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should also include an evaluation process for the lessons learnt.

12.5 RESPONSIBILITIES AND PARTNERSHIPS

Security is a sovereign function and hence is the responsibility of the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the Government of Maharashtra to ensure secured travelling to the public including Metro Rail System.

12.6 PROPOSED PROVISIONS FOR SECURITY SYSTEM

1. CCTV coverage of all Metro Rail System stations. With a provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer

and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations. Cost of this is included in Telecom estimate.

2. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required. Cost of one baggage scanner is Rs. 15.0 Lacs approximately, on 2013 prices.

3. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations. Cost of one Multi-zone DFMD is Rs 2.15 Lacs approximately.

4. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station. Cost of one HHMD is Rs 6000/- approximately at 2012 prices.

5. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of DMRC. Cost 1.25 crores including vehicle.

6. Bomb Blanket at least one per station and Depots. Cost is Rs. 50,000/- per bomb blanket.

7. Wireless Sets (Static and Hand Held) as per requirement of security agency.

8. Dragon light at least one per station and vital installation.

9. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.

10. Dog Squads (Sniffer Dog), at least one dog for 4 Metro Rail System stations which is at par with current arrangement of Delhi Metro. Cost of one trained sniffer dog is Rs 1.25 Lacs approximately. Dog Kennels along with provision for dog handlers and MI room will also be provided by Metro Rail System train depot administration including land at suitable places line wise.

11. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of Metro Rail System train depot administration Metro Rail System station.

12. Bullet proof jackets and helmets for QRTs and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 Metro Rail System stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.

13. Furniture to security agency for each security room, and checking point at every entry point at stations. Scale is one office table with three chairs for security room and office of GO and one steel top table with two chairs for checking point.

14. Ladies frisking booth - 1 per security check point (AFC Array)
    Wooden Ramp - 1 per DFMD for security check points.

15. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof Morcha, as per requirement.

16. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.

20. The provision procurement of all the above hardware is included in the cost of Stations.

CHAPTER -13

DISASTER MANAGEMENT MEASURE

13.1 INTRODUCTION

“Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation.” Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area”. As per World Health Organization (WHO):

“Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area.”

A disaster is a tragic event, be it natural or manmade, which brings sudden and immense agony to humanity and disrupts normal life. It causes large scale human suffering due to loss of life, loss of livelihood, damages to property and persons and also brings untold hardships. It may also cause destruction to infrastructure, buildings, communication channels essential services, etc.

13.2 NEED FOR DISASTER MANAGEMENT MEASURES

The effect of any disaster spread over in operational area of Metro Rail System is likely to be substantial as Mumbai Metro will be dealing with thousands of passengers daily. Disaster brings about sudden and immense misery to humanity and disrupts normal human life in its established social and economic patterns. It has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro Rail System. Therefore there is an urgent need to provide for an efficient disaster management plan.

13.3 OBJECTIVES

The main objectives of this Disaster Management Measures are as follows:

- Save life and alleviate suffering.

- Provide help to stranded passengers and arrange their prompt evacuation.
- Instill a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation.
- Lay down the actions required to be taken by staff in the event of a disaster in VMRT in order to ensure handling of crisis situation in coordinated manner.
- To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

13.4 LIST OF SERIOUS INCIDENTS REQUIRING USE OF PROVISIONS OF THE DISASTER MANAGEMENT MEASURES

Medium Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

- **Man Made Disaster**
  1. Terrorist attack
  2. Bomb threat/ Bomb blast
  3. Hostage
  4. Release of Chemical or biological gas in trains, stations or tunnels
  5. Fire in Metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
  6. Train accident and train collision/derailment of a passenger carrying train.
  7. Sabotage
  8. Stampede

- **Natural Disaster**
  1. Earthquakes
  2. Floods

13.5 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

A. The National Disaster Management Authority (NDMA) Establishment of National Disaster Management Authority:-

(1) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (The Disaster Management Act, 2005), an authority to be known as the National Disaster Management Authority.

(2) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central

Government and, unless the rules otherwise provide, the National Authority shall consist of the following:-

(a)The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;
(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disaster Management Authority

Establishment of State Disaster Management Authority:-

(1) Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(2) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:-

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;
(b) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;
(c) The Chairperson of the State Executive Committee, ex officio.

(3) The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the State Authority.

(4) The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, ex officio: Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority: Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary
(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.
(3) State Level Committee under the chairmanship of Chief Secretary.
(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
(iii) The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan and of any amendment thereto, to the District Authority.

13.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

To prevent emergency situations and to handle effectively in case 'one arises' there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

(A) FIRE DETECTION AND SUPPRESSION SYSTEM
(B) SMOKE MANAGEMENT
(C) ENVIRONMENTAL CONTROL SYSTEM (ECS)
(D) TRACK-WAY EXHAUST SYSTEM (TES)
(E) STATION POWER SUPPLY SYSTEM
(F) DG SETS & UPS
(G) LIGHTING SYSTEM
(H) STATION AREA LIGHTS
(I) SEEPAGE SYSTEM
(J) WATER SUPPLY AND DRAINAGE SYSTEM
(K) SEWAGE SYSTEM
(L) ANY OTHER SYSTEM DEEMED NECESSARY

The above list is suggestive not exhaustive actual provisioning has to be done based on site conditions and other external and internal factors.

13.7 PREPAREDNESS FOR DISASTER MANAGEMENT

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their wellbeing seeking their cooperation.
Since learning can only be perfected by ‘doing’ the following Mock Drills is considered essential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train
f. Hot line telephone communication with state disaster management authority.

13.8 COMMUNICATION WITH STATE DISASTER MANAGEMENT CELL

Operation Control Centre will have a hotline connection with the State Disaster Management cell so as to avoid any time loss in communication of the information.

CHAPTER – 14

COST ESTIMATES

14.1 INTRODUCTION

Project Cost estimates for Mumbai Metro Line No. 12 from Kalyan to Taloja has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction etc. at March 2018 price level.

While preparing the cost estimates, various items have generally been grouped under three major heads on the basis of:-

(i) Route km. Length of alignment
(ii) No. of units of that item and
(iii) Item being an independent entity.

All items related with alignment, permanent way, OHE, signaling and telecommunication, have been estimated on rate per route km basis. The cost of elevated stations includes civil work for station structures, architectural finishes, platform, roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc. have been worked out separately. These rates do not include cost of permanent way, O.H.E., power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, etc. costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-III. A suitable escalation factor has been applied to bring these costs to March 2018 price level. In addition, the rates of Civil works of elevated portion have been escalated by 10% to compensate the higher costs in Mumbai compared to Delhi. Taxes & Duties such as Customs Duty, CGST, SGST and IGST wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost of Mumbai Metro Line-12 from Kalyan to Taloja at March 2018 price level works out to **Rs. 4132 Crores** excluding applicable Taxes & Duties of **Rs. 606 crores** as tabulated hereunder.

Table 14.1 – Details of Capital Cost

Name of the section	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
Kalyan to Taloja	4132	606	4738

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 land has been minimized as far as possible. Elevated alignment is proposed within the Right of way as far as possible. The land acquisition is required to be done mainly for exit & entries, for running section in private agricultural land and at locations where alignment runs outside the ROW.

Cost of Govt. land is based on the rate presently being charged by the concerned authorities. Private and Private Agricultural land for MRTS project shall be acquired by MMRDA/ Maharashtra State Government and compensation shall be paid as per Land Acquisition Act 2013 (MUTP Act), MMRDA Act. The average rate of private and private-agri land has been worked out to be Rs.20 Crore and Rs.5 Crore per hectare respectively on the basis of latest information available.

Provision for Rehabilitation and Resettlement is made separately.

In addition to the lands required permanently, some areas of land (Pvt. as well as Pvt.-Agri) are proposed to be taken over temporarily for construction depots and site office. Ground rent charges @ 5% per year for a period of 4 years have been provided in project cost estimates.

Details of the land with costs have been shown in the cost estimate.

14.2.2 Formation and Alignment

Elevated section: For elevated viaduct, the rates adopted are based on the completion cost for these works of Phase-II and ongoing Phase-III works, duly updated to March 2018 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 been arrived based on Delhi metro Phase-III accepted rates added by 10% more for higher cost at Mumbai compared to Delhi

14.2.4 Permanent way

For elevated alignment ballastless track and for depot, ballasted track is proposed except for washing lines, repair lines etc. Rates adopted are based on similar works done in Phase-II and ongoing Phase-III works duly updated to March 2018 price level.

14.3 DEPOT

Depot near Pisarve Depot Station has been planned for this corridor.

14.4 UTILITY DIVERSIONS, ENVIRONMENTAL PROTECTION, MISCELLANEOUS OTHER WORKS

Provisions have been made to cover the cost of utility diversions, miscellaneous road works involved, road diversions, road signages etc. and environmental protection works on route km basis, based on the experience gained from the works done in Phase- III of Delhi Metro.

14.5 REHABILITATION AND RESETTLEMENT

Provisions have been made on fair assessment basis, to cover cost of relocation of Jhuggies, shops, residential Houses on private land etc.

Provisions for barracks and security equipment for CISF and Staff Quarters for O&M Wing have been made in the cost estimates on the basis of average cost involved per km length in the recent past.

14.6 TRACTION AND POWER SUPPLY

Provisions have been made to cover the cost of O.H.E., Auxiliary sub stations, receiving substations, service connection charges, SCADA and miscellaneous items, on route km basis separately for elevated and at-grade section (Depot Connection).

Provisions towards cost of lifts, escalators for elevated stations have been made in the cost estimates. Rates provided are based on cost of similar ongoing Phase-III works duly updated to March 2018 price level.

14.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based on the completion cost of similar works for Delhi Metro under Phase-II and ongoing Phase-III works. These rates include escalation during manufacturing and supply of equipment and their installation at site.

14.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on accepted rates for similar work of Phase-II and ongoing Phase-III works duly updated to March 2018 price level.

14.9 ROLLING STOCK

Rate was adopted based on Mumbai Metro Line-3.

14.10 SECURITY

A lump sum provision for providing security infrastructure in the station premises has been made on running kilometer basis. Adopted rates are as taken in phase III DPR suitably escalated to current price level.

14.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 2.65 Crore per station has been made to have seamless integration of metro stations with other modes of transport. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

14.12 GENERAL CHARGES AND CONTINGENCES

Provision @ 5% has been made towards general charges on all items, except cost of land, which also includes the charges towards Detailed Design Charges (DDC), etc. Provision for contingencies @ 3 % has been made on all items including general charges.

14.13 CAPITAL COST ESTIMATES

14.13.1 Metro Line-12 from Kalyan to Taloja

The overall Capital Cost for Mumbai Metro Line-12 from Kalyan to Taloja at March 2018 price level works out to **Rs. 4132 Crores** excluding applicable Taxes & Duties of **Rs. 606 crores** as tabulated hereunder.

Table 14.2 - Capital Cost Estimate

Total length = 20.756 km (Completely Elevated)

Total Station =17 (All Elevated)

March 2018 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Private -Agricultural Land	ha	5.00	49.731	248.66
b	Private	ha	20.00	1.080	21.60
1.2	Temporary Land (@5% pa for 4 years)	Ha.			
a	Private -Agricultural Land		1.00	6.6	6.60
b	Private		4.00	2.2	8.80
1.3	**R & R incl. Hutments etc.**	R. Km.	4.12	7.4	30.49
	Subtotal (1)				**316.14**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	35.00	20.756	726.46
2.2	Depot entry connection	R. Km.	35.00	0.500	17.50
2.3	Additional Cost for Special Spans	LS			20.00
	Subtotal (2)				**763.96**
3.0	**Station Buildings**				
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	27.00	14	378.00
b	Type (A) way side- EM works including lifts and escalators	Each	9.05	14	126.70
c	Type (B) Way side with signalling-civil works	Each	29.00	2	58.00
d	Type (B) Way side with signalling-EM works including lifts and escalators	Each	9.05	2	18.10
e	Type (C), Terminal station -civil works	Each	31.00	1	31.00
f	Type (c), Terminal station -EM works including lifts and escalators	Each	9.05	1	9.05
3.2	Half height Platform Screen Doors (PSD)	Each	2.79	34	94.86
3.3	OCC bldg.				
a	Civil works	LS			60.00
b	EM works etc	LS			40.00
	Subtotal (3)				**815.71**
4.0	**Depot**	LS			
4.1	Depot				
a	Civil works	LS			250.00
b	EM works	LS			25.00
c	M&P for Rolling stock	LS			50.00
d	Depot 25 kV AC Traction (OHE)	LS			25.00
	Subtotal (4)				**350.00**
5.0	**P-Way**				
5.1	Ballast less track for Elevated section	R. Km.	9.79	21.256	208.10
5.2	Ballasted track for Depot	R. Km.	5.38	5.00	26.90
	Subtotal (5)				**235.00**
6.0	**Traction & power supply incl. OHE , ASS etc. Excl. lifts & Escalators**				
6.1	Elevated Section 25 kV AC Traction (OHE) with ASS & Cabling	R.Km.	7.19	21.256	152.83

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
6.2	RSS (GIS)	Each	61.27	2.00	122.54
	Subtotal (6)				**275.37**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	12.50	21.256	265.70
7.2	Automatic fare collection	Stn.			
	a) Elevated stations	Each	6.28	17	106.76
	Subtotal (7)				**372.46**
8.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works	R. Km.	5.14	21.256	109.26
b	EM works	R. Km.	4.00	21.256	85.02
	Subtotal (8)				**194.28**
9.0	**Rolling Stock (3.2 m wide Coaches)**	Each	9.00	45	405.00
	Subtotal (9)				**405.00**
10.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.08	21.256	1.70
b	EM works etc	R.Km.	0.33	21.256	7.01
	Subtotal (10)				**8.71**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.99	21.256	42.30
b	EM works etc	R.Km.	0.50	21.256	10.63
	Sub Total (11)				**52.93**
12.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal Integration	Each	2.65	17	45.05
	Sub Total (12)				**45.05**
13.0	**Total of all items except Land**				**3548.96**
14.0	**General Charges incl. Design charges @ 5 % on all items except land#**				**177.45**
15.0	**Total of all items including G. Charges except land**				**3726.40**
16.0	**Contingencies @ 3 %**				**111.79**
17.0	**Gross Total**				**3838.20**
	Cost without land			**=**	**3838**
	Cost with land including contingencies on land			**=**	**4132**

#In accordance with MoUD's letter F.No.K-14011/58/2013-MRTS-I(Vol.I)

Table 14.3 - Details of Taxes and Duties

Basic Customs duty =	5.1500
CGST Customs Duty =	9.4635
SGST Customs Duty =	9.4635
Total Customs Duty =	**24.0770**
General IGST =	12
General CGST =	6
General SGST =	6

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total Taxes & Duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated	763.96		91.68	**91.68**
2	**Station Buildings**				
	a) Elevated station - civil works	467.00		56.04	**56.04**
	b) Elevated station-EM works	153.85	7.41	14.77	**22.18**
	c) OCC bldg-civil works	60.00		7.20	**7.20**
	d) OCC bldg-EM works	40.00	1.93	5.76	**7.69**
3	**Depot**				
	Civil works	250.00	18.06	21.00	**39.06**
	EM, M&P works and OHE	100.00	4.82	14.40	**19.22**
4	**P-Way**	235.00	45.26	8.46	**53.72**
5	**Traction & power supply**				
	Traction and power supply	275.37	26.52	29.74	**56.26**
6	**S and T Works**				
	S & T	265.70	51.18	9.57	**60.74**
	AFC	106.76	19.28	4.80	**24.08**
	PSD	94.86	18.27	3.41	**21.69**
7	**R & R hutments**	30.49		3.66	**3.66**
8	**Misc.**				
	Civil works	187.04	0.00	22.45	**22.45**
	EM works	113.93	0.00	20.51	**20.51**
9	**Rolling stock**	405.00	58.78	5.99	**64.77**
10	**Rent on Temporary Land**	15.40		2.77	**2.77**
11	**General Charges**	177.45		31.94	**31.94**
	Total	**3741.80**	**251.50**	**354.15**	**605.65**
	Total taxes & Duties				**606**
Rate of Taxes & Duties on Total cost without taxes & duties					**16.19%**
Total Central GST & Basic Customs duty					329.72
Total State GST					275.93
Total Taxes & Duties					**605.65**

CHAPTER - 15

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

15.1 INTRODUCTION

The Mumbai Metro Rail Project i.e. Line 12 from Kalyan to Taloja (Extension of Line 5 metro project) is proposed to be constructed at an estimated cost of Rs. 4738.00 Crore with all taxes and land cost. The route length of the proposed metro rail system and estimated cost at March 2018 price level without and with all taxes are placed in table 15.1 as under:

Table 15.1 Cost Details

Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)
Line 12 from Kalyan to Taloja (Extension of Line 5)	20.756	4132.00	4738.00

The estimated cost at March 2018 price level includes an amount of Rs.8.71 Crore as one-time charges of security personal towards cost of weapons, barricades, and handheld 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

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with all taxes has been calculated by taking escalation factor @ 5% per annum. The taxes and duties consist of Custom Duty (CD), Central Goods and Service Tax (CGST), State Goods and Service Tax (SGST), Integrated Goods and Service Tax (IGST). Mumbai metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective concessional CD rate on supply of goods works out to 24.077% {Basic CD @ 5%, IGST @ 18%} on the imported portions. Post-GST, the GST rate on construction of original works of metro project has been considered @ 6% each for CGST and SGST while the GST rate has been considered @ 18% for supply of indigenously manufactured items and services. The above taxes and duties have been considered for working out the estimated taxes and duties. It has been assumed that Maharashtra State Government will provide the land worth Rs.368 crore on completion cost basis either free of cost or shall provide Interest Free Subordinate Debt. The Interest Free Subordinate Debt is repayable in 5 equal instalments after repayment of Multilateral/Overseas Development Assistance Loan.

It is assumed that the construction work will start on 01.11.2019 and is expected to be completed on 31.10.2024 with Revenue Opening Date (ROD) as 01.11.2024 for the above 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 and all taxes & duties)

Figures in Rs. Crore

Financial Year	Estimated Cost including cost of land and all taxes & duties at March 2018 Price Level	Completion Cost including cost of land and all taxes & duties
2019-20	214.00	225.00
2020-21	523.00	577.00
2021-22	964.00	1116.00
2022-23	1183.00	1438.00
2023-24	1103.00	1408.00
2024-25	441.00	591.00
2025-26	310.00	436.00
Total	**4738.00**	**5791.00**

Although the construction is expected to get over by 31st October 2024, the cash flow spill over up to March 2026 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

The cost of Land of Rs. 368 crore included in the above completion cost will be provided free of cost by the Maharashtra Government.

15.2.2 Additional Capital

Based on Traffic Study, the additional capital requirement during the life cycle of the project is tabulated as under:-

Table 15.3 Additional Capital (Rolling Stock)

Rs. In Crore

Year	No. of Rolling Stock	Amount
2031-32	45	844

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, and

(iii) Energy costs

The requirement of staff has been assumed @ 30 persons per kilometre based on DMRC's current practice. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The 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. 6 per unit which has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 5.00% per annum. The O&M costs have been tabulated in Table 15.4 as below:

Table 15.4 Operation and Maintenance Costs

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2024	-	2025	22.41	12.97	12.14	47.52
2025	-	2026	58.62	32.69	30.60	121.91
2026	-	2027	63.90	34.33	32.13	130.35
2027	-	2028	69.65	36.04	33.74	139.43
2028	-	2029	75.91	37.84	35.42	149.18
2029	-	2030	82.75	39.74	37.20	159.68
2030	-	2031	90.19	41.72	39.05	170.97
2031	-	2032	98.31	43.81	63.19	205.31
2032	-	2033	107.16	46.00	66.35	219.51
2033	-	2034	116.80	48.30	69.67	234.77
2034	-	2035	127.32	50.71	73.15	251.18
2035	-	2036	138.78	53.25	76.81	268.84
2036	-	2037	151.27	55.91	80.65	287.83
2037	-	2038	164.88	58.71	84.68	308.27
2038	-	2039	179.72	61.64	88.92	330.28
2039	-	2040	195.89	64.73	93.36	353.98
2040	-	2041	213.52	67.96	98.03	379.52
2041	-	2042	232.74	71.36	102.93	407.03
2042	-	2043	253.69	74.93	108.08	436.69
2043	-	2044	276.52	78.67	113.48	468.68
2044	-	2045	301.41	82.61	119.16	503.17
2045	-	2046	328.53	86.74	125.12	540.39
2046	-	2047	358.10	91.08	131.37	580.55
2047	-	2048	390.33	95.63	137.94	623.90
2048	-	2049	425.46	100.41	144.84	670.71
Total			**4523.86**	**1467.78**	**1998.01**	**7989.65**

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 indicated in table 15.5 below: -

Table 15.5 Projected Ridership

Financial Year	Trips per day (lakhs)
2024-25	1.11
2031-32	2.62

b. The growth rate for traffic is assumed @13.05% Per Annum till 2031-32 and @ 1.15% per annum thereafter.

c. These are the traffic figures considering the fast development in the area upto year 2031, particularly in the land identified for Property Development.

15.3.2.2 Trip Distribution

The trip distribution has been worked out for the fare structure proposed and traffic study conducted by MMRDA taking an average lead of 11.06 KM which is shown in Table 15.6 below: -

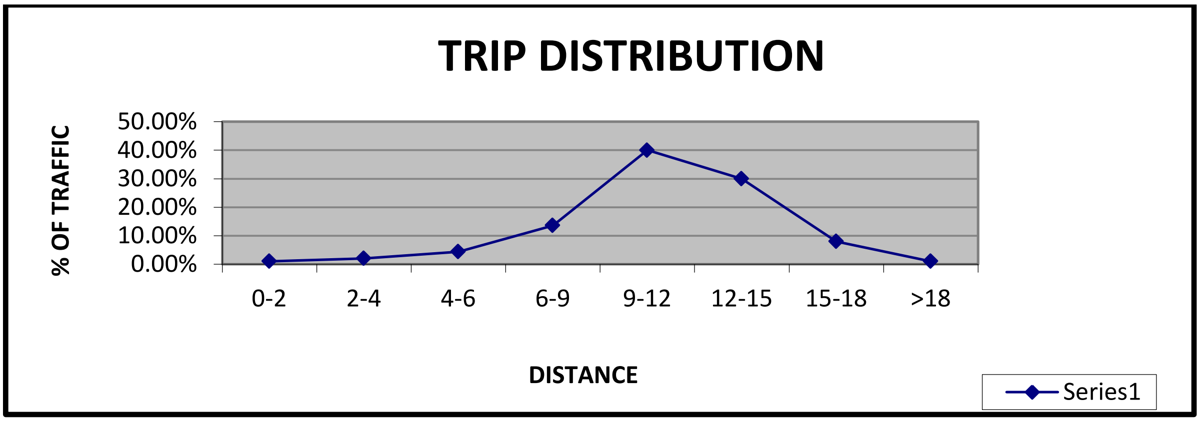
Table 15.6 Trip Distribution

Distance (km)	Percent distribution
0-2	1.00%
2-4	2.00%
4-6	4.39%

Distance (km)	Percent distribution
6-9	13.61%
9-12	40.00%
12-15	30.00%
15-18	8.00%
>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 2024-25 has been assumed based on the details provided by MMRDA. Considering the increase in the Consumer Price Index (CPI) and input costs of operation since then, the fare structure has been escalated by using @14.00% once in every two years. The fare structure for the FY 2024-25 as per the proposed fare slabs is shown in the table 15.7 below:

Table 15.7 Fare Structure in 2024-25

Sr. No.	Distance	Proposed Fare
1	0-2	11
2	2-4	13
3	4-6	16
4	6-9	20
5	9-12	22
6	12-15	24
7	15-18	26
8	>18	30

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

Year 2024-25	
SLAB	**FARE (Rs)**
0-3 km	10.00
3-12 km	20.00
12-18 km	30.00
18 km and more	40.00

15.3.3 Non Fare Box Revenue

- **Non Fare Box Revenue from Property Business and Advertisement –** Other revenues from Property Business and advertisement have been assumed @ 10% of the fare box revenues during the first five years of operations and thereafter @ 20% of the fare box revenues. Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises.

- **Non Fare Box Revenue from Property Development -** SPV/BOT operator will engage a developer/Concessionaire for generating rental income. It is assumed that about 40 Hectare. i.e., 1,20,00,000 square feet area will be available for property development with a FSI of 3. The developer will bring equity to the extent of Rs. 665.00 crore and the balance amount towards construction shall be raised by SPV as 12% Market Debt. The current rental revenue in Mumbai City is Rs. 40 per Sq. ft. The estimated development cost will be Rs.2651.00 crore. It is assumed that the rental revenue will accrue to the developer from the FY 2025-26 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
2020	-	2021	480			347	21		368		-133	
2021	-	2022	504			371	46		785		-133	
2022	-	2023	529			396	54		1235		-133	
2023	-	2024	555			422	61		1718		-133	
2024	-	2025	583			450	66		2234		-133	
2025	-	2026		147	15			223	2011	268	93	-452
2026	-	2027		203	20			223	1788	241	98	-379
2027	-	2028		284	28			223	1565	215	103	-285
2028	-	2029		447	45			223	1342	188	108	-117
2029	-	2030		751	75			223	1119	161	113	179
2030	-	2031		788	79			223	896	134	119	233
2031	-	2032		828	83			223	673	108	125	289

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
2032	-	2033		869	87			223	450	81	131	347
2033	-	2034		912	91			223	227	54	138	406
2034	-	2035		958	96			227	0	27	145	463
2035	-	2036		1006	101						152	753
2036	-	2037		1056	106						160	790
2037	-	2038		1109	111						168	830
2038	-	2039		1164	116						176	872
2039	-	2040		1223	122						185	916
2040	-	2041		1284	128						194	962
2041	-	2042		1348	135						204	1009
2042	-	2043		1415	142						214	1059
2043	-	2044		1486	149						225	1112
2044	-	2045		1560	156						236	1168
2045	-	2046		1638	164						248	1226
2046	-	2047		1720	172						260	1288
2047	-	2048		1806	181						273	1352
2048	-	2049		1897	190						287	1420
Total			**2651**	**25899**	**2592**	**1986**	**248**	**2234**		**1477**	**3490**	**15441**

15.4 FINANCIAL INTERNAL RATE OF RETURN (FIRR)

The Financial Internal Rate of Return (FIRR) for 30 years business model including construction period without PD income and with PD income is (-) 1.39% and 6.00%. The FIRR with all taxes & duties including land cost without PD income and with PD income is produced in Table 15.9 (A) and 15.9 (B):-

Table 15.9 (A) –FIRR without PD income

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
2019	-	2020	225				225			0	-225
2020	-	2021	577				577			0	-577
2021	-	2022	1116				1116			0	-1116
2022	-	2023	1438				1438			0	-1438
2023	-	2024	1408				1408			0	-1408
2024	-	2025	591	0	48		639	35	4	39	-599
2025	-	2026	436	0	122		558	95	10	105	-453
2026	-	2027	0	0	130		130	125	13	138	8
2027	-	2028	0	0	139		139	141	14	155	16
2028	-	2029	0	0	149		149	182	18	200	51
2029	-	2030	0	0	160		160	206	41	247	87
2030	-	2031	0	0	171		171	262	52	314	143
2031	-	2032	0	844	205		1049	295	59	354	-695
2032	-	2033	0	0	220		220	340	68	408	188
2033	-	2034	0	0	235		235	344	69	413	178
2034	-	2035	0	0	251		251	397	79	476	225
2035	-	2036	0	0	269		269	402	80	482	213
2036	-	2037	0	0	288		288	465	93	558	270
2037	-	2038	0	0	308		308	470	94	564	256
2038	-	2039	0	0	330		330	544	109	653	323

Year			Outflow					Cash Flow			
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2039	-	2040	0	0	354		354	550	110	660	306
2040	-	2041	0	0	380		380	636	127	763	383
2041	-	2042	0	0	407	0	407	644	129	773	366
2042	-	2043	0	0	437	0	437	741	148	889	452
2043	-	2044	0	0	469	0	469	749	150	899	430
2044	-	2045	0	0	503	870	1373	862	172	1034	-339
2045	-	2046	0	0	540	913	1453	871	174	1045	-408
2046	-	2047	0	0	581	0	581	1,004	201	1205	624
2047	-	2048	0	0	624	0	624	1,015	203	1218	594
2048	-	2049	0	0	671	0	671	1,172	234	1406	735
Total			**5791**	**844**	**7991**	**1783**	**16409**	**12,547**	**2451**	**14998**	**(-)1.39%**

Table 15.9 (B) –FIRR with PD income

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
2019	-	2020	225				225			0	-225
2020	-	2021	577				577			0	-577
2021	-	2022	1116				1116			0	-1116
2022	-	2023	1438				1438			0	-1438
2023	-	2024	1408				1408			0	-1408
2024	-	2025	591	0	48		639	35	4	39	-599
2025	-	2026	436	0	122		558	95	-442	-347	-905
2026	-	2027	0	0	130		130	125	-366	-241	-371
2027	-	2028	0	0	139		139	141	-271	-130	-269
2028	-	2029	0	0	149		149	182	-99	83	-66
2029	-	2030	0	0	160		160	206	200	406	246
2030	-	2031	0	0	171		171	262	259	521	350
2031	-	2032	0	844	205		1049	295	319	614	-435
2032	-	2033	0	0	220		220	340	381	721	501
2033	-	2034	0	0	235		235	344	440	784	549
2034	-	2035	0	0	251		251	397	503	900	649
2035	-	2036	0	0	269		269	402	793	1195	926
2036	-	2037	0	0	288		288	465	837	1302	1014
2037	-	2038	0	0	308		308	470	877	1347	1039
2038	-	2039	0	0	330		330	544	926	1470	1140
2039	-	2040	0	0	354		354	550	971	1521	1167
2040	-	2041	0	0	380		380	636	1026	1662	1282
2041	-	2042	0	0	407	0	407	644	1073	1717	1310
2042	-	2043	0	0	437	0	437	741	1133	1874	1437
2043	-	2044	0	0	469	0	469	749	1187	1936	1467
2044	-	2045	0	0	503	870	1373	862	1254	2116	743
2045	-	2046	0	0	540	913	1453	871	1313	2184	731
2046	-	2047	0	0	581	0	581	1,004	1388	2392	1811
2047	-	2048	0	0	624	0	624	1,015	1454	2469	1845
2048	-	2049	0	0	671	0	671	1,172	1537	2709	2038
Total			**5791**	**844**	**7991**	**1783**	**16409**	**12547**	**16697**	**29244**	**6.00%**

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 Income (Sensitivity Analysis)

Capital Cost with Central Taxes but without land cost			
20% increase in capital cost	**10% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
5.04%	5.50%	6.55%	7.18%
Revenue			
20% decrease in Fare Box revenue	**10% decrease in Fare Box revenue**	**10% increase in Fare Box revenue**	**20% increase in Fare Box revenue**
5.03%	5.53%	6.45%	6.88%
O&M Cost			
10% increase in O&M cost		**10% decrease in O&M cost**	
5.72%		6.28%	

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 only the availability of funds for construction but coupled with this objective of providing initial finances are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self-sustainable system in the long run by
  - Low infrastructure maintenance costs
  - Longer life span
  - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai, Bengaluru, Mumbai Line-3, Nagpur, Lucknow Metro projects are funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

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 Central and State Government Control Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC)/Chennai Metro Rail Corporation (CMRL) etc.

(ii) Design, Built, Fund, Operate & Transfer (DBFOT), and

(iii) Public Private Partnership

15.5.1 SPV (DMRC/CMRL/BMRC) Model: -The State Government has already formed a fully owned SPV in the name of Mumbai Metro Rail Corporation (MMRC), which is responsible for the implementation of Metro Line 3, while all the other Metro rail corridors will be implemented by MMRDA.

- **ODA/Multilateral funding Loan: -**Overseas Development assistance from Japan International Cooperation Agency (JICA), AFD, KFW, EIB, etc. may be availed of for the Mumbai metro rail projects with interest @ 1.40% to 2.00% PA (excluding onetime front end fee @0.20% on the sanctioned loan) by GOI and lend it to the SPV on back to back basis. The loan is repayable in 30 years including moratorium period of 10 years. The loan is being provided by JICA to GOI which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Normally, JICA funds for underground civil including track works, Electrical, Signalling &Telecom and Rolling Stock only. Since the loan will be in Japanese Yen, fluctuation in exchange rate at the time of repayment shall be borne by the Government of Maharashtra. Alternatively, JICA can release the loan to the SPV for which a sovereign guarantee will be required from Central Government. Foreign exchange variation in such eventuality will be borne either by the SPV or GOM. In either case loan shall be repaid by SPV from the income streams of metro operations. The loan can also be availed from other lending agencies like AFD, KFW, EIB etc whose interest rate is linked with six monthly LIOBOR.

- **Modified JICA Loan:** The union cabinet chaired by the PM has given its approval for modification of existing guidelines of the policy on bilateral official development assistance for Development Corporation from with bilateral partners. As per the discussions with JICA officials, JICA may extend only the modified step loan for the new projects in India at an interest rate of 0.20% per annum. The tenure of the loan is 40 years with 12 years moratorium period. JICA shall fund the project to the extent of 85% of the cost of the project excluding the cost of the land, cost of Rehabilitation and Resettlement and taxes and duties. In case JICA agree to fund the project, the full loan i.e., Rs.3005 crore shall be funded by JICA. In that case there will be no need to borrow from Market Borrowing.

- **Loan from Asian Development Bank (ADB)/World Bank: -**The Loan shall be available from ADB/World Bank, but as per the experience it’s processing and approval normally takes 8-12 months. The interest rate is linked with prevailing 6 monthly LIBOR. These bilateral funding institutions also charge some margin ranging from 200 basis points to 300 basis points. Loan from these institutions may delay the implementation of the project resulting in avoidable increase in the completion cost due to time taken during finalization of loan agreement. Recently, Bangalore Metro availed ADB loan; however loan is yet to be disburse.

- **Loan from Bank and Financial Institutions:** -Funds can be arranged from domestic Financial Institutions like India Infrastructure Finance Company Limited (IIFCL), India Development Financing Corporation (IDFC), Life Insurance Corporation of India (LIC), IDBI Bank, ICICI Bank Ltd etc. These institutions are increasingly engaged to fund infrastructure projects subject to their commercial viability against guarantee from GOI. There are many models available under which the funds can be arranged by these financial institutions with or without syndicating with other commercial banks. IIFCL e.g. fund 20% of the project cost and arrange balance through the syndication of commercial banks with a lead banker among the consortium of bankers. The loan can be given for a period of 20-30 years with interest rate ranging from 9.50% to 12% PA. IIFCL can also provide 100% funding against GOI guarantee. They arrange ECB to the extent of foreign currency requirement at very competitive rate. The funding arrangement may require the central government guarantee as well. Since the rate of interest of these financial institutions is much higher than the interest rates of soft loan provided by JICA considering the exchange rate variation will be to GOI & GOM account, GOI and GOM shall have to bear the interest difference and provide suitable subsidy to the SPV to make the project financially sustainable.

MOUD vide letter no. F.No. K-14011/03/2017-UT-V-Part(1) dated 6th July 2017 has proposed for sharing of overall Goods and Service Tax (GST) in the ratio of 1:2. The funding pattern under this model (SPV) with sharing of overall taxes and duties, post GST in the ratio of 1:2 is placed in table 15.11 as under: -

Table 15.11 Funding pattern under SPV model (with all taxes and land)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount	% of contribution
Equity By GOI	837.00	15.43%
Equity By GOM	837.00	15.43%
SD for Overall Taxes by GOM (2/3)	248.00	4.57%
SD for Overall Taxes by GOI (1/3)	496.00	9.15%
1.40% Loan from Multilateral/Overseas Development Agencies or 12% Domestic Market Borrowings	3005.00	55.42%
Total	**5423.00**	**100.00%**
SD for Land by GOM	368.00	
Total	**5791.00**	
PTA for Interest During Construction @1.40% by GOM	74.00	
Grand Total	**5865.00**	

- **Private Participation under SPV:** The private participation either for complete provisioning of metro rail or for some unbundled components will form an essential requirement for all metro rail project proposals seeking central financial assistance as per new Metro Policy 2017 issued by Ministry of Housing and Urban Affairs (MH&UA). Hence, it is advisable to include lifts and escalator and AFC system for private participation under the model of Kochi Metro, Nagpur Metro, Noida Metro.

15.5.2 Design, Built, Fund, Operate & Transfer (DBFOT) 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 Equity internal rate of return (EIRR) 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 DBFOT – (16% EIRR) (With additional PD Income)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1085.00	20.00%
VGF by GOM	3135.00	57.82%
Equity by Concessionaire	141.00	2.60%
Concessionaire's debt @12% PA	1062.00	19.58%
Sub-Total	**5423.00**	**100.00%**
Land Free by GOM	368.00	
Sub-Total	**5791.00**	
IDC	166.00	
Grand Total	**5957.00**	

15.5.3 Public Private Partnership (PPP) Model: - Under this option, Government funds the fixed infrastructure such as land and basic civil structures, and the private investor funds all the systems such as rolling stock, signalling, power supply, traction, track, fare collection, E&M works etc including station architectural finishes. An example of this is Delhi Metro Airport line. Under this arrangement the government's investment will be about 57% of the cost of the Project and the PPP operator funds the remaining 43%. Under this model the concessionaire, operates and maintains the system to the required and agreed service and safety levels. All the revenues will accrue to the Operator and at the end of the concession period the project is handed over to the owner. Ridership risks are taken by the operator or shared by the operator and owner. The PPP operator pays a specified amount every year to the Govt. out of his revenues. It could be that he may even need a viability gap funding (VGF). The VGF (positive or negative) will be known only after competitive bidding. Based on the experience gained in Delhi Metro Airport line, DMRC does not recommend the proposal on PPP mode.

15.6 RECOMMENDATIONS

The FIRR for the corridors with all taxes and without additional PD income and with additional PD income works out to (-) 1.39% and 6%. However, FIRR is not the only criteria to take up the metro project.

As per Metro Rail Policy 2017, issued by the Ministry of Housing and Urban Affairs, (MOH&UA), GOI, apart from financial viability, the economic and social viability of the project is also required to be assessed. The Economic Internal Rate of Return (EIRR) for any metro rail project proposal should be 14% and above for consideration of its approval. Accordingly, the metro corridor as discussed above are recommended for implementation provided the required EIRR works out to 14% or above.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 15.13 as under;

Table 15.13

Rs. In crore

Particulars	SPV Model	DBFOT Model with PD
GOI	1085.00	1085.00
GOM	1701.00	3503.00
Total	**2786.00**	**4588.00**

Considering the difference in the contribution of funds under SPV owned by GOI & GOM vis-a-vis BOT model, it is recommended to implement the project under SPV model (completely Government Funded) as per the funding pattern given in Table 15.11. However, the state government may also explore the other sources of revenue from Transit Oriented Development and Value Capture Financing, which will be made available to metro authorities to meet out the O&M Expenses and servicing the debt properly. The cash flow sheet under SPV without PD income & PD income and DBFOT model with PD income is enclosed at Table 15.14, 15.15 and 15.16 respectively.

The funding pattern assumed under SPV model with Multilateral / Bilateral Loan / Market Borrowing and DBFOT model is depicted in the pie chart i.e., Figure 15.2 & 15.3 as under: -

Figure 15.2 Funding pattern under SPV Model

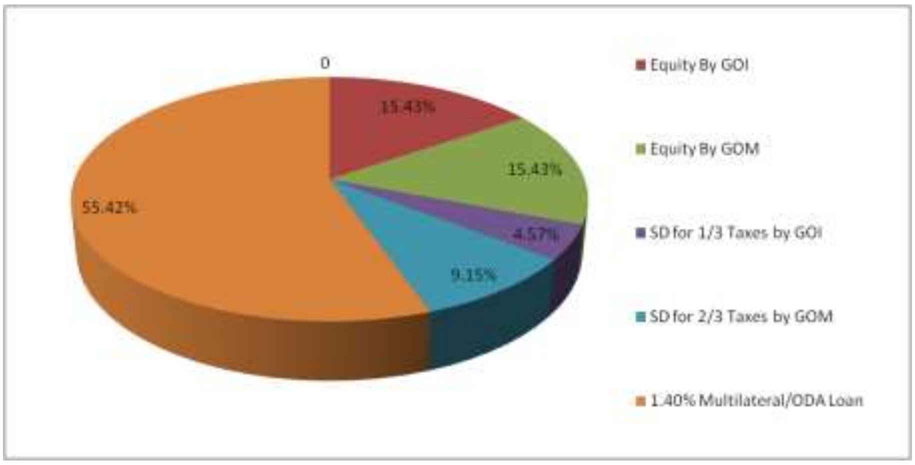
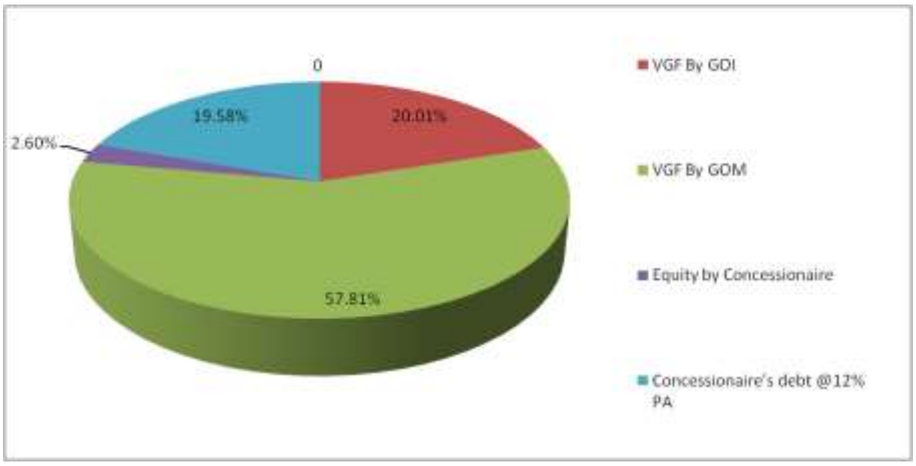


Figure 15.3 Funding pattern under DBFOT Model



MML 12: Kalyan – Taloja Metro Rail Corridor, Mumbai

Table 15.14

CAPITAL COST-FIXED 4738

CAPITAL COST - CURRENT 5791

DOMESTIC FUNDING - BASE CASE

IDC rate: 0.20% Interest rate: 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
2019 - 2020	225					225			0	-225	236	11	11	0	0	0	0	0				
2020 - 2021	577					577			0	-577	657	80	91	0	0	0	0	0				
2021 - 2022	1116					1116			0	-1116	662	-454	-363	363	363	0	9	372				
2022 - 2023	1438					1438			0	-1438	664	-774	-1137	1137	774	0	11	1157				
2023 - 2024	1408					1408			0	-1408	567	-841	-1978	1978	841	0	22	2020				
2024 - 2025	591	0	48	73		639	35	4	39	-599	0	-591	-2569	2569	591	0	32	2643	0	-81	-8	-8
2025 - 2026	436	0	122	176		558	95	10	105	-453	0	-436	-3005	3005	436	0		3079	40	-233	-57	-65
2026 - 2027	0	0	130	176		130	125	13	138	8		0	0	0	0	0		3079	43	-211	-35	-101
2027 - 2028	0	0	139	176		139	141	14	155	16		0	0	0	0	0		3079	43	-204	-28	-128
2028 - 2029	0	0	149	176		149	182	18	200	51		0	0	0	0	0		3079	43	-168	8	-120
2029 - 2030	0	0	160	176		160	206	41	247	87		0	0	0	0	154		2925	43	-132	-110	-230
2030 - 2031	0	0	171	176		171	262	52	314	143		0	0	0	0	154		2771	41	-74	-52	-282
2031 - 2032	0	844	205	201		1049	295	59	354	-695		0	0	0	0	154		2617	39	-91	-888	-1170
2032 - 2033	0	0	220	201		220	340	68	408	188		0	0	0	0	154		2463	37	-49	-2	-1172
2033 - 2034	0	0	235	201		235	344	69	413	178		0	0	0	0	154		2309	34	-57	-10	-1182
2034 - 2035	0	0	251	201		251	397	79	476	225		0	0	0	0	154		2155	32	-9	39	-1144
2035 - 2036	0	0	269	201		269	402	80	482	213		0	0	0	0	154		2001	30	-18	29	-1115
2036 - 2037	0	0	288	201		288	465	93	558	270		0	0	0	0	154		1847	28	41	88	-1027
2037 - 2038	0	0	308	201		308	470	94	564	256		0	0	0	0	154		1693	26	29	76	-951
2038 - 2039	0	0	330	201		330	544	109	653	323		0	0	0	0	154		1540	24	98	145	-806
2039 - 2040	0	0	354	201		354	550	110	660	306		0	0	0	0	154		1386	22	83	131	-675
2040 - 2041	0	0	380	201		380	636	127	763	383		0	0	0	0	154		1232	19	163	210	-465
2041 - 2042	0	0	407	201	0	407	644	129	773	366		0	0	0	0	154		1078	17	148	195	-270
2042 - 2043	0	0	437	201	0	437	741	148	889	452		0	0	0	0	154		924	15	236	283	13
2043 - 2044	0	0	469	201	0	469	749	150	899	430		0	0	0	0	154		770	13	216	263	277
2044 - 2045	0	0	503	227	870	1373	862	172	1034	-339		0	0	0	0	154		616	11	293	-504	-227
2045 - 2046	0	0	540	254	913	1453	871	174	1045	-408		0	0	0	0	154		462	9	242	-571	-798
2046 - 2047	0	0	581	254	0	581	1,004	201	1205	624		0	0	0	0	154		308	6	364	464	-334
2047 - 2048	0	0	624	254	0	624	1,015	203	1218	594		0	0	0	0	154		154	4	336	436	102
2048 - 2049	0	0	671	254	0	671	1,172	234	1406	735		0	0	0	0	154		0	2	479	579	681
	5791	844	7990	4985	1783	16408	12,547	2451	14998	-1.39%	2786				3005	3079	74		622	1401	681	

Table 15.15

MML 12: Kalyan – Taloja Metro Rail Corridor, Mumbai

CAPITAL COST-FIXED		4738																				
CAPITAL COST - CURRENT		5791																				
DOMESTIC FUNDING - BASE CASE																	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
2019 - 2020	225					225			0	-225	236	11	11	0	0	0	0	0				
2020 - 2021	577					577			0	-577	657	80	91	0	0	0	0	0				
2021 - 2022	1116					1116			0	-1116	662	-454	-363	363	363	0	9	372				
2022 - 2023	1438					1438			0	-1438	664	-774	-1137	1137	774	0	11	1157				
2023 - 2024	1408					1408			0	-1408	567	-841	-1978	1978	841	0	22	2020				
2024 - 2025	591	0	48	73		639	35	4	39	-599	0	-591	-2569	2569	591	0	32	2643	0	-81	-8	-8
2025 - 2026	436	0	122	176		558	95	-442	-347	-905	0	-436	-3005	3005	436	0		3079	40	-685	-509	-517
2026 - 2027	0	0	130	176		130	125	-366	-241	-371		0	0	0	0	0		3079	43	-590	-414	-932
2027 - 2028	0	0	139	176		139	141	-271	-130	-269		0	0	0	0	0		3079	43	-489	-313	-1244
2028 - 2029	0	0	149	176		149	182	-99	83	-66		0	0	0	0	0		3079	43	-285	-109	-1353
2029 - 2030	0	0	160	176		160	206	200	406	246		0	0	0	0	154		2925	43	27	49	-1304
2030 - 2031	0	0	171	176		171	262	259	521	350		0	0	0	0	154		2771	41	133	155	-1149
2031 - 2032	0	844	205	201		1049	295	319	614	-435		0	0	0	0	154		2617	39	169	-628	-1777
2032 - 2033	0	0	220	201		220	340	381	721	501		0	0	0	0	154		2463	37	264	311	-1466
2033 - 2034	0	0	235	201		235	344	440	784	549		0	0	0	0	154		2309	34	314	361	-1105
2034 - 2035	0	0	251	201		251	397	503	900	649		0	0	0	0	154		2155	32	415	463	-643
2035 - 2036	0	0	269	201		269	402	793	1195	926		0	0	0	0	154		2001	30	695	742	99
2036 - 2037	0	0	288	201		288	465	837	1302	1014		0	0	0	0	154		1847	28	785	832	931
2037 - 2038	0	0	308	201		308	470	877	1347	1039		0	0	0	0	154		1693	26	812	859	1790
2038 - 2039	0	0	330	201		330	544	926	1470	1140		0	0	0	0	154		1540	24	915	962	2752
2039 - 2040	0	0	354	201		354	550	971	1521	1167		0	0	0	0	154		1386	22	944	992	3744
2040 - 2041	0	0	380	201		380	636	1026	1662	1282		0	0	0	0	154		1232	19	1062	1109	4853
2041 - 2042	0	0	407	201	0	407	644	1073	1717	1310		0	0	0	0	154		1078	17	1092	1139	5992
2042 - 2043	0	0	437	201	0	437	741	1133	1874	1437		0	0	0	0	154		924	15	1221	1268	7260
2043 - 2044	0	0	469	201	0	469	749	1187	1936	1467		0	0	0	0	154		770	13	1253	1300	8561
2044 - 2045	0	0	503	227	870	1373	862	1254	2116	743		0	0	0	0	154		616	11	1375	578	9139
2045 - 2046	0	0	540	254	913	1453	871	1313	2184	731		0	0	0	0	154		462	9	1381	568	9707
2046 - 2047	0	0	581	254	0	581	1,004	1388	2392	1811		0	0	0	0	154		308	6	1551	1651	11358
2047 - 2048	0	0	624	254	0	624	1,015	1454	2469	1845		0	0	0	0	154		154	4	1587	1687	13045
2048 - 2049	0	0	671	254	0	671	1,172	1537	2709	2038		0	0	0	0	154		0	2	1782	1882	14927
	5791	**844**	**7990**	**4985**	**1783**	**16408**	**12,547**	**16697**	**29244**	**6.00%**	**2786**				**3005**	**3079**	**74**		**622**	**15647**	**14927**	

MML 12: Kalyan – Taloja Metro Rail Corridor, Mumbai — **Table 15.16**

CAPITAL COST-FIXED			4738												MB		12%	100.00%	12.00%				
CAPITAL COST - CURRENT			1203														0.00%	100.00%	0.00%				
DOMESTIC FUNDING - BASE CASE																			12.00%				
Year	**Completion Cost**	**Additional Capital**	**Running Expenses**	**Depreciation**	**Replacement Cost**	**Total Cost**	**Fare box Revenue**	**PD & Advertisement**	**Total Revenue**	**Net Cash Flow for IRR**	**Concessioner Equity**	**Availability of cash**	**Cumulative cash**	**Cum. Loan**	**Loan**	**Repayment of Loan**	**IDC**	**Cumulative loan incl. IDC**	**Interest**	**Profit before Tax**	**Cash Balance**	**Cumulative Cash**	**Return on Equity (EIRR) Pre-Tax**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2019 - 2020	55					55			0	-55	28	-27	-27	27	27	0	2	29					-28
2020 - 2021	106					106			0	-106	28	-78	-105	105	78	0	8	115					-28
2021 - 2022	219					219			0	-219	28	-191	-295	295	191	0	24	329					-28
2022 - 2023	286					286			0	-286	28	-258	-553	553	258	0	51	638					-28
2023 - 2024	269					269			0	-269	28	-241	-794	794	241	0	81	960					28
2024 - 2025	170	0	48	41		218	35	4	39	-178		-170	0	0	0	0		960	115	-164	-123	-123	-123
2025 - 2026	98	0	122	41		220	95	-442	-347	-567		-98	-98	98	98	0		1058	121	-631	-590	-713	-590
2026 - 2027	0	0	130	41		130	125	-366	-241	-371		0	-98	98	0	0		1058	127	-539	-498	-1212	-498
2027 - 2028	0	0	139	41		139	141	-271	-130	-269		0	-98	0	0	0		1058	127	-437	-396	-1608	-396
2028 - 2029	0	0	149	41		149	182	-99	83	-66		0	-98	0	0	0		1058	127	-234	-193	-1801	-193
2029 - 2030	0	0	160	41		160	206	200	406	246		0	-98	0	0	35		1023	127	78	84	-1717	84
2030 - 2031	0	0	171	41		171	262	259	521	350		0	-98	0	0	35		987	123	186	192	-1525	192
2031 - 2032	0	844	205	41		1049	295	319	614	-435		0	-98	0	0	35		952	118	249	-589	-2114	-589
2032 - 2033	0	0	220	41		220	340	381	721	501		0	-98	0	0	35		917	114	346	352	-1762	352
2033 - 2034	0	0	235	41		235	344	440	784	549		0	-98	0	0	35		882	110	398	404	-1358	404
2034 - 2035	0	0	251	41		251	397	503	900	649		0	-98	0	0	35		846	106	502	508	-850	508
2035 - 2036	0	0	269	41		269	402	793	1195	926		0	-98	0	0	35		811	102	784	789	-61	789
2036 - 2037	0	0	288	41		288	465	837	1302	1014		0	-98	0	0	35		776	97	876	882	820	882
2037 - 2038	0	0	308	41		308	470	877	1347	1039		0	-98	0	0	35		741	93	905	910	1731	910
2038 - 2039	0	0	330	41		330	544	926	1470	1140		0	-98	0	0	35		705	89	1010	1016	2746	1016
2039 - 2040	0	0	354	41		354	550	971	1521	1167		0	-98	0	0	35		670	85	1041	1047	3794	1047
2040 - 2041	0	0	380	41		380	636	1026	1662	1282		0	-98	0	0	35		635	80	1161	1167	4960	1167
2041 - 2042	0	0	407	41	0	407	644	1073	1717	1310		0	-98	0	0	35		600	76	1193	1199	6159	1199
2042 - 2043	0	0	437	41	0	437	741	1133	1874	1437		0	-98	0	0	35		564	72	1324	1330	7489	1330
2043 - 2044	0	0	469	41	0	469	749	1187	1936	1467		0	-98	0	0	35		529	68	1359	1364	8853	1364
2044 - 2045	0	0	503	67	870	1373	862	1254	2116	743		0	-98	0	0	35		494	63	1482	644	9497	644
2045 - 2046	0	0	540	68	913	1453	871	1313	2184	731		0	-98	0	0	35		458	59	1516	636	10133	636
2046 - 2047	0	0	581	41	0	581	1004	1388	2392	1811		0	-98	0	0	35		423	55	1715	1721	11855	1721
2047 - 2048	0	0	624	41	0	624	1015	1454	2469	1845		0	-98	0	0	35		388	51	1753	1759	13614	1759
2048 - 2049	0	0	671	41	0	671	1172	1537	2709	2038		0	-98	0	0	35		353	47	1951	1956	15570	1956
	1203	**844**	**7990**	**1078**	**1783**	**11820**	**12547**	**16697**	**29244**	**14.20%**	**141**				**892**	**705**	**166**		**2352**	**17824**	**15570**		**16.06%**

CHAPTER – 16

ECONOMIC APPRAISAL

16.0 ALIGNMENT DESCRIPTION AND ISSUES

In the present chapter, the section namely Kalyan to Taloja (length 20.756 km), which is an extended part of the Metro Line 5 is considered for the economic appraisal. Traffic input will be the boarding on the stations within the section and the passenger km travelled within the section. All other parameter values will remain unchanged.

At March-2018 price level estimated cost with all taxes, duties & land cost (Rs/Crore) is derived as Rs. 4738Cr. which is the sum of different cost components such as Civil Construction, Rolling Stock, Electrical Work, Signalling, Electronics and telecommunication equipments, land cost etc. Recurring costs include Power consumption, Staff Cost and Other Maintenances. These are distributed year wise known as cost stream. Details may be seen in the Financial appraisal chapter.

16.1 INTRODUCTION TO ECONOMIC APPRAISAL METHODOLOGY

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

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

In highway construction projects, ‘without’ is taken as “base case” and ‘with’ implies ‘alternative case’. In ‘alternative case’ a portion of traffic on the road is diverted to a new road which is estimated first. Then the difference between maintenance & construction cost for ‘base case’ and for ‘alternative case’ which is known as relative road agency cost (RAC) is derived. Difference between road user cost for ‘base case’ and of ‘alternative case’ is also derived which is known as relative road user cost (RUC). Difference between RAC and RUC calculated for each year generates net benefit stream. Economic indicators (EIRR, BC Ratio, NPV) are the obtained.

In metro projects, same principal is followed but procedure is slightly different. Here, diverted traffic is nothing but the passengers shifted from road based modes to metro. Travel time saving is the difference between time which would be taking on metro and road based transports for same distance. Fuel cost saving is the difference between the cost of the fuel burnt on road based modes by the shifted passengers and the energy cost of running the metro rail which is a part of the maintenance cost. Thus benefits are directly obtained by correlating with them with the passenger km (ridership and average trip length is multiplied to get passenger km). As is done in highway projects, net benefit is obtained by subtracting the cost of the project (incurred for construction (capital) and maintenance (recurring) costs for the metro line) from the benefits derived from pass km savings in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first three items (given in **Table 16.1**) are direct benefits due to shifting of trips to metro, but other secondary benefit components are due to decongestion effect on the road, reduction of emission, accident, saving of fuel and time by remaining road passengers and road maintenance cost.

Cost components are first estimated applying market values then distributed year wise after applying escalation factors. This is commonly known as completion cost. Tax components are added while arriving at completion cost. For financial analysis these exercises are necessary, but for economic analysis all additional cost components from the asset values are to be removed.

Values of Benefit components are mostly economic values except the fuel and vehicle maintenance cost which are estimated from market cost. Economic factors which are used for each component are also given in table 16.1. Overall economic value of benefit components is 100% of the estimated value.

Table 16.1: Cost/Benefit Components due to Metro

	Cost/Benefit Components	Economic Factors
1	Construction Cost	100%
2	Maintenance Cost	100%
3	Annual Time Cost Saved by Metro Passengers	100%
4	Annual Fuel Cost Saved by Metro Passengers	100%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	100%
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	100%
10	Annual Infra Structure Maintenance Cost	100%

16.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in table 16.2.

Table 16.2: Values adopted for some important variables

	Values	Important variables
1	Rs. 1.11/min (2017 value)	Weighted value of Time is taken from per capita income of Maharashtra State(https://mahades.maharashtra.gov.in/files/publication/ESM_17_18_eng.pdf)
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). Taken from Wadala to Kasarvadavali Metro Corridor (Mumbai Line 4).
6	26.43%	Passenger km – Vehicle km conversion factor derived from assumed Occupancy data and Modal Split within study area
7	Graph 16.1	Fuel Consumption of vehicles at a given speed is derived from Road User Cost Study Model (CRRI-2010)
8	Rs. 1.0/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km
9	3.59 min/km	Average Time Saved for average trip length (km) journey after Shifting (Derived from modal split -Table 16.7 and speed and delay survey) and then multiplied by mode wise journey discomfort factor
10	24.54 kmph	Average Journey Speed

Source- DPR of CSTM to Shivaji Chowk Metro Corridor Mumbai Line 4

Table 16.3: Vehicle Operating Cost (VOC) in Rs.(2014)

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	6.16	3.18	1.88	0.12	0.11	2.08	3.65
Capital Cost	4.81	2.14	1.34	0.18	0.20	0.72	3.43
Total VOC	10.96	5.32	3.21	0.31	0.31	2.80	7.08

As there is substantial number of trips by local train (EMU), VOC cost of train is derived from energy (electricity) consumed which is about Rs. 175.5 per train km carrying 3000 passenger and running @33 km per hour. Energy charge is taken as Rs. 8 per KWH.

Table 16.4 Journey Time, VOC and Time Cost

Mode	Initial Fare	Running Fare	VOC /passenger km (Rs.)	Time Cost /passenger km (Rs.)
Bus	10	0.5	0.66	0.826
Train	10	0.1	0.05	1.042
Two Wh.	10	2	1.67	1.291

Mode	Initial Fare	Running Fare	VOC /passenger km (Rs.)	Time Cost /passenger km (Rs.)
Four Wh.	25	12.5	5.69	9.326
Three Wh.	20	10	2.60	9.358
Private Bus & Others	10	0.6	0.70	0.885

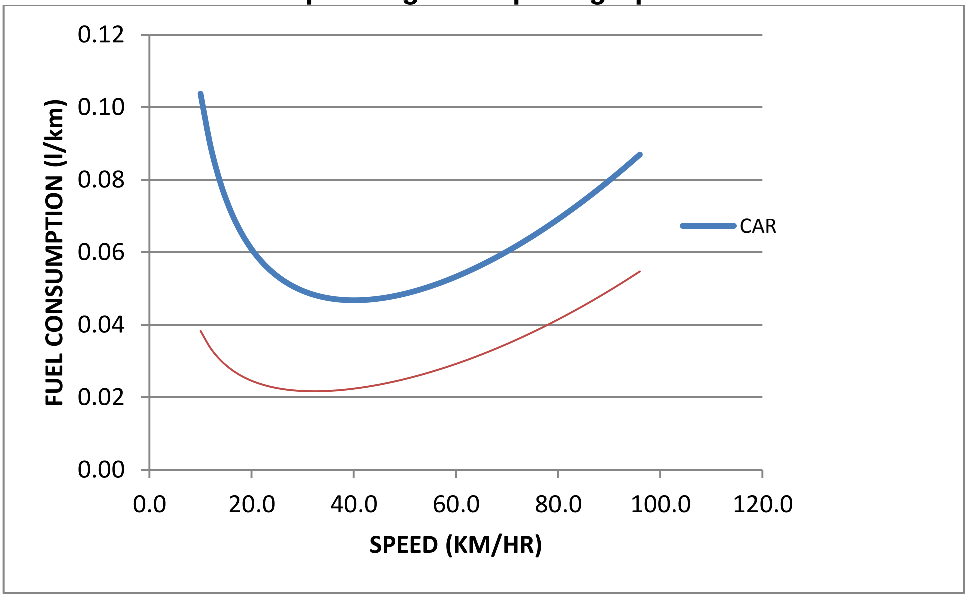
Table 16.5: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

VEHICLE	CO	HC	NOX	PM	CO	CO2
BUS	3.72	0.16	6.53	0.24	3.72	787.72
2W-2 STROKE	1.4	1.32	0.08	0.05	1.4	24.99
2W-4 STROKE	1.4	0.7	0.3	0.05	1.4	28.58
MINI BUS	2.48	0.83	8.26	0.58	2.48	358.98
4W-SMALL	1.39	0.15	0.12	0.02	1.39	139.51
4W-LARGE	0.58	0.05	0.45	0.05	0.58	156.55
TATA MAGIC	1.24	0.17	0.58	0.17	1.24	160
3W	2.45	0.75	0.12	0.08	2.45	77.89
Cost	RS. 100000 PER TON					500

Table 16.6: Accident Rate and Cost in Rs

Expected Accident Rate in the year 2021	/Cr. Vehicle KM	Average Cost in lakh Rs
All Types except Fatal.	1.82	2.30
Fatal Accident.	0.22	10.26

Figure 16.1 Fuel Consumption/against speed graph for Car and two wheeler



Traffic demand estimates used for economic analysis are given in tables 16.7.

Table 16.7: Summary of the Ridership for Mumbai Line 4 Extension (Kalyan to Taloja)

Particulars	2021	2024	2031	2041
Trips/day	110579	143291	262320	294400

Particulars	2021	2024	2031	2041
Section Length	20.756	20.756	20.756	20.756
Average Trip length	11.06	11.06	10.34	10.34
Passenger km	1223004	1584803	2712389	3044096
Passenger km/km	58923	76354	130680	146661

Source: Traffic Study Report

In this area, public transport system is good (passenger - train 27.64%, Bus 49.90%). Personalised mode passenger (car and two wheelers)-trips are 18.09% and IPT modes are carrying 4.37% passengers. Vehicular trips made by Public modes is 12% and 15% by IPT modes and 73% 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%

(Source- DPR of CSTM to Shivaji Chowk Metro Corridor Mumbai Line 4)

16.3 ECONOMIC BENEFIT STREAM

For deriving the values of economic indicators (EIRR, NPV, BCR), cost and benefit stream table is constructed in terms of money value. Socio-Economic Benefits are first quantified and converted in to money cost. Tables 16.9, show components of benefit values (economic).

Table 16.9 Stream of Economic Benefit Values for Kalyan to Taloja

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle O&M 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
2024	2025	328	74	128	5.72	1.03	14	0.63	16	566
2025	2026	375	80	143	6.42	1.15	15	0.71	18	640
2026	2027	429	87	161	7.21	1.28	17	0.79	20	724
2027	2028	491	94	181	8.09	1.42	20	0.88	23	818
2028	2029	562	101	203	9.09	1.58	22	0.98	26	926
2029	2030	644	109	228	10.20	1.76	25	1.74	29	1049
2030	2031	737	118	256	11.46	1.96	29	1.93	32	
2031	2032	863	132	297	13.30	2.25	34	2.21	37	1382
2032	2033	896	132	308	13.80	2.31	36	2.25	39	1430
2033	2034	952	136	327	14.66	2.43	39	2.36	41	1515
2034	2035	1011	139	348	15.57	2.56	43	2.46	44	1605
2035	2036	1074	142	369	16.54	2.69	46	2.57	46	1700
2036	2037	1141	146	392	17.57	2.83	50	2.68	49	1801
2037	2038	1212	150	417	18.66	2.98	54	2.79	52	1909
2038	2039	1287	153	442	19.82	3.13	59	2.90	56	2023
2039	2040	1417	161	483	21.63	3.39	65	3.25	61	2215
2040	2041	1560	170	527	23.61	3.66	72	3.65	66	2426
2041	2042	1717	179	575	25.76	3.96	80	4.09	72	2657
2042	2043	1890	188	628	28.12	4.28	89	4.59	79	2911
2043	2044	2081	198	685	30.69	4.63	99	5.14	86	3189
2044	2045	2291	208	748	33.50	5.00	110	5.76	94	3495
2045	2046	2522	219	816	36.56	5.41	122	6.46	103	3830
2046	2047	2777	230	891	39.90	5.84	135	7.24	112	4197
2047	2048	3057	242	972	43.55	6.32	150	8.12	122	4601
2048	2049	3365	254	1061	47.53	6.83	166	9.10	133	5044

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 2019-20 to 2048-49 out of which 5 years (2019-2024) are marked as construction period. In 2044-46 major repairing and replacement cost is envisaged. Operation is expected to start in 2024-25 (5th Year).

Cost stream generated are shown in **Table 16.10.**

Table 16.10: Completion Cost stream

		Completion Cost	
Year	Year	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs
2019	2020	225	0
2020	2021	577	0
2021	2022	1116	0
2022	2023	1438	0
2023	2024	1408	0
2024	2025	591	48
2025	2026	436	122
2026	2027	0	130
2027	2028	0	139
2028	2029	0	149
2029	2030	0	160
2030	2031	0	171
2031	2032	844	205
2032	2033	0	220
2033	2034	0	235
2034	2035	0	251
2035	2036	0	269
2036	2037	0	288
2037	2038	0	308
2038	2039	0	330
2039	2040	0	354
2040	2041	0	380
2041	2042	0	407
2042	2043	0	437
2043	2044	0	469
2044	2045	870	503
2045	2046	913	540
2046	2047	0	581
2047	2048	0	624
2048	2049	0	671

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 2019-2048.

On the basis of **completion** cost, EIRR is **14.51%,** B/C Ratio is 3.3 and NPV is 37434 Cr, which shows that the project is economically viable. With 12 % discount, EIRR (completion cost) is **2.24%** and B/C ratio is 1.2. NPV is Rs 1264 Cr.

Table 16.11: Economic Indicator Values

Kalyan-Taloja	(Completion Cost Basis)	
	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Cumulative cost (Cr.)	16408	5445
Cumulative benefit(Cr.)	53842	6708
Benefit Cost Ratio	3.3	1.2
NPV(Cr.)	37434	1264
EIRR	14.51%	2.24%

16.6 SENSITIVITY ANALYSIS FOR KALYAN TO TALOJA

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** (Completion Cost basis). 2048-49 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%	14.51%	3.28	16408	2.24%	1.23	5444.67
-10%	0%	13.72%	3.07	16408	1.54%	1.15	5444.67
-20%	0%	12.89%	2.86	16408	0.79%	1.08	5444.67
0%	10%	13.35%	2.98	18048	1.20%	1.12	5989.13
0%	20%	12.31%	2.73	19689	0.28%	1.03	6533.60
-10%	10%	12.58%	2.79	18048	0.51%	1.05	5989.13
-20%	20%	10.74%	2.38	19689	-1.12%	0.90	6533.60

Sensitivity analysis in **table 16.12** shows that economic indicator values namely EIRR is just within the limit of acceptance as also the B/C ratios.

16.7 QUANTIFIED BENEFITS

Benefits which are shown in previous tables are money value of the benefits. These benefits are first quantified and then converted into money value. For brevity, only 5 year estimates (2022-2026) are shown in **table 16.13** (Reduction of Vehicle gas Emission). It is seen that reduction of CO_2 will be 246117 tons in 2024 and particulate matters (PM) is reduced by 13.9 tons in 2024.

Table 16.13 Environmental Benefits Quantified

Tons/Year	2024	2025	2026	2027	2028
CO	223	239	255	273	292
HC	47	50	54	58	62
NOX	136	146	156	167	178
PM	13.9	14.9	15.9	17.0	18.2
SO2	0.77	0.82	0.88	0.94	1.01
CO2	24617	26326	28155	30110	32202
Total Emission Saved	**25038**	**26777**	**28637**	**30626**	**32753**

From **Table 16.14**, it may be seen that in 2024, due to shifting, metro passengers time saving will be 3.50 Cr. (10 million) hour, fuel saving by metro passengers will be 11.54 thousand tons. Amount of travel in terms of vehicle km reduced due to shifting to Metro Rail is 4.40 thousand KM which is equivalent to reduction of 8054 vehicles from the road. About 4 fatal accidents and 26 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	2024	2025	2026	2027	2028
Annual Time Saved by Metro Passengers in Cr. Hr.	3.50	3.81	4.15	4.53	4.94
Annual Fuel Saved by Metro Passengers in thousand Tons.	11.54	12.47	13.48	14.58	15.78
Daily vehicles reduced (off the road)	8054	8614	9212	9852	10536
CO2 reduced in thousand tons	24.62	26.33	28.15	30.11	32.20
Other gases reduced in thousand tons	0.421	0.450	0.482	0.515	0.551
Reduced No of Fatal Accidents in Year	3.53	3.74	3.96	4.20	4.45
Reduced No of Other Accidents in year	25.68	27.21	28.82	30.52	32.33
Annual Vehicle km Reduced in Thousand Km.	4.40	4.70	5.03	5.38	5.75

CHAPTER – 17

IMPLEMENTATION

17.1 INTRODUCTION

Mumbai Metro Line-12 from Kalyan to Taloja is South-West extension of Line-5. Length of this corridor is 20.756km, having 17 stations. The entire Line-12 is elevated.

Estimated Cost of the project at March 2018 price level is Rs. 4738 crores inclusive of all taxes & duties and land cost. Completion cost with all taxes & duties and land cost and escalation at 5% p.a. works out to Rs. 5791 Crores (excluding IDC) and Rs. 5865 Crore (including IDC).

MOUD vide letter no. F.No. K-14011/03/2017-UT-V-Part(1) dated 6th July 2017 has proposed for sharing of overall Goods and Service Tax (GST) in the ratio of 1:2.

17.2 POSSIBLE MODELS FOR FINANCING A METRO PROJECT

1. A Design, Built, Fund, Operate & Transfer (DBFOT)
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. DBFOT model:

Under 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 Equity internal rate of return (EIRR) in the range of 16% to 18% or a comfort of guaranteed ridership.

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 DBFOT 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 DBFOT 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 LINE-12 FROM KALYAN TO TALOJA

World over Metro projects cannot be financially viable and depend upon generous concessions and subsidies. The financial internal rate of return for this corridor with all taxes and without additional PD income and with additional PD income works out to **(-) 1.39% and 6.00% respectively.**

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

Out of the 3 PPP models in the country, Delhi Airport Line has been a total failure since the Concessionaire has voluntarily withdrawn with claims through arbitration. In the case of Bombay Metro Line No.1 which is only 11 km length had taken more than 6 years for completion and the cost had gone up 2 times. Concessionaire is representing to government for allowing him to charge very high fare in spite of very good ridership leading to loading the public financially.

In the case of the Hyderabad Metro the PPP Concessionaire withdrew from the project and another Concessionaire namely L&T is implementing the project. The financial performance of this project is yet to be assessed. Considering the global scenario and the experience in our own country DMRC does not recommend either the BOT model or PPP route for implementing this Line (Line-12).

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 Metropolitan Region Development Authority (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 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 MMRDA will need a fairly big organisation to oversee the G.C. work. It will be difficult for MMRDA to mobilize required technical persons with experience and knowledge and the establishment cost of 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 MMRDA for this project can be a very small lean and efficient organization responsible for land acquisition and mobilization of funds. The entire Metro project can be entrusted on turnkey basis and on deposit terms to an experienced organization such as DMRC who has the experience and track record and competency of technical manpower. DMRC is implementing on similar basis Jaipur Metro for Rajasthan Government and Kochi Metro for Kerala Government and Greater Noida Metro project for the Greater Noida Authority. Similarly Dahisar (E) to D.N. Nagar Corridor (Line-2A) and Swami Samarth Nagar to Vikhroli (EEH) Corridor (Line-6) has been handed over to DMRC on a turnkey basis for implementation. Similarly, this Line may be handed over to DMRC for implementation. DMRC generally charges 6% of the project cost for the total turnkey implementation. This will be the cheapest and quickest way of completing the project in time.

17.6 CONTRACT PACKAGES FOR IMPLEMENTATION OF THE PROJECT

The project may be implemented in nine packages as under.

Package –1: Starting from chainage -110.313 m and upto Sonarpada proposed Metro Station (including).

Package - 2: Starting Sonarpada station (excluding) upto Bale station (including).

Package – 3: Starting Bale station (excluding) upto Taloja Dead end.

Package - 4: Detailed design consultant for corridor including Depot.

Package - 5: Construction of boundary wall for depot, earth work, filling and construction of workshop, inspection bay, stabling lines etc.

Package – 6: System Contracts: Supply and installation of traction power system (3rd bay) including sub-station.

Package – 7: Supply and installation of signaling system (CBTC)

Package - 8: Supply and installation of AFC System.

Package - 9: Supply and commissioning of rolling stock.

Any other small package may be decided at the time of implementation of the Project.

17.7 IMPLEMENTATION SCHEDULE

A suggested project implementation schedule for Project Implementation is given in Table 17.1

Table 17.1 Project Implementation Schedule

Sl. No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D+0.5 month
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D+1 month
4.	Sanction of Project by GOI	D+2 months
5.	Selection of GC	D+12 months
6.	Tendering	D+24 months
7.	Implementation of the project	D+57 months
8.	Testing and Commissioning	D+59 months
9.	CMRS Sanction	D+60 months
10.	ROD	D+60 months

17.8 HIGH POWER COMMITTEE

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Maharashtra should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project. This Committee should meet once a month and sort out all problems brought before it by MMRDA. It is reliably learnt that for the Delhi Metro also such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro Rail Project.

17.9 CONCESSION FROM GOVERNMENT

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return. With reasonable fare level, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level. Following are the taxes and duties, which have to be borne by a metro project:

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- GST on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- GST on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- GST on works contracts to be executed for the implementation of the project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

As in the case of Delhi Metro, the State Government should exempt/reimburse the State Goods and Services Tax (SGST) to this Metro project. It should also exempt the following:

MOUD vide letter no. F.No. K-14011/03/2017-UT-V-Part(1) dated 6th July 2017 has proposed for sharing of overall Goods and Service Tax (GST) in the ratio of 1:2. Maharashtra State Government may pursue the Central government to extend the same benefit to MMRDA.

In the case of Delhi Metro project, the Union Government has granted exemption from payment of Custom Duty and Excise Duty while the Delhi Government has agreed to give exemption from payment of Sales Tax and on works contracts. Delhi Metro Rail Corporation is also pursuing with the Government for exemption from tax on electricity being consumed by Delhi Metro for its operation and maintenance.

It is recommended that similar exemptions from taxes and duties be granted by the Central Government/Maharashtra Government for Mumbai Metro. In this connection it may be mentioned that the Central Government has been encouraging infrastructure projects in the country through fiscal and non-fiscal concessions. Cities have emerged as the engines of growth and mass transport systems today are one of the most important pre-requisites for the balanced growth of the city. The

Government can demonstrate the importance it attaches to this sector by granting the above concessions which would not only help reduce the initial cost of the project so that Mumbai Metro remains commercially viable during its operation phase but also send strong signals to the effect that it is committed to a safer and pollution free city. Moreover, public transport is employment-friendly and favours social balance in a sustainable way since it allows access to jobs and services to all.

17.10 LEGAL COVER FOR MUMBAI METRO

Implementation of proposed Metro Corridor may be done under “The Metro Railways (Amendment) Act 2009”. The copies of the Gazette notification and the amendment are put up enclosure to this chapter.

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रजिस्ट्री सं॰ डी॰ एल॰-33004/99

REGD. NO. D. L.-33004/99

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The Gazette of India

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PART II—Section 3—Sub-section (ii)

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शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे ।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

बिमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No. K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।

Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/Bhadra 5, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[26*th August*, 2009.]

An Act further to amend the Metro Railways (Construction of Works) Act, 1978 and to amend the Delhi Metro Railway (Operation and Maintenance) Act, 2002.

BE it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009. Short title and commencement

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (3), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area"

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

2 of 1985. '(*ka*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (*2*), after clause (*b*), the following clauses shall be inserted, namely:— Amendment of section 6.

"(*ba*) develop any metro railway land for commercial use;

(*bb*) provide for carriage of passengers by integrated transport services or any other mode of transport;".

9. Section 7 of the Delhi Metro Railway Act shall be renumbered as sub-section (*1*) thereof and after sub-section (*1*) as so renumbered, the following sub-section shall be inserted, namely:— Amendment of section 7.

24 of 1989. "(*2*) The Commissioner shall function under the administrative control of the Chief Commissioner of Railway Safety appointed under section 5 of the Railways Act, 1989.".

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:— Substitution of new section for section 12.

"12. The Chief Commissioner of Railway Safety shall, for each financial year, prepare in such form, and within such time, as may be prescribed, an annual report giving a full account of the activities of the Commissioners during the financial year immediately preceding the financial year in which such report is prepared and forward copies thereof to the Central Government.". Annual report.

11. In section 13 of the Delhi Metro Railway Act, for the word "Commissioner", the words "Chief Commissioner of Railway Safety" shall be substituted. Amendment of section 13.

12. In section 23 of the Delhi Metro Railway Act, in sub-section (*1*), for the words "Hindi and English", the words "Hindi, English and official language of the State in which such station is located" shall be substituted. Amendment of section 23.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted. Amendment of section 26.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:— Amendment of section 34.

"(4) The Central Government and the State Government shall nominate one member each to the Fare Fixation Committee:

Provided that a person who is or has been an Additional Secretary to the Government of India or holds or has held an equivalent post in the Central Government or the State Government shall be qualified to be nominated as a member.".

Amendment of section 38.

15. In section 38 of the Delhi Metro Railway Act, in sub-section (2), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted.

Amendment of section 85.

16. In section 85 of the Delhi Metro Railway Act,—

(i) in sub-section (1), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted;

(ii) in sub-section (2), for the words "Government of the National Capital Territory of Delhi in the Delhi Gazette", the words "State Government" shall be substituted.

T.K. VISWANATHAN,
Secretary to the Govt. of India.

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CHAPTER – 18

CONCLUSIONS AND RECOMMENDATIONS

18.1 MMRDA has carried out Comprehensive Transportation Study (CTS) of Mumbai Metropolitan Region (MMR) in 2005-2008. As per the recommendations in the Comprehensive Transportation Study of MMR and considering the need of better public transport to cater the rapid growth of urbanization in Kalyan–Dombivli, Taloja/Navi Mumbai due to upcoming international airport being implemented by CIDCO, MMRDA has proposed to extend the Metro Line-5 (Thane – Bhiwandi – Kalyan) up to Taloja (Navi Mumbai Metro) which further connects to Navi Mumbai International Airport (NMIA).

Area along this corridor is not much habitated. Most of the length of the corridor is passing through agriculture and barren land. MRTS corridors are generally planned along the highly populated areas to fulfill the transportation need of the masses living in that area. However, as brought out in the meetings by MMRDA, they intend to develop the area along this corridor at a very fast rate to provide houses for all. They have also planned developmental sites namely Kalyan Growth Centre and NAINA along this corridor. 40 Ha of land has also been identified for Property Development. Purpose of this corridor is to decongest the Mumbai city and accelerate the development activities in the area covered by this corridor. Hence, this corridor is only a development corridor and will need special efforts if Government decides to implement it.

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

Estimated Cost of the project at March 2018 price level is 4738 Crore with land and all the taxes, duties. Completion cost with 5% p.a. escalation is estimated to be Rs.5791 Crores including land and all the taxes, duties, but excluding IDC. IDC will be additional Rs. 74 Crores.

18.2 The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc., with a few negative impacts (especially during implementation phase of the project) for which Environmental Management Plan has been suggested.

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

18.4 The fare structure has been prepared based on prevailing fare structure in different PT/IPT modes as indicated in the Finance Chapter. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 14%.

18.5 As in the case of Delhi Metro, the State Government should exempt/reimburse the State Goods and Services Tax (SGST) to MMRDA. It should also exempt the following:

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

18.6 MOUD vide letter no. F.No. K-14011/03/2017-UT-V-Part(1) dated 6th July 2017 has proposed for sharing of overall Goods and Service Tax (GST) in the ratio of 1:2 (GOI : State Government). Maharashtra State Government may pursue the Central Government to extend the same benefit to MMRDA.

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

The Financial Internal Rate of Return (FIRR) for the project has been assessed as **6.00% (With additional PD income from 40 Ha land)**. The Economic Internal Rate of Return (EIRR) works out to **14.51%.**

18.8 Meanwhile the State Government should notify this alignment and freeze all future developments along the proposed route to avoid infructuous expenditure.

18.9 It is recommended that 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 one time green cess on existing vehicles.
- Property development on Government land.

Appendix

MMRDA's Comments/Remarks & DMRC's Responses on Draft DPR of Mumbai Metro Line 12

Sr. No	Particulars-As per DPR	Remarks	DMRC's Response
1.	**Executive Summary :**		
a	**0.4.1.3 Design Speed** The maximum **sectional speed** will be 80 Kmph	The maximum **operating speed** will be 80 Kmph	Changed.
b	**0.4.2 Alignment :**	Name of stations should be incorporated as sent earlier.	Incorporated.
c	**Table 0.11 Station Accommodation Requirements** **Tunnel Ventilation Room,** **Tunnel Ventilation Shaft, Chiller Room, Space for Cooling Towers**	As Metro Line 12 contains all elevated stations, tunnel ventilation system is not needed.	Removed.
d	**0.8.7 Electric Power Tariff** The cost of electricity is a significant part of Operation and Maintenance Charge –s of the Metro System, which constitutes about 30-38 % of total annual Working cost.	The cost of electricity is a significant part of Operation and Maintenance Charge –s of the Metro System, which constitutes about 30-38 % of total annual **operating** cost.	Changed.
e	**0.14 Cost Estimate** **Summary of Cost Estimate**	Table 0.18 Capital Cost Estimate should be replaced by Table 14.2 Capital Cost Estimate (Chapter No. 14)	Replaced.
f	Index Plan MML- 12 Kalyan to Taloja	Name of stations should be incorporated as sent earlier	Incorporated.
2.	**Chapter 4 Civil Engineering**	Name of stations should be incorporated as sent earlier wherever required.	Incorporated.
3.	**Chapter 9 Environment & Social Impact Assessment**	Name of stations should be incorporated as sent earlier wherever required.	Incorporated.
4.	**Chapter 14 Cost Estimate** Rolling Stock Adopted rates are based rates of similar works of Mumbai Metro Line -3 duly adopted to March 2018 price level.	The kindly express rate was adopted based on Mumbai Metro Line -3	Changed.

Sr. No	Particulars-As per DPR	Remarks	DMRC's Response
5.	**Chapter 15** **15.3.3 Non Fare Box Revenue** Non Fare Box Revenue from Property Development SPV/BOT operator will engage a developer for generating rental income. It is assumed that about 40 ha. i.e. 1,20,00,000 square feet area will be available for property development with a FAR of 3	SPV/BOT operator will engage a developer for generating rental income. It is assumed that about 40 ha. i.e. 1,20,00,000 square feet area will be available for property development with an FSI of 3	Changed.
6.	**3.2.2 Merits and Demerits of various traction systems (Page- No 77)** **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.	**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~~ **5% as compared to 21 %** in 750V DC 3rd rail traction system.	Line loses in case of 3rd rail 750V dc system is in the range of 16% to 21%. Hence the figure of 12% less losses in 25kV AC system as compared to 750 V dc system is taken.
7.	**3.2.2 Merits and Demerits of various traction systems (Page- No 77)** **Easy of capacity enhancement –** Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation.	**Easy of capacity enhancement –** Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation. **However after a certain limit , OHE Equipments may also need upgradation.**	The RSS capacity can be enhanced up to the limit of OHE Capacity. Therefore no need to change in DPR. Final capacity may be decided at the time of detailed design stage.
8.	**3.2.2 Merits and Demerits of various traction systems (Page- No 78)** Traction equipments in 25 kV AC system are standardized & mostly indigenously available. In DC traction system it is mostly imported.	Traction equipments in 25 kV AC system are standardized & mostly indigenously available. In DC traction system it is mostly imported **and Steel structures are mostly non- standard.**	This is not a detailed design document.

Sr. No	Particulars-As per DPR	Remarks	DMRC's Response
9.	**3.2.2 Merits and Demerits of various traction systems (Page- No 79)** Substation spacing: The inter-spacing between sub-station is almost double in of 2x25 kV system as compared to conventional system. Therefore the number of substation almost reduces to half in the 2x25 kV AT system (with proper planning) as compared to the conventional system. This brings in substantial saving of costly space of around 2000 sq. m. in Mumbai metro area, besides saving due to use of lesser high voltage cable.	Substation spacing: The inter-spacing between sub-station is almost double in of 2x25 kV system as compared to conventional system. Therefore the number of substation almost reduces to half in the 2x25 kV AT system (with proper planning) as compared to the conventional system. This brings in substantial saving of costly space of around 2000 sq. m. in Mumbai metro area, besides saving due to use of lesser high voltage cable. **But there will be need to provide AT Station between Substations, which will also require land thus increasing cost.**	No comment.
10.	**3.5 Automatic fare Collection System (Page – No 98)** **3.5.1-** The proposed AFC system shall be of **<u>Contactless Smart Token</u>** / Card type. For multiple journeys, the stored value smart card shall be utilized and for the single journey, the smart media shall be as utilized as contactless smart token. 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.	In DPR as per Item 3.5.1, Automatic Fair Collection (AFC) System contact less smart token is mentioned, however QR coded tickets are proposed for single journey.	**The Paragraph may be read as:** **3.5 Automatic fare Collection System (Page – No 98)** **3.5.1**- The proposed AFC system shall be of Contactless Smart Token / Card type. For multiple journeys, the stored value smart card shall be utilized and for the single journey, the smart media shall be as utilized as contactless smart token **and QR Code / bar code / NFC based ticketing**. The equipment 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

Sr. No	Particulars-As per DPR	Remarks	DMRC's Response
			Contactless system proves cheaper due to reduced maintenance, less wear and tear and less prone to dusty environment.
11.	**3.5.2 Gate (Page No -99).** Retractable Flap Type/**Paddle Type Control Gates** are proposed which offer high throughput, require less maintenance and are latest in modern systems internationally. All these gates will have a functionality of Auto Top on smart cards in case balance goes below the threshold value (as per choice / business rule).	In Item 3.5.2, Paddle Type Control Gates are mentioned in DPR, It is not proposed for AFC System.	**The Paragraph may be read as:** **3.5.2 Gate (Page No. - 99).** Retractable Flap Type Control Gate is proposed which offer high throughput, require less maintenance and are latest in modern systems internationally. All these gates will have a functionality of Auto Top on smart cards in case balance goes below the threshold value (as per choice / business rule). The type of control gate may be finalised at detailed design stage
12.	**3.6.5 Performance Parameters (Page- 111)** The recommended performance parameters based MoHUA guideline on Standardization of Rolling Stock and Signaling Systems for Metro Rail, dated April 21, 2017: Maximum Design Speed: ~~90~~ kmph Maximum Operating Speed: ~~80~~ kmph	The recommended performance parameters based MoHUA guideline on Standardization of Rolling Stock and Signaling Systems for Metro Rail (Revised) Maximum Design Speed: ~~90~~ 95 kmph Maximum Operating Speed: ~~80~~ 85 kmph	The mentioned performance parameters are in line with MoHUA guidelines on Standardization of Rolling Stock and Signaling Systems for Metro Rail dated April 21, 2017 and there are no revised guidelines. Thus performance parameters may be retained as communicated earlier i.e. Maximum Design Speed - 90 kmph Maximum Operating Speed - 80 kmph
13.	**8.4 b- 750-850 V DC third rail traction system:-Demerits (Page 248)-** **Low levels of regeneration-** The regeneration is 18%, because 60% of regenerated energy in a 750 V dc system is possible to be retrieved.	**Low levels of regeneration-** The regeneration is 18%, because 60% of regenerated energy in a 750 V dc system is **not** possible to be retrieved.	Only 60% of re-generated energy in dc traction is possible to retrieve. Therefore chapter statement is already correct.
14.	**8.6 Auxiliary supply arrangements for elevated stations (Page 250)-**	Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform	315 kVA transformer capacity is sufficient for elevated/at grade station. 500 kVA transformer capacity may be considered

Sr. No	Particulars-As per DPR	Remarks	DMRC's Response
	Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 300 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415 kV) of 315 kVA capacity are proposed to be installed at the elevated/ at grade stations (one transformer as standby).	level inside a room. The auxiliary load requirements have been assessed **at ~~300~~ 250 kW** for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415 kV) of **~~315~~ 500 kVA** capacity are proposed to be installed at the elevated/ at grade stations (one transformer as standby).	for interchange station. Final capacity of transformer may be decided at the time of detailed design stage.
15.	**8.8 25 KV Ac Flexible Overhead Equipment (OHE) System (Page – 251)** 25 kV AC flexible OHE system shall comprise 150 sq.mm silver copper contact wire and 65 sq.mm Magnesium Copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be Aluminium Conductor Steel Reinforced (ACSR) of 93.3 sq.mm cross section.	25 kV AC flexible OHE system shall comprise 150 sq.mm silver copper contact wire **and ~~65~~ 120 sq.mm** Magnesium Copper catenary wires. Because of the advancements in telecom technology, booster transformer has not been in the scope & Return conductor (RC) shall be Aluminium Conductor Steel Reinforced (ACSR) of 93.3 sq.mm cross section.	In this section headway vary between 6.0 minutes to 6.25 minutes. 65 Sq. mm Magnesium Copper Catenary wire is sufficient. Final sizing of Catenary may be decided at the time of detailed design stage as per the simulation study.
16.	**15.5.1.1 SPV (DMRC/CMRL/BMRC) Model (Page No- 357)** 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 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 Metro Line 3-while all the other Metro rail corridors will be implemented by MMRDA.**	Corrected
17.	**Title No. 8.1:** In First paragraph of parameter one line is missing.	Missing Comment on '(ii) Regeneration by rolling stock – 30%'	As per MoUD guideline specific energy consumption 50kWhr/ 1000GTKM is considered. Re-generation already

Sr. No	Particulars-As per DPR	Remarks	DMRC's Response
			considered in SEC specified by MoUD.
18.	**Title No. 8.3:** The high voltage power supply network of Mumbai city was studied in brief.	This section is not a part of Mumbai City; this area comes in Thane District. Please change accordingly,	Changed from Mumbai City to Mumbai Metropolitan Region
19.	**Title No. 8.10:** one information Missing.	BMS system to be added in LIST.	In elevated station, BMS system is hardly used and not required.
20.	**Title No. 8.11:** It is, therefore, proposed to provide a standby DG set of 160 kVA	In other DPR 180kVA is mentioned.	Final capacity may be decided at the time of detailed design study.
21.	**Title No. 8.11:** UPS Supply is to also be considered for following emergency services: • Emergency Lighting • Fire Detection & Fire Alarm system. • Station Control Room • Control Supply.	Missing Items: (i) Signaling & telecommunications (ii) Lift operation (iii) Fare collection system Items Newly Added Station Control Room, Control Supply	Included.