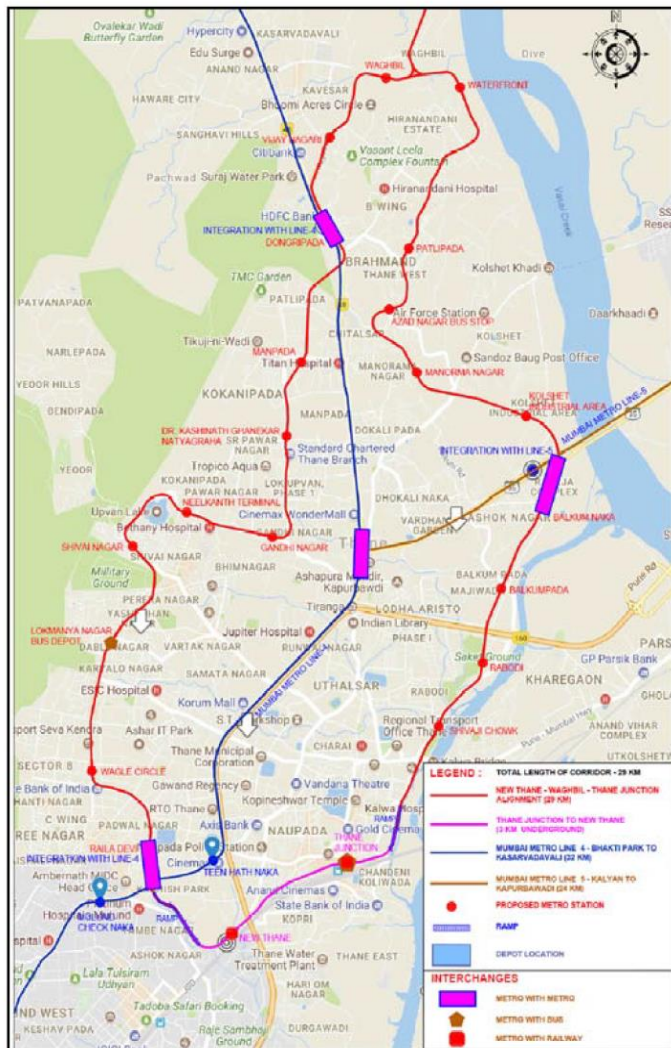




MAHARASHTRA METRO RAIL CORPORATION LIMITED

ALTERNATIVES ANALYSIS & DETAILED PROJECT REPORT FOR THANE METRO RAIL



FINAL DPR

SEPTEMBER 2023

IRITES
THE INFRASTRUCTURE PEOPLE
(A Government of India Enterprise)

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SALIENT FEATURES

SALIENT FEATURES

1. GAUGE(STANDARD) : 1435mm

2. CORRIDOR AND ROUTE LENGTH

Corridors	Elevated (Km)	Underground (Km)	Total Length (Km)
New Thane to New Thane (Ring Corridor)	26	3	29

3. TRAFFIC FORECAST

Year	Maximum PHPDT	Daily Ridership (in Lakh)
2029	23,320	6.47
2035	29,489	7.61
2045	31,393	8.72

4. NUMBER OF STATIONS

Corridors	Elevated Stations	Underground Stations	Total
New Thane to New Thane (Ring Corridor)	20	2	22

5. STATION PLANNING

Two typical designs have been suggested for various station types and these will form basis for planning of all the stations.

Sr. No.	Proposed Type	Elevated or U/G	Station Size
1	Type 1	Elevated	140.00m x 21.95m
2	Type 2	Underground	190.00m x 23.55m

6. INTERMODAL INTEGRATION

Feeder Bus Services, Public Bicycle Sharing, Parking and Pedestrian facilities (footpath, Zebra crossing, table top etc) have been proposed.

7. TRAIN OPERATION PLAN

Corridor	Items	2029	2035	2045	2051
New Thane to New Thane(Ring Corridor)via Dongripada & Thane Junction	Cars/ Train	3,6	3,6	3,6	6
	Headway in Sec.	225.0	225.0	200.0	200.0
	Trains/hr	17(12,5)	16 (5,11)	18(3,15)	18
	Capacity (6p/m ²)	17038	21134	25902	28332
	Capacity (8p/m ²)	21686	26887	32949	36036
	Design PHPDT	16800	21000	26000	28000

8. SPEED

- a) Design Speed : 80 kmph
- b) Scheduled Speed : 34 kmph

9. SIGNALLING & TELECOMMUNICATION

- Type of Signaling: Communication based Train Control System (CBTC) with continuous automatic train control permitting an operational headway of 90 seconds.
- Telecommunication: Integrated System with Optical Fibre Transmission System, SCADA, CCTV, Central Voice Recording System (CVRS) etc.

10. FARE COLLECTION

Automatic Fare Collection System with recharging of Travel Cards using Cash, Debit/ Credit Cards and Net-banking/web portal etc.

11. ROLLING STOCK

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC Every coach is fully interchangeable with any other coach of same type.
2	Train Composition	3 Car: DMC+TC+DMC, 6 Car: DMC–TC-MC-MC-TC-DMC
3	Coach construction	Light weight stainless steel/ Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	25 kV AC OHE System

12. TRACTION POWER SUPPLY

- Voltage: 25KV OHE
- Power Demand (MVA)

Load	Year			
	2029	2035	2045	2051
Traction	14.95	18.32	22.50	24.66
Auxiliary	11.08	11.08	12.10	13.13
Total	26.03	29.40	34.60	37.78

- Sub Stations

Grid sub-station	RSS of Metro Authority Proposed	Approx. Dist. GSS to RSS
400kV MSETCL Substation, Kalwa	Shivaji Chowk RSS (220/33 kV)	5 km
MSED 220kV sub-station, Thane	Gandhi Nagar RSS (220/33 kV)	6 km

13. DEPOTS

Maintenance facilities at Kasarvadavali Depot: 18 Ha.

14. ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

Both negative and positive environment impacts associated with the proposed metro corridor during various phases of project cycle have been identified. Cost of environmental management plans have been estimated at Rs. 15.27 crore.

Social Impact Assessment has been carried out on the basis of sample socio-economic survey. The cost for implementation of Resettlement and Rehabilitation Plan is included in the Land cost.

15. DISASTER MANAGEMENT& SECURITY MEASURES

An effective system will be planned under the provision of 'Disaster Management Act, 2005' for the metro system.

Various security measures like CCTV cameras, baggage scanners, metal detectors, bomb detection equipment, wireless sets, snuffer dogs and related facilities will be part of station security system.

16. TRANSIT ORIENTED DEVELOPMENT

The broad estimation of revenue from TOD and other non fare box sources is-

Year	Revenue (Rs. In Crores)						
	TOD (VCF)			OTHER SOURCES			Total
	Premium on Additional FSI	1% Additional Surcharge on Property Transactions	Development Charge	Advt.	Leasing of Commercial Space in Stations	Semi-naming Rights of Stations	
2029	89.3	151	187	74.1	24.7	34.0	560
2035	78.1	170	210	188.3	70.6	72	784
2045	90.1	207	256	427.5	160.3	117	1257

17. CAPITAL COST (JULY 2023 PRICE) LEVEL

S.No	Cost Component	Total (Rs Crore)
1	Construction Cost without land & R&R, taxes	6033
2	Land Cost including R&R Costs	3170
3	Construction Cost including land & R&R	9203
4	Total Cost with Land & R&R & Taxes	10369
5	Total Cost with land and Central Taxes only	9827

18. PROJECT COMPLETION COST

With escalation factor of 5% p.a. the completion cost under different scenarios are:-

Completion Cost	Amount (Rs Crore)
Cost without taxes & Land & R&R	6846
Cost With Central Taxes and without Land & R&R	7554
Cost with all taxes and Land & R&R	11584

19. RECOMMENDED FUNDING PATTERN

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1151.13	15.30%
Equity by Govt. of Maharashtra	1151.13	15.30%
SD for CT by Govt. of Maharashtra	354.11	4.70%
SD for CT by GoI	354.11	4.70%
Soft Loan from bilateral/multilateral funding agencies	4515.72	60.00%
Total Cost excluding Land, R&R and PPP	7526.20	100.00%
Contribution by Local Bodies as Grant	200.00	
SD for land and R&R by Govt. of Maharashtra	3414.20	
State Taxes towards Completion Cost	615.64	-
IDC by GoM	312.71	
Total Cost including Land, R&R, State Taxes and IDC	12068.76	-
PPP Component	131.34	
Total Completion Cost	12200.10	

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

* On behalf of Govt of Maharashtra - TMC may bear the cost

20. FINANCIAL ANALYSIS

FIRR with project cost including all taxes, estimated fare and non-fare box revenues is estimated at 15.06%.

21. ECONOMIC ANALYSIS

EIRR in economic terms is 23.80% for the proposed Thane Metro Ring corridor.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

0.1 PROFILE OF THE CITY

Thane is the third most industrialized district in Maharashtra. A part of Mumbai Metropolitan Region, Thane has become almost a part of Mumbai due to its proximity.

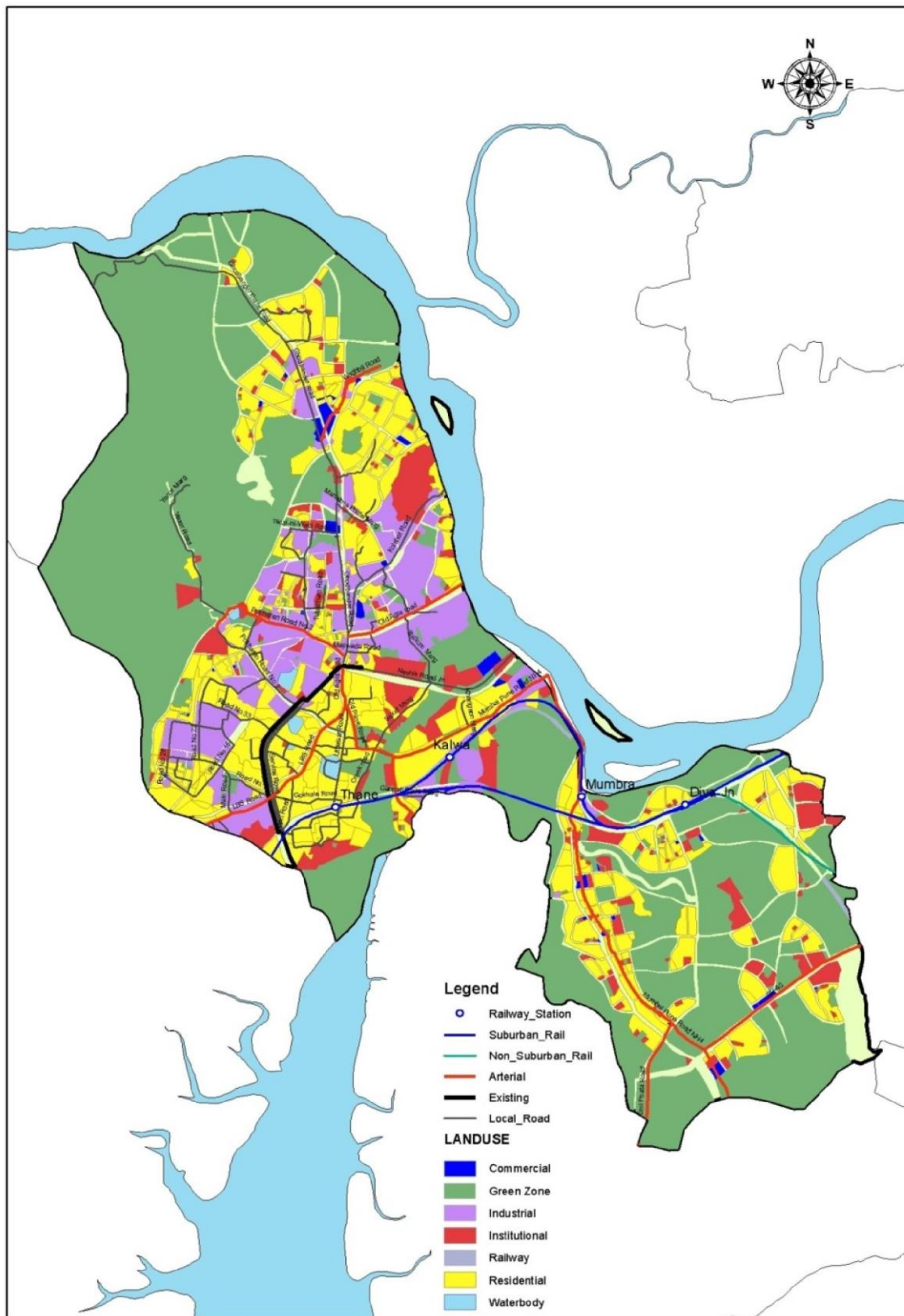
Thane is located on the Northern extremity of Greater Mumbai adjoining Ulhas River and Creek. Boundaries of Greater Mumbai and Thane are contiguous and extend till Bhiwandi and Kalyan - Dombivli. The city is located on latitude 720 50' North with longitude 190 10' East.

Thane became District Headquarter and came up as an Industrial Town during 1960-70. The major industrial estates like Wagle, Kalwa, Kolshet and Balkum complex were developed and experienced significant growth during this decade. The City comprises of a number of lakes such as Siddheshwar Lake, Brahmala Lake, Jail Lake, Kachrali lake, Masunda Lake etc. The geographical jurisdiction of the Thane city spreads over an area of 147 sq. km and the same is taken as the study area (**Figure 0.1**).

Thane has experienced a rapid growth in urbanisation during last few decades. As per census 2011, the population of TMC was 18.4 Lakh. The projected population for the year 2017, 2027, 2035 and 2045 is 20.7 Lakh, 27.3 Lakh, 35.0 Lakh and 39.4 Lakh respectively.

In order to alleviate the transport related problems in the City and to meet the increasing travel demand of the area, State Government has decided to introduce an efficient, safe and high-capacity public transport system in Thane. Government of Maharashtra through MAHA metro has decided to prepare Comprehensive Mobility Plan (CMP), Alternative Analysis Report (AAR) and Detailed Project Report (DPR). CMP has prepared by another consultant (M/S Tandon Urban Solutions Pvt. Ltd. (TUSPL)). RITES has been engaged by Maha-Metro on behalf of Thane Municipal Corporation for "preparation of Alternative Analysis Report and Detailed Project Report for Thane".

FIGURE 0.1 : STUDY AREA MAP



0.2 EXISTING TRANSPORT SYSTEM IN THE CITY

- 0.2.1. The registered vehicles in Thane have increased significantly over the years. The numbers of vehicle registration per year have increased from 13.9 lakh (2011) to 19.4 lakh in 2017 year.
- 0.2.2. About 67% of the road network has less than 20m ROW, 21% has ROW between 20-30m and merely 12% of the road has ROW more than 30m. 92% of the road network has footpath available along the road. Average Journey Speed during peak period for city as a whole is observed to be 20 kmph.
- 0.2.3. There are 5 major bus terminals in the City, namely, SATIS Thane West, Lokmanya Nagar, Thane Station East, Wagle Aagar and Chendani.
- 0.2.4. Study area is served majorly by 4 railway stations, namely, Thane, Kalwa, Mumbra and Diva.

0.3 TRAVEL CHARACTERISTIC AND DEMAND

- 0.3.1. A total of 95 traffic zones in Study Area have been considered. The projected population, employment in the years 2027, 2035 and 2045 is presented in the **Table 0.1**.

TABLE 0.1: STUDY AREA POPULATION FORECAST FOR HORIZON YEARS

S.No.	Area	Population (Lakh)			
		2017	2027	2035	2045
1	Thane Municipal Corporation	20.68	27.34	34.99	39.45

Source: MAHA- Metro (CMP, 2018)

- 0.3.2. A four-stage travel demand model has been developed for transport demand forecasting as part of CMP and the same has been adopted in the DPR. The maximum peak hour peak direction trips (PHPDT) and the daily ridership are shown in the **Table 0.2**. Total Daily ridership on the metro corridor for the years 2027, 2035 and 2045 is expected to be 5.76 Lakh, 7.61 Lakh and 8.72 Lakh passengers respectively.

TABLE 0.2: MAXIMUM PHPDT AND DAILY RIDERSHIP

Year	Maximum PHPDT	Daily Ridership (in Lakh)
2029	23,320	6.47
2035	29,489	7.61
2045	31,393	8.72

0.4 SYSTEM & TECHNOLOGY SELECTION

The urban transport requirements of Thane have been evaluated based on projected traffic demand. Considering the city specific characteristics, traffic demand, availability of right of way and possible integration with Mumbai metro corridor, a Metro rail system with combination of 3 and 6 car train composition - which can cater to a maximum of about 32,000 PHPDT, is proposed.

0.5 CIVIL ENGINEERING & ALIGNMENT DETAILS

i. Geometric Design Parameters

TABLE 0.3: DESIGN CRITERIA

S. No.	Criteria	Dimension
1	Gauge	1435 mm
2	Design Speed	80Kmph
3	Maximum Axle Load	16T
4	Electric Power Collection	25 KV AC (OHE)

TABLE 0.4: HORIZONTAL CURVE PARAMETERS

Description	U/G Section	Elevated Section
Desirable Minimum Radius	300 m	200 m
Absolute minimum Radius	200 m	120 m
Minimum curve radius at stations	1000 m	
Maximum permissible cant (Ca)	110 mm*	
Maximum cant deficiency (Cd)	85 mm	
* The applied cant will be decided in relation to normal operating speeds at specific locations like stations/vicinity to stations.		

TABLE 0.5: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.10 m	9.50 m
Station w/o Scissor Cross-over	4.10 m	13.50 m
Station with Scissor Cross-over	4.50 m	13.50 m

TABLE 0.6: TRACK CENTRE AND HEIGHT IN UNDERGROUND SECTION

Description	Minimum Track Centre	General Depth below Ground Level
Running section by TBM	15.00 m	15.00 m
Running section by cut & cover except ramp	4.60 m	12.60 m

Description	Minimum Track Centre	General Depth below Ground Level
Stations by cut & cover and island platform of 12 m	15.00 m	15.0 m
Stations by cut & cover and side platform	4.60 m	15.0 m

TABLE 0.7: GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 3%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

TABLE 0.8: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

ii. Engineering Survey

Topographical Surveys along the proposed Ring Corridor was conducted based on differential GPS.

iii. Geotechnical Investigations

Total 30BHs were drilled for the proposed Metro Ring Corridor. 29BHs along the corridor and 1BH in Depot area. These boreholes have been drilled to the maximum depth of 21.00m below ground level for sub soil/Rock exploration. For different type of foundations following is recommended for:

- Since heavy loads are to be transferred to sub soil strata at viaduct part of alignment therefore, Pile Foundations is recommended for the viaduct part.
- The load capacities of piles are based on empirical correlation's and to be confirmed by conducting pile load test as per IS: 2911 (Part 4) on test piles before execution of working piles.
- Since the proposed site is situated in seismic Zone III of the seismic zonation map of India, suitable seismic coefficient commensurate to seismic Zone III (IS: 1893) to be adopted in the design of the structures.

iv. Alignment Description

TABLE 0.9: ALIGNMENT BREAKUP

Alignment Type	From (m)	To (m)	Length (m)
Underground	0.0	317.0	317.0
Switch over Ramp (-)8.0m to (+)7.5m	317.0	1181.0	864.0
Elevated	1181.0	24917.0	23736.0
Switch over Ramp (+)7.5m to (-)8.0m	24917.0	25342.0	425.0
Underground	25342.0	27400.2	2058.2
Depot Entry	0	1177.7	1177.7
Total			28577.9

Total 22 stations have been proposed, out of which 20 are elevated and 2 are underground stations.

TABLE 0.10: ABSTRACT OF HORIZONTAL CURVES

S. No.	Curve Radius	No. of Occurrences	Length (m)	Percentage
1	≤150	31	5570.59	42.51
2	>150 <300	25	3699.48	28.23
3	≥300 ≤ 500	17	2815.94	21.49
4	>500 ≤ 800	6	629.70	4.80
5	>800 ≤ 1000	0	0.00	0.00
6	>1000	3	389.83	2.97
	Total	82	13105.544	100.00

TABLE 0.11: ABSTRACT OF GRADIENTS

S. No.	Description	No's of Occurrences	Length (m)	Percentage
1	Level (0%)	26	8056	29.40
2	>0% to 1%	15	5073	18.51
3	>1% to 2%	9	2255	8.23
4	>2% to 3%	23	7172	26.18
5	>3%	13	4844	17.68
	TOTAL	80	27400	100.00

v. Land Requirement

Abstract of land requirements for different components of corridors given in **Table 0.12**.

TABLE 0.12: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
Central Govt	Alignment / Stations, ancillary buildings & Misc.	0.4368	0	0.1115
	Parking cum PD	0	0	0
	Total	0.4368	0	0.1115
State Govt	Alignment / Stations, ancillary buildings & Misc. RSS, etc	5.6470	0	1.8363
	Depot	0	0	0
	Parking cum PD	0.7150	0	0
	Casting Yard	0	50	0
	Total	6.3620	50	1.8363
Private	Alignment / Stations, ancillary buildings & Misc., RSS, etc	2.5748	0	1.9355
	Depot & entry/exit	18.6343	0	0
	Parking cum PD	0.64	0	0
	Total	21.8491	0	1.9355
Grand Total		28.6479	50	3.8833

0.6 STATION PLANNING

0.6.1. Station Planning

The stations have been planned based on the following parameters:

- The peak hour traffic load for each station.
- Stations are planned for 6 cars train.
- The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the point of safety does not exceed 4.0 minutes for enclosed station and 5.5 minutes for open station (As per NBC 2016 Guidelines)
- The station planning is in compliance to the “Guidelines and space Standards for Barrier Free Built Environment for Disabled and Elderly persons” published by the Ministry of Urban Affairs and Employment India in 1998.

Two typical designs have been suggested (**Table 0.13**) and these will form basis for planning of all the stations (**Table 0.14**).

TABLE 0.13: TYPICAL STATION DESIGNS

Sr. No.	Proposed Type	Elevated U/G	Remarks
1	Type 1	Elevated	140.00m x 21.95m
2	Type 2	Underground	190.00m x 23.55m

TABLE 0.14: STATION TYPOLOGY AND DETAILS

Sn	Station Name	Chainages (M)	Inter-Station Distance (M)	Cumulative Distance (M)	Elevated/ Underground
Corridor: New Thane To New Thane(Ring Corridor) Via Dongripada & Thane Junction					
1	New Thane	0	-	0	Underground
2	Raila Devi	1664	1664	1664	Elevated
3	Wagle Circle	2903	1239	2903	Elevated
4	Lokmanya Nagar Bus Depot	4291	1388	4291	Elevated
5	Shivai Nagar	5520	1229	5520	Elevated
6	Neelkanth Terminal	6774	1254	6774	Elevated
7	Gandhi Nagar	7634	860	7634	Elevated
8	Dr. Kashinath Ghanekar Natyagraha	9032	1398	9032	Elevated
9	Manpada	9792	760	9792	Elevated
10	Dongripada	11622	1830	11622	Elevated
11	Vijay Nagari	12372	750	12372	Elevated
12	Waghbil	13611	1239	13611	Elevated
13	Waterfront	14685	1074	14685	Elevated
14	Patlipada	16734	2049	16734	Elevated
15	Azad Nagar Bus Stop	17581	847	17581	Elevated
16	Manorma Nagar	18616	1035	18616	Elevated
17	Kolshet Industrial Area	19954	1338	19954	Elevated
18	Balkum Naka	21118	1164	21118	Elevated
19	Balkumpada	22098	980	22098	Elevated
20	Rabodi	22986	888	22986	Elevated
21	Shivaji Chowk	23873	887	23873	Elevated
22	Thane Junction	25841	1968	25841	Underground

0.6.2. NMV and Pedestrian Facilities

Pedestrian facilities like continuous footpath of 1.8m to 3.0m (as per land availability), demarcation of pick and drop for PT/IPT, Zebra crossing at

intersections, table top crossings, relocation of encroachments, strengthen of ROW have been proposed near the station influence area for ease for pedestrian movement. For non motorized vehicles facilities like cycle tracks have been planned on the basis of land availability near the station for seamless movement.

0.6.3. Accessibility for Differently-abled

The Metro Rail system should be user-friendly ensuring accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems and the elderly persons. The standards are extracted from 'Guidelines for Pedestrian Facilities' and 'NFPA Guidelines', 'Space Standards for Barrier Free Built Environment for differently-abled and Elderly Persons' and other standards.

0.6.4. Parking at Stations

Dedicated parking provision for commuters is one of the key factors determining success of the metro system. Parking provisions along with priority to pedestrians through Foot Over Bridges and Bus feeder services will encourage more commuters to use the metro system who could safely park their vehicles at the nearest station, walk to the station or rely on feeder connectivity. A total of 13,550 Sqm of area along the Ring Corridor is proposed exclusively for parking near six stations.

0.7 INTERMODAL INTEGRATION

0.7.1 Intermodal Integration with Existing Modes

The intermodal integration proposals have been formulated for facilitating traffic dispersal and circulation facilities based on the following considerations:

- Minimizing pedestrian/vehicle conflicts and effective passenger interchange with feeder modes.
- Facilitating passenger interchange with other transit systems
- Circulation area with adequate parking space, designated space for embarking and disembarking for vehicular traffic
- Availability of total carriageway and footpath widths required to cater to the proposed traffic volumes and relocation of vendors/hawkers

0.7.2 Feeder Services

The feeder buses have been proposed of high quality, ultra-modern and customer

oriented that can deliver fast, comfortable and cost-effective urban mobility. Easy- to-board (low floor), attractive and environmentally friendly buses with airconditioning having capacity of 35 (Mini-buses) are proposed for feeder system.

The facilities of feeder buses have been estimated for peak hours of various horizon years 2029, 2035 and 2045. The total number of buses required are 72, 83 and 86 in the year 2029, 2035 and 2045 respectively. Public bicycle sharing is provided for the passengers for about 2 km of the metro stations influence area. The total number of public bicycle required in the year 2045 is 562.

The essential features of an integrated multi-modal urban transport system including physical integration of public transport services, fares, ticketing, infrastructure provision, management, pricing, and integration of transport authorities have been proposed.

0.8 TRAIN OPERATION PLAN

The underlying operation philosophy is to provide mass rapid transit services with optimal utilisation of fixed Infrastructure and rolling stock planning.

- The frequency of train services is optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency is provided during lean period so as to keep the option of this service attractive during lean period as well.
- The frequency of services is regulated to meet the growing traffic demand in horizon years.
- Basic unit selected is two motor car and one trailer car.

The train operation plan for the proposed corridor is based on the following:

- Running of services for 16 hours of a day (6:00 hrs to 22:00 hrs) with a station dwell time of 20-30 second.
- Scheduled speed of 34 kmph.
- Make up time of 5 to 10% with 8-12% coasting.
- Adequate services to ensure comfortable journey for commuters even during off peak periods.

The train composition, capacity and headway required for the operation in proposed corridor is given below:

The car composition to be adopted is given below-

DMC : Driving Motor Coach

TC : Non-Driving Trailer Coach

3-Car Rake Composition: **DMC-TC-DMC**

Driving Motor Coach (DMC):	247 (43 seated + 204 standing) @ 6 passengers/m ²
	: 315 (43 seated + 272 standing) @ 8 passengers/m ²
Trailer Coach (TC)	: 270 (50 seated + 220 standing) @ 6 passengers/m ²
	: 343 (50 seated + 293 standing) @ 8 passengers/m ²
3 Car Train	: 764 (136 seated + 628 standing) @ 6 passengers/m ²
	: 973 (136 seated + 837 standing) @ 8 passengers/m ²
6 Car Train	: 1574 (286 seated + 1288 standing) @ 6 passengers/m ²
	: 2002 (286 seated + 1716 standing) @ 8 passengers/m ²

Every coach shall be fully interchangeable with any other coach of same type. The train operation plan envisaged for Thane Metro is given in **Table 0.15**.

TABLE 0.15: TRAIN OPERATION PLAN FOR THE CORRIDOR

Corridor	Items	2029	2035	2045	2051
New Thane to New Thane(Ring Corridor)via Dongripada & Thane Junction	Cars/ Train	3,6	3,6	3,6	6
	Headway in Sec.	212.0	225.0	200.0	200.0
	Trains/hr	17(12,5)	16 (5,11)	18(3,15)	18
	Capacity (6p/m ²)	17038	21134	25902	28332
	Capacity (8p/m ²)	21686	26887	32949	36036
	Design PHPDT	16800	21000	26000	28000

The above train operation and headway for different horizon years is proposed to meet the Peak hour peak direction traffic demand (PHPDT) with standees @ 6 passengers/ m² in most of the sections, Other sections are meeting with standees @ 8 passengers/ m². For a small section (few stations) train will run with passenger discomfort. This arrangement will optimize the rolling stock requirement as well as operating expenses.

Rolling Stock requirement for different horizon years has been calculated based on the train operation plan (**Table 0.16**).

TABLE 0.16: RAKE REQUIREMENT FOR THANE METRO

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
New Thane to New Thane (Ring Corridor) via Dongripada & Thane Junction	2029	50	3 car	150
	2035	60	3 car	180
	2045	73	3 car	219
	2051	41	6 Car	246

0.9 SIGNALING AND TELECOMMUNICATION

0.9.1 Signaling System

The signaling system shall provide the means of an efficient train control ensuring safety in train operations. It assists in optimization of metro infrastructure investment and running of efficient train services on the network. **Table 0.17** shows the standards that will be adopted with regard to the Signaling system.

TABLE 0.17: STANDARDS TO BE ADOPTED FOR SIGNALING SYSTEM

Description	Standards
CBTC System	IEEE 1474
Grade of Automation	GoA 2
Interlocking	Computer Based Interlocking (CBI) adopted for station having switches and crossing shall be Hot Standby system with object controller conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for increased reliability and less maintenance efforts.
Train Protection Systems (ATP)	Automatic train protection system conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
ATS	Automatic Train Supervision System, movement of all trains to be logged on to a central computer and displayed on workstations in operation control centre (OCC) and at SCR. Remote control of stations from the OCC as well as local control from the interlocked stations. The OCC shall be the primary control having a backup control centre (BCC) to take over the operation if the OCC is to be evacuated due to unforeseen situation. ATS/ATO will conform to SIL2 level of CENELEC standards EN 50126, EN 50128 and EN 50129.

Description	Standards
Immunity to External Interference.	All data transmission on Optical Fiber Cables/Radio. All signaling cables will be separated from power cables. CENELEC standards EN50121-2&4 and EN50082-2 and EN 50081-2 as applicable for EMI/EMC.
Fail Safe Principles	SIL4 safety levels as per CENELEC standard for signal application.
Fall back system	Digital Axle Counter
Other Items	Suitable International Standards like CENELEC etc. shall be followed as per good industry practices.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of signaling 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.

0.9.2 Telecommunication System

The telecommunication system acts as communication backbone for signaling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network.

The proposed telecom system and transmission media will have following sub-systems:

- IP, GE based Transmission System
- Telephone Exchange
- Mobile Radio Communication System
- Public Address System
- Centralized Clock System
- Passenger Information Display System
- Close Circuit Television
- Central Voice Recording System (CVRS) and
- Supervisory Control and Data Acquisition (SCADA) System
- Wi-Fi Services
- LED Display Walls

0.10 FARE COLLECTION SYSTEM

0.10.1. Mass Rapid Transit Systems handle a 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, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare

collection system meets these requirements.

0.10.2. Platform Screen Doors (PSD)

Platform Screen Doors (PSD) are proposed at stations to screen the passengers on the platform from the track. These glass doors shall be powered for automatic operation and located along the platform at the platform edge throughout the passenger area. The door locations will be corresponding to the train car passenger door locations. Opening/closing of the PSD will be after receipt of the doors open/ doors close command signals from the Signalling Link.

There are mainly two options for providing Platform Screen Doors viz Full height PSD or Half height PSD. To ensure the safety of the passengers, Half Height Platform Screen Doors is proposed to be provided at all the elevated stations and Full Height Platform Screen Doors at all the U/G stations to reduce the energy consumption.

0.11 ROLLING STOCK

- a) The salient features of Rolling Stock proposed for the Thane Metro are presented in **Table 0.18**.

TABLE 0.18: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3 Car: DMC+TC+DMC 6 CAR: DMC–TC-MC-MC-TC-DMC
3	Coach construction	Light weight stainless steel/ Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	25 kV AC OHE System

- b) Coach Dimensions: The following coach dimensions are proposed to be chosen for Thane Metro (**Table 0.19**).

TABLE 0.19: COACH DIMENSIONS

Type of Coach	Length	Width	Height
Driving Motor Car (DMC)	21.64 m	2.9 m	3.9 m
Trailer car (TC)	21.34 m	2.9 m	3.9 m

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

0.12 POWER SUPPLY AND TRACTION

25kV AC Overhead Catenary system is proposed to be adopted for Thane Metro corridor. The power requirements of a metro system are determined by peak-hour power demand for traction and auxiliary applications. The ultimate (design) power requirement for this corridor will be conceptualized considering following norms, directives/ guidelines:

- Train operation with 6 car rakes with carrying capacity of 1574 passengers (standing @ 6 passengers/ m²).
- Peak period headway of 200 seconds for the corridor.
- Specific energy consumption of rolling stock – 75 KWh / 1000 GTKM
- Regeneration @ 30%
- At grade/ Elev. station load – initially 200kW, ultimate design 300 kW
- Underground station load – initially 2000kW, ultimate design 2500 kW
- Depot auxiliary load – initially 1500kW, ultimate design 2000 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, power demand estimation for the proposed Thane Metro corridor is given in **Table 0.20**.

TABLE 0.20: POWER DEMAND ESTIMATION (MVA)

Load	Year			
	2029	2035	2045	2051
Traction	14.95	18.32	22.50	24.66
Auxiliary	11.08	11.08	12.10	13.13
Total	26.03	29.40	34.60	37.78

0.12.1 Sources of Power Supply

Thane City has 220kV, 132kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridor. Keeping in view of the reliability requirements and considering the complete length of corridor, three Receiving Sub-stations are proposed to avail power supply for traction as well as auxiliary services from the Maharashtra Power Transmission Company Limited (MSETCL) grid sub-stations at 220 kV voltage through cable feeders for the proposed

Thane Metro corridor (Table 0.21).

TABLE 0.21: SOURCES OF POWER SUPPLY (PROPOSED)

Grid sub-station	RSS of Metro Authority Proposed	Approx. Dist. GSS to RSS
400kV MSETCL Substation, Kalwa	Shivaji Chowk RSS (220/33 kV)	5 km
MSED 220kV sub-station, Thane	Gandhi Nagar RSS (220/33 kV)	6 km

0.12.2 Auxiliary Supply Arrangements And Standby Power Supply

Auxiliary sub-stations (ASS) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 200 kW in the initial years and is likely to reach 300 kW in the horizon year. Similarly, for the underground stations, the auxiliary load requirements have been assessed at 2000 kW for underground station which is likely to increase to 2500 kW in the horizon year. The average load considered for elevated station and underground station will have to be fine tuned to suit station requirement during detailed design stage.

Each elevated station is provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 500 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. Two transformers (33kV/415V, 3-phase) of 2500 kVA at each underground ASS for the underground stations are proposed to be installed (one transformer as standby). Apart from stations, separate ASS is required at depot with 2x2000 kVA auxiliary transformers to cater to depot cum workshop load.

0.12.3 Solar Energy Harnessing System

Provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations/sheds and buildings is proposed for Thane metro. Based on the solar radiation intensity in the city of Thane, the peak solar power generation of Thane Metro corridor is expected to be about 50 kWp for the elevated stations and about 2000 kWp for maintenance

0.13 VENTILATION AND AIR-CONDITIONING SYSTEM

The air conditioning and ventilation requirement in the elevated stations of the Thane Metro is mainly for the ancillary spaces such as staff room, equipment rooms

etc.

The Ventilation and Air-conditioning (VAC) system requirements for the underground sections include the following:

- Station Air-conditioning System
- Ventilation System for station plant rooms (Ancillary spaces)
- Station Smoke Management System
- Tunnel Ventilation System

Tunnel Ventilation System (TVS) is provided in a Subway system to carry out the following functions:

- a) Train Pressure relief during normal operation
- b) Ventilation during maintenance periods, if required
- c) Removal of smoke during emergency conditions
- d) Maintenance of smoke free evacuation route and provision of adequate fresh air during fire related emergencies.

0.14 MAINTENANCE DEPOT

The Maintenance facilities for New Thane to New Thane (Ring Corridor) of Thane Metro Rail System are proposed to be provided near Kasarvadavali for about 41 rakes of 6 cars for maintenance and repairs of the rolling stock. The depot will have infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signaling& Telecommunication; Automatic Fare Collection etc.

The proposed arrangement for stabling and maintenance facilities for are given below in **Table 0.22**.

TABLE 0.22: MAINTENANCE DEPOT FOR THANE METRO CORRIDOR

Infrastructure	Kasarvadavali Depot
Stabling Lines	41 lines of 6 car each
Inspection Lines	4 lines of 6 car each
Workshop Lines	3 lines of 6 car each

0.15 ENVIRONMENTAL IMPACT ASSESSMENT

0.15.1. Environmental Impact Assessment

Environmental baseline data was collected in the month of April 2018.

Water consumption for construction activities is of the order of 252 KLD. At labour camps, estimated water requirement is 623 KLD, waste water and solid waste generated will be about 498 KLD and 1335 Kg per day respectively. Muck generation due to project construction is 9.25 lakh cum of which 4.65 lakh cum may have to be disposed of. During construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: CO, HC, NO_x, PM, CO₂ and VOC will be about 45 ton, 1.4 ton, 94 ton, 2 ton, 5847 ton and 15 ton respectively. Such transportation is estimated to result in fugitive dust emission of about 11.1 ton.

During operation, water requirement at stations will be 518 KLD, waste water generated will be 275 KLD (266 station + 9 KLD depot) and 55 KLD effluent from Depot, solid waste generated at the stations will be 17 cum per day. Water required in the depot for train maintenance purpose is estimated at 68.47 KLD and requirement for staff working in depot is calculated as 11.8 KLD. Water requirement during operation will be met through public water supply.

There are approximately 662 trees which are likely to be felled or transplanted. 251 no. trees will be felled during construction. Some part of the alignment is along the existing Development Plan Road (i.e. the Road is outside the compound wall of SGNP) near the Dongripada Station, near the Lokmanya Nagar Bus depot, near Pokharan Road no. 1 station to Nilkanth Terminal. The proposed alignment passes along the existing and proposed Development Plan Road adjacent to CRZ 1A/CRZ II Zone.

Some of the key features of the environment management plan are as follows:

- Noise barrier is proposed for elevated section which falls adjoining to SGNP.
- 3721 tree will be planted to compensate the felling of the 251 trees.
- To recharge the ground water, RWH is proposed in Depot and Elevated section of the project.

Estimated environmental cost for the proposed environment management plan is about Rs 15.27 crore that includes the compensatory afforestation, Noise barrier, Environmental monitoring.

Training and environment division. Cost of solar installations on stations and in depot, rain water harvesting on stations and in depot, water treatment plant in depot and green belt at depot are not included in this estimate.

0.15.2. Social Impact Assessment

The objectives of the Social Impact Assessment are (i) to prepare a draft inventory of structures, affected families and persons, (ii) to identify major social impacts and (iii) to prepare preliminary Resettlement Action Plan (RAP). The preliminary SIA which includes RAP has been prepared in accordance with State policy and guidelines. The base line data has been collected from secondary sources such as the Census and the Statistical Hand Book and primary data are being collected through household survey conducted by RITES Social team during June-July 2018.

The proposed MRTS project shall require acquisition of 28.6479 ha in which 21.8491 ha is private land and remaining 6.7988 ha is Government land. Total 80 properties will be affected out of which 36 are residential, 40 are commercial and 4 are other structures. There are 132 affected families consisting 620 persons. The socio-economic survey results indicate that sex ratio is 753 female per 1000 males. The average age of surveyed population is 30 years. Majority of the surveyed families are Hindu followed by Muslim in the project area. Majority of families speak Marathi as mother tongue. Small, medium and large size families are found in the proposed corridor. About 92% of surveyed people are literate and majority of them have studied up to primary, upper primary and high school. Majority of surveyed family members are married. Average family income is Rs. 21184/- per month.

Compensation for land acquisition, resettlement and rehabilitation has been considered as per State policy and guidelines. Maha Metro will be responsible for implementation of resettlement and rehabilitation component of the proposed corridor. Maha Metro will coordinate with all implementing agencies like Project Management Consultant (PMC), Non-Government Organisation (NGO), Rehabilitation & Resettlement (R&R) Implementation Support Consultant and supervise their work and monitor the progress of the project. Social Management Unit (SMU) of Maha Metro shall look after land acquisition and rehabilitation activities of the project. The responsibility of NGO will be assisting SMU of Maha Metro in implementation of R&R activities. A Social Development Consultant will be appointed by Maha Metro to assist in the R&R implementation process. Grievances of PAPs will be first brought to the attention of field level staffs of Maha Metro. Grievances not redressed by the staffs (field level) will be brought to the Grievance Redressal Committee (GRC). The period for implementation of RAP has been taken

as approx. two and half years. The tentative cost for implementation of Resettlement and Rehabilitation Plan is INR.5.044 crore.

0.16 DISASTER MANAGEMENT AND SECURITY MEASURES

0.16.1 Disaster Management Measures

An effective system needs to be in place under the provision of 'Disaster Management Act, 2005'. Provisions at metro stations include Fire Detection and Suppression System, Environmental Control System (ECS), Tunnel Ventilation System, Track-way Exhaust System (TES), Power Supply System, DG Sets & UPS, Water Supply and Drainage System, Lights and other facilities which may be deemed necessary. In order to be prepared for any disaster, it is essential to train the concerned staff in situations such as fire, rescue of disabled trains, evacuation, etc. and mock drills need to be conducted.

0.16.2 Security Measures

Security system for metro system plays an important role in helping the system to become the preferred mode choice for commuters. The three phases of security system followed include Prevention, Preparedness and Recovery. Various provisions like CCTV cameras, baggage scanners, metal detectors, bomb detection equipment, wireless sets, sniffer dogs and related facilities will be part of station security system.

0.17 COST ESTIMATES

0.17.1. Capital Cost Estimate

Cost estimate for Thane Metro Ring corridor has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation at July 2023 price (**Table 0.23**) .

The rates of items other than land are based on Benchmarking of Cost Estimates for Metro Rail Projects by MoHUA published in February 2019. The rates of cost components at February 2019 price level are given in **Table 17.2**. However, last accepted rates of Pune Metro have been considered for the UG section by T.B.M in alignment & formation and UG section civil works. Serial number of items in the table denotes the serial number of items in detailed cost estimate. Escalation of 5% per annum is applied to bring the rates at current price level of July'2023.

TABLE 0.23: ABSTRACT OF COST ESTIMATE

(Rs. In Crore)

S.No	ITEM	TOTAL AMOUNT
1	Alignment and Formation	1,633.76
2	Station Buildings incl. Civil works, EM works, ECS, TVS, Lift, escalators & Architectural Finishes etc	1,278.13
3	Depot including civil, EM, Machinery & plants, general works & OCC building	211.80
4	P-Way for main line, depot and depot connectivity	291.69
5	Traction & power supply for main line and depot incl. OHE, ASS, GIS etc.	422.84
6	Signalling and Telecom. etc.	338.46
7	Environment	11.56
8	Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management	213.05
9	Capital Expenditure on Security including civil and EM works	10.14
10	Staff Quarters including civil, electrical works	51.64
11	Capital Expenditure on Inter modal integration including Footpath for pedestrians	82.23
12	Rolling Stock	1,200.00
13	Total Cost at July, 2023 price levels (Excluding Land, R&R, PPP, IDC, General Charges, Contingencies, Central & State Taxes)	5,745.30
14	General Charges @ 5% on all items except land	287.27
15	Contingencies @ 3 % on all items except land	172.36
16	Total Cost at July, 2023 price levels incl. General Charges and Contingencies (Excluding Land, R&R, PPP, IDC, Central & State Taxes)	6,204.93
17	Escalation at 5 % pa on all items except contingencies	813.06
18	Total Cost incl. General Charges, Contingencies, Escalation, (excluding Land, R&R, PPP, IDC, Central & State Taxes)	7,017.99
19	Central GST & Basic Customs duty	624.10
20	Escalation at 5% pa on Central Taxes including Basic Customs Duty	84.12
21	Total Cost incl. General Charges, Contingencies, escalation, Central Taxes (excluding Land, R&R, PPP, IDC, State Taxes)	7,726.20
22	State GST including escalation @ 5% pa	615.64
23	Interest during Construction (IDC) including Front End Fee	312.71
25	Land including escalation @ 5% pa	3,414.20
26	PPP component (Lifts and Escalators installations) incl. Central and State Taxes, escalation etc	131.34
27	Total Completion Cost	12,200.10

0.17.2. O&M Estimate

The total O&M cost including additional and replacement cost in the year 2029, 2035 and 2045 are estimated at Rs. 337.66 Crore, 522.72 Crore and Rs. 1081.64

Crore respectively.

0.18 TRANSIT ORIENTED DEVELOPMENT

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. TOD focuses on creation of high density mixed land use development in the influence zone of transit stations, i.e. within the walking distance of (500-800 m) of transit station.

In the absence of notified TOD Policy for Thane Metro, TOD policy for Nagpur Metro has been considered for the study. The estimated revenue from TOD has been determined through value capture finance. In similar lines with Nagpur Metro, three tools of VCF i.e. 1% additional surcharge on property transactions, 100% increase in development charge & premium from additional FSI in TOD corridor have been proposed for revenue estimation as a part of TOD study. As revenue from VCF tools is expected to be shared for other infrastructure projects, it is expected that 50% of the revenue earned from sale of additional FSI will come to Thane metro.

Apart from TOD, the other sources like advertisement in trains and stations, leasing of commercial space in stations, semi-naming rights of stations have been identified as non fare box revenue sources and the revenue from respective sources have been estimated. The broad estimation of revenue from TOD and other non fare box sources is presented in **Table 0.24**.

TABLE 0.24: REVENUE ASSESSMENT FROM TOD & OTHER NON-FARE BOX SOURCES

Year	Revenue (Rs. In Crores)						
	TOD (VCF)			OTHER SOURCES			Total
	Premium on Additional FSI	1% Additional Surcharge on Property Transactions	Development Charge	Advt.	Leasing of Commercial Space in Stations	Semi-naming Rights of Stations	
2029	89.3	151	187	74.1	24.7	34.0	560
2035	73.9	170	210	188.3	70.6	72	784
2045	90.1	207	256	427.5	160.3	117	1257

0.19 FINANCIAL ANALYSIS & NON FARE BOX REVENUE ASSESSMENT

0.19.1 Capital Cost

The Construction cost of the metro corridor at July, 2023 prices is estimated at Rs. **6032.57** Crore. The total cost of project including land & R&R cost is estimated at Rs. **8915.35** Crore. The capital cost components at July, 2023 are given in **Table 0.25**.

TABLE 0.25 CAPITAL COSTS JULY' 2023 (RS. IN CRORE)

S.No	Cost Component	Total
1	Construction Cost without land & R&R	6032.57
2	Land Cost including R&R Costs	3170.05
	· Private land	2643.40
	· Govt land	526.65
3	Construction Cost including land & R&R	9202.62
	Taxes	1166.62
	· Central Taxes	624.10
	· State Taxes	542.52
4	Total Cost with Land & Taxes & R&R	10369.24
5	Total Cost with land and Central Taxes only	9826.72

0.19.2 Completion Cost

With escalation factor of 5% p.a. the completion cost under different scenarios are as per **Table 0.26**.

Table 0.26 DETAILS OF COMPLETION COSTS (Rs in Crore)

Completion Cost	Amount
Cost without taxes, Land & R&R	6,846
Cost with Central Taxes and without Land & R&R	7,554
Cost with all taxes and Land & R&R (without PPP component & IDC)	11,584

0.19.3 Project Revenue

The Revenue for Thane metro mainly consists of fare box collection and revenue from other non-fare box sources such as property development, advertisement, parking, taxes etc. Estimation of revenue from fare box and non-fare box source has been made.

The total annual revenue through the fare box and other sources for the proposed corridor is given in **Table 0.27**.

**TABLE 0.27 TOTAL REVENUE COLLECTION (RS. IN CRORE)- DMRC REVISED
FARES**

Source of Revenue	2029	2035	2045
Fare Box Revenue	1171	2206	5114
Non Fare Box Revenue	560	779	1225
Total Revenue	1731	2985	6339

The FIRR for the project with capital costs including all taxes and revenue from fare box and non-fare box sources works out to be **15.06%**.

0.19.4 Alternate Means of Financing

The models considered for financing the Thane metro are:

- Equity Sharing Model (SPV fully under Government Control)
- Built, Operate & Transfer (BOT) or Public Private Partnership (PPP)
- Grant by the Central Government

0.19.5 Recommended Funding Plan

Recommended funding pattern is placed at **Table 0.28**

**Table 0.28 FUNDING PATTERN UNDER EQUITY SHARING MODEL (PROJECT COST WITH
CENTRAL TAXES)**

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1151.13	15.30%
Equity by Govt. of Maharashtra	1151.13	15.30%
SD for CT by Govt. of Maharashtra	354.11	4.70%
SD for CT by GoI	354.11	4.70%
Soft Loan from bilateral/multilateral funding agencies	4515.72	60.00%
Total Cost excluding Land, R&R and PPP	7526.20	100.00%
Contribution by Local Bodies as Grant	200.00	
SD for land and R&R by Govt. of Maharashtra	3414.20	
State Taxes towards Completion Cost	615.64	-
IDC by GoM	312.71	
Total Cost including Land, R&R, State Taxes and IDC	12068.76	-
PPP Component	131.34	
Total Completion Cost	12200.10	

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

* On behalf of Govt of Maharashtra - TMC may bear the cost

0.19.6 Private Sector Participation

As per Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail. Accordingly, under SPV model for implementation of Thane Metro project following activities have been identified for private participation:

- i. Private sector participation in Automatic Fare System by completely outsourcing operation of Ticket Operating Machines (TOMs), Ticket Vending Machines (TVMs) and Card Recharge Machines including Smart Cards provisions and Merchant Acquirer functions on similar lines as Lucknow Metro.
- ii. Maintenance contracts with System suppliers for Rolling Stock and Signaling systems in place of in-house maintenance.
- iii. Station Civil and E&M maintenance and parking management.
- iv. Exploring long term lease of Elevators at Metro Stations

0.20 ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV.

The EIRR works out to 23.80%, ENPV@14% works out to Rs. 11749 Crores and ENPV@8.00% works out to Rs. 38052 Crore. Sensitivity analysis of the EIRR with 5% to 15% cost overrun and reduction in traffic materialization (separately) has been carried out. The EIRRs under these scenarios are given in **Table 0.29**.

TABLE 0.29: EIRR AND SENSITIVITY ANALYSIS

S. No.	Factor	Range in percentage		
		5%	10%	15%
1	Cost overruns due to delay or other factors	22.52	21.16	20.46
2	Increase in Maintenance Cost	22.97	22.52	22.16
3	Reduction in Ridership	21.87	21.11	20.34
4	Reduction in benefits	21.76	20.87	19.94
5	Combination of reduction in benefits and increase in cost	21.01	19.45	17.94

0.21 IMPLEMENTATION PLAN

0.21.1 Project Implementation Plan

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as DPR is approved by Government of Maharashtra (GoM), and Maha Metro. The possible dates of important milestones are given in **Table 0.30**.

TABLE 0.30: PROJECT IMPLEMENTATION SCHEDULE

S.No	Tasks	Timelines
1	State Government Approval of DPR	August, 2021
2	Approval of GoI	January, 2024
3	Appointment of Interim Consultant	January, 2024
4	Appointment of General Consultants	April, 2024
5	Commencement of Civil Works	October, 2024
6	Commencement of Operation	January, 2029

0.21.2 Implementation Structure

Maharashtra has a successful example of metro operation in Mumbai on SPV model by Mumbai Metro Rail Corporation Limited (MMRCL). Nagpur Metro Rail Phase-1 and Pune Metro project is also implemented on SPV model by Maha Metro. Similarly, Thane Metro project may also be implemented on SPV model. However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model. The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

0.21.3 Legal and Institutional Framework for Implementing Project**i. Legal Framework**

The legislation for construction of Nagpur and Pune Metro may also provide legal cover for construction of Thane Metro. Implementation of proposed Thane Metro can be done under “The Metro Railways (Amendment) Act 2009”.

ii. Institutional Arrangements

Effective institutional arrangement is needed to enable the Metro project to be implemented without any loss of time and cost over-run. The details of possible arrangements are discussed in following sections. Experience of implementing Delhi, Mumbai and Nagpur & Pune Phase 1 metro projects has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro rail project.

It is suggested to have a two tier organization with well-defined responsibilities for getting this project executed. At the apex will be the Maha Metro - the organization with full mandate and total power. The second level will be a project management team called “General Consultants”, engaged by the Maha Metro on contract basis and fully responsible for planning, design and project management. In fact they will be the “Engineers” for the Maha Metro, who is the “Client”. The detailed design consultants may be engaged by General Consultants as their Sub- Consultants within their own contract responsibilities. Since the alignment is a mix of elevated and underground, it is recommended that the contracts be made on “design and build” basis, based on broad technical specifications and performance requirements drawn up by the General Consultants.

Chapter – 1

PROFILE OF THE CITY

1. PROFILE OF THE CITY

1.1 GENERAL/HISTORICAL BACKGROUND

Apart from Udaipur, another city of the southern suburb of India is known as the 'City of Lakes' which is Thane, a city in Maharashtra. Thane is the third most industrialized district in Maharashtra. A part of Mumbai Metropolitan Region, Thane has become almost a part of Mumbai due to its proximity.

Thane became District Headquarter and came up as an Industrial Town during 1960-70. The major industrial estates like Wagle, Kalwa, Kolshet and Balkum complex were developed and experienced significant growth during this decade. . The city comprises of a number of lakes such as Siddheshwar Lake, Brahmala Lake, Jail Lake, Kachrali lake, Masunda Lake etc. Sir Patrick Geddes, an eminent British Town Planner during his visit to the city in 1915, was impressed by the lakes and had suggested preservation & beautification of lakes. The city is also known as Lake City because of the 35 lakes encompassing an area of about 40 Ha. The geographical jurisdiction of the Thane city spreads over an area of 147 sq. km.

Thane Municipal Corporation came into existence on 1st October, 1982. The area of the Thane Municipal Corporation has been divided into 95 electoral wards. There are a total of nine Administrative wards, which called Prabhag Samitees. All the works of the TMC are planned taking into consideration these Prabhag's namely Mumbra, Kalwa, Uthalsar, Kopri, Naupada, Majiwada, Vartaknagar, Waghle, and Railadevi. The city's proximity to the commercial capital of India and its location at the geographical centre of Mumbai Metropolitan Region has given tremendous impetus to the growth of housing and industries in and around the city. During the last two decades, a number of industries have come up in Thane-Belapur Industrial area, Wagle Industrial Estate, Kalwa Industrial Estate and Kolshet-Balkum complex along Thane-Ghodbunder Road.

As per census 2011, the population of TMC was 18.4 lakh. Thane has experienced a rapid growth in population during last few decades. Annual population growth during 1991-2001 was 4.65%.

As the Indian economy is moving in a more outward oriented fashion, rising per capita incomes and changes in economy structure are generating greater

demand for mobility to meet business and personal needs. There is an increase in demand for physical infrastructure in general and transportation in particular. Rapid urbanization and intense commercial developments in the recent past have resulted in steep rise in travel demand putting Thane's transport infrastructure to stress.

In order to alleviate the transport related problems in the City and to meet the increasing travel demand of the area, State Government has decided to introduce an efficient, safe and high capacity public transport system in Thane. Government of Maharashtra through MAHA metro has decided to prepare Comprehensive Mobility Plan (CMP), Alternative Analysis Report (AAR) and Detailed Project Report (DPR). CMP has prepared by another consultant (M/S Tandon Urban Solutions Pvt. Ltd. (TUSPL)). RITES has been engaged by Maha-Metro on behalf of Thane Municipal Corporation for preparation of Alternative Analysis Report and Detailed Project Report for Thane.

CMP identified various short, medium and long-term measures of transport infrastructure in the City. It recommends mass rapid transport systems in two phases as presented in **Figure 1.1**. In phase-1, the length of MRTS corridor is about 27.5 Kms as identified HCMTR. In phase-2, MRTS of about 33.5 Kms connecting Thane to Navi Mumbai.

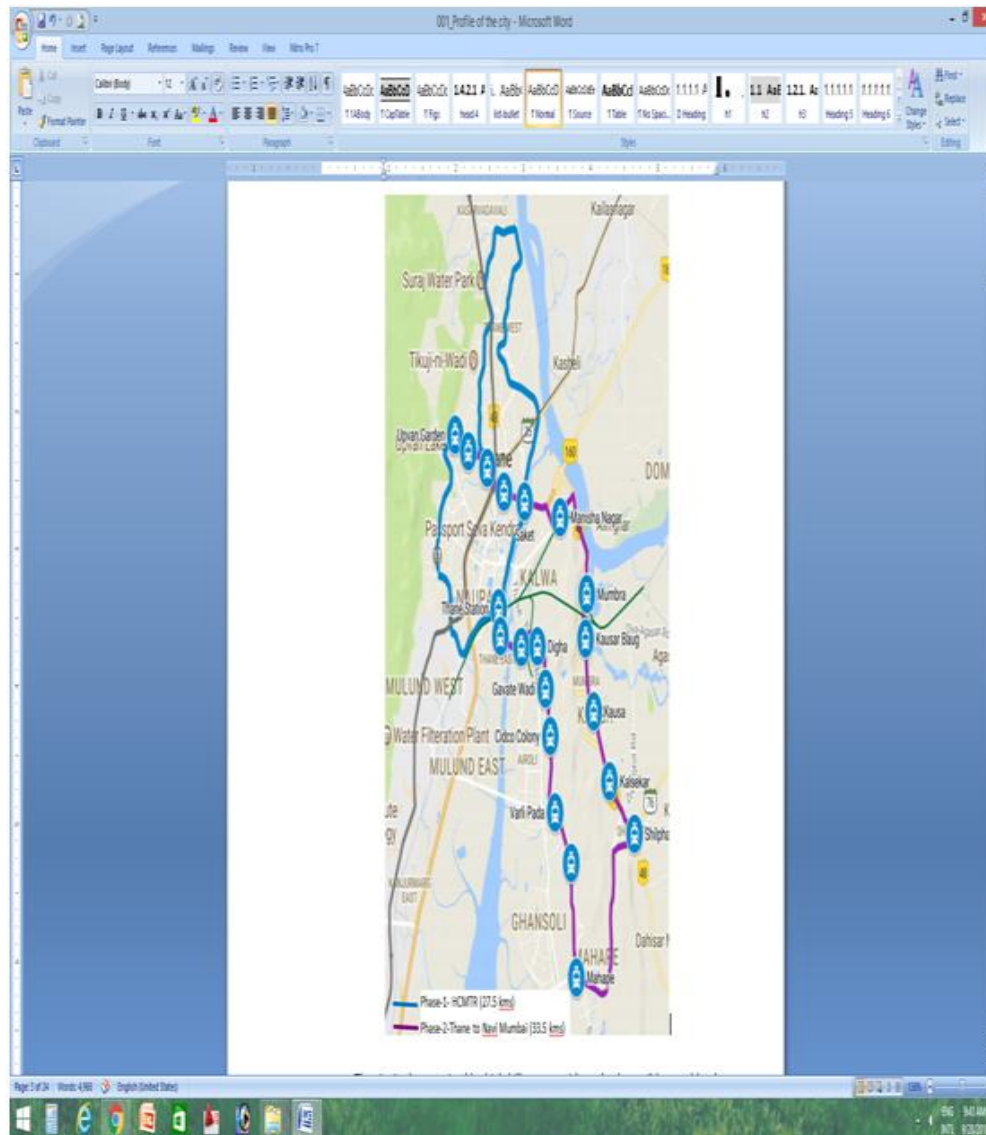
AAR has also been prepared in 2018 in order to identified the best suitable mass transport system along major travel corridor as identified in the CMP and recommend metro rail system for the City of Thane to meet the estimate travel demand for the horizon years.

1.2 LOCATION, CLIMATE, PHYSICAL SETTINGS & REGIONAL LINKAGES

1.2.1. Location, Climate and Physical Setting

The city of Thane is located on the Northern extremity of Greater Mumbai adjoining Ulhas River and Creek. In fact, boundaries of Greater Mumbai and Thane are contiguous and extend till Bhiwandi and Kalyan - Dombivli. The city is located on latitude 72° 50' North with longitude 19° 10' East. The Central railways main and suburban lines pass through the city, which connect the city to north-north east and south, southeast parts of the India. The city is located at the mean sea level on the northern part of the Konkan region.

FIGURE 1.1: PROPOSED THANE MRTS CORRIDORS AS PER CMP



The city is characterized by high hills on one side and submersible marshland along the Thane Creek, and Ulhas River bank on the other side. The plain terrain forms a wide belt along the foothills & away from creek water, Ulhas riverbanks. Such a situation has also affected the growth and placement of various activities. The highway runs centrally through the plains and windings along the foot of the hills.

The Thane Climate is typically coastal, sultry and not very hot. It is observed that the mean maximum temperature varies from 35°C to 40°C during the whole year. Due to humidity during this period, the weather condition is intolerable being sultrier. The weather is tolerable during the months of December to February with temperature ranging from 25°C to 35°C being minimum out of the year. The area receives average rainfall of 2500 mm to

3000 mm viz. in rainy season while the dry period is observed in the summer and winter seasons.

The range of variation in humidity is from 40% to 100%. The highest humidity is observed in the month of August. The overall humidity throughout the year in the city is on the higher side. The average humidity throughout the year is 44% and the maximum humidity experienced during the year in the monsoon months is about 98%.

The wind direction is predominantly from west and northwest of the town for maximum period of the year. The mean wind velocity is about 11 km/hr. The maximum velocity varies from 15 to 19 km/hr during June to August.

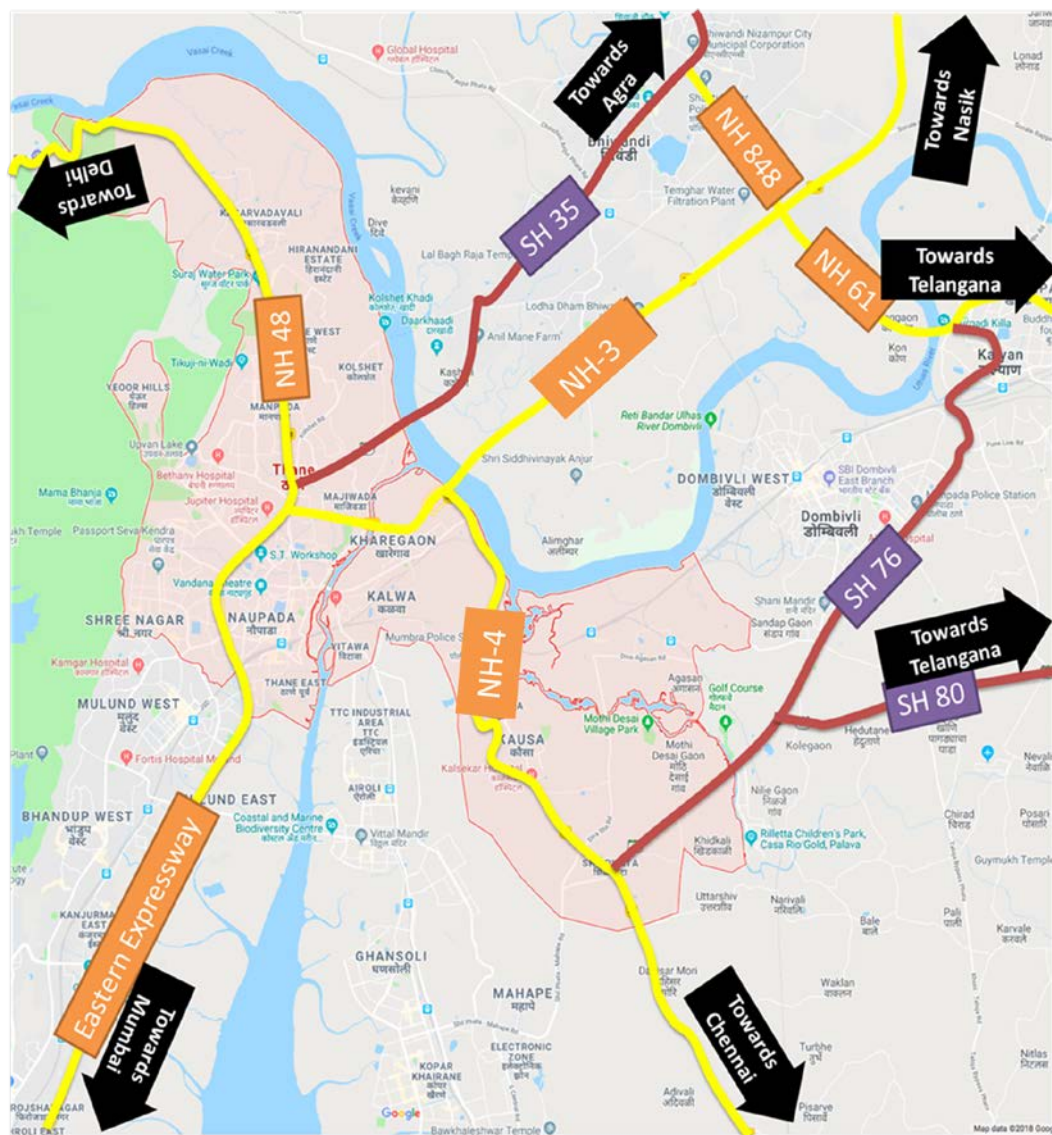
The district lies in area which is formed of alluvium of the early quaternary period. In the district, no hard or consolidated rock exposures are encountered. The main constituents (sand, silt and clay) of alluvium occur in variable proportions in different sections. The mineral products of the district of saline earth from which salt are derived and limestone conglomerates.

1.2.2. Regional Linkages

Thane is well connected to other regions by an extensive network of Railways and Roadways. The important highways viz. Mumbai- Agra Road (NH-3), Mumbai-Pune-Bangalore Road (NH-4), Eastern Express Highway and Ghodbunder Road (an important link between Eastern Express Highway, NH-3 and NH-8) pass through Thane, which connect the city to all parts of India through road network and hence carry maximum traffic in the city road network. Because of this mature rail and road network, Thane city is well connected to Greater Mumbai, Kalyan, Vasai Virar and Bhiwandi. The important national port of Mumbai and Navi Mumbai are at about 25 -30 km from the city.

At present, the nearest operational airport is Chhatrapati Shivaji International Airport at Mumbai which is about 15-20 km from Thane. **Figure 1.2** shows the regional linkage of Thane.

FIGURE 1.2: REGIONAL LINKAGES OF THANE



1.3 DEMOGRAPHIC & SOCIO-ECONOMIC PROFILE

1.3.1 Population Growth

The city of Thane has been the key center of industrial activities which are considered as the engines of the economic growth. The demographic profile shows continuous growth in the population of the city which mainly attributes to the industrial, commercial, administrative and strategic development of the city. The overall economy is versatile and the city does not have a predominant economic base.

The demographic characteristics i.e. the emerging trend in population growth, its characteristics, spatial distribution are sure to have profound influence on the structure and size of the City.

As per Census 2011, population of Thane city is about 18.41 lakh. The population of Thane has been increasing consistently since 1961, with an average decadal growth rate of 69%. Population of the city has increased by 45.85% in last 10 years. Annual population growth during 2001-2011 was 4.2%.

The intra city population of Thane are most densely populated areas followed by areas of Mumbra and Kalwa, Wagle Estate and Vartaknagar has the largest population whereas, the least population areas is sheelphata and Diva.

TABLE 1.1: PERCENTAGE OF POPULATION DECADAL VARIATION

Census Year	Population	(%) Decadal Variation
1961	136591	
1971	261615	91.5317
1981	474170	81.2473
1991	795833	67.8371
2001	1262551	58.6452
2011	1841488	45.8545

Source: CMP Thane, 2018

1.3.2 Employment

The Work force participation rate as per Thane Municipal Corporation for the year 2001 was 33.3% and for the year 2011 was 34.2%. Based on the population, employment for TMC area is presented in **Table 1.2**.

TABLE 1.2: EMPLOYMENT GROWTH AND FORECAST FOR TMC AREA

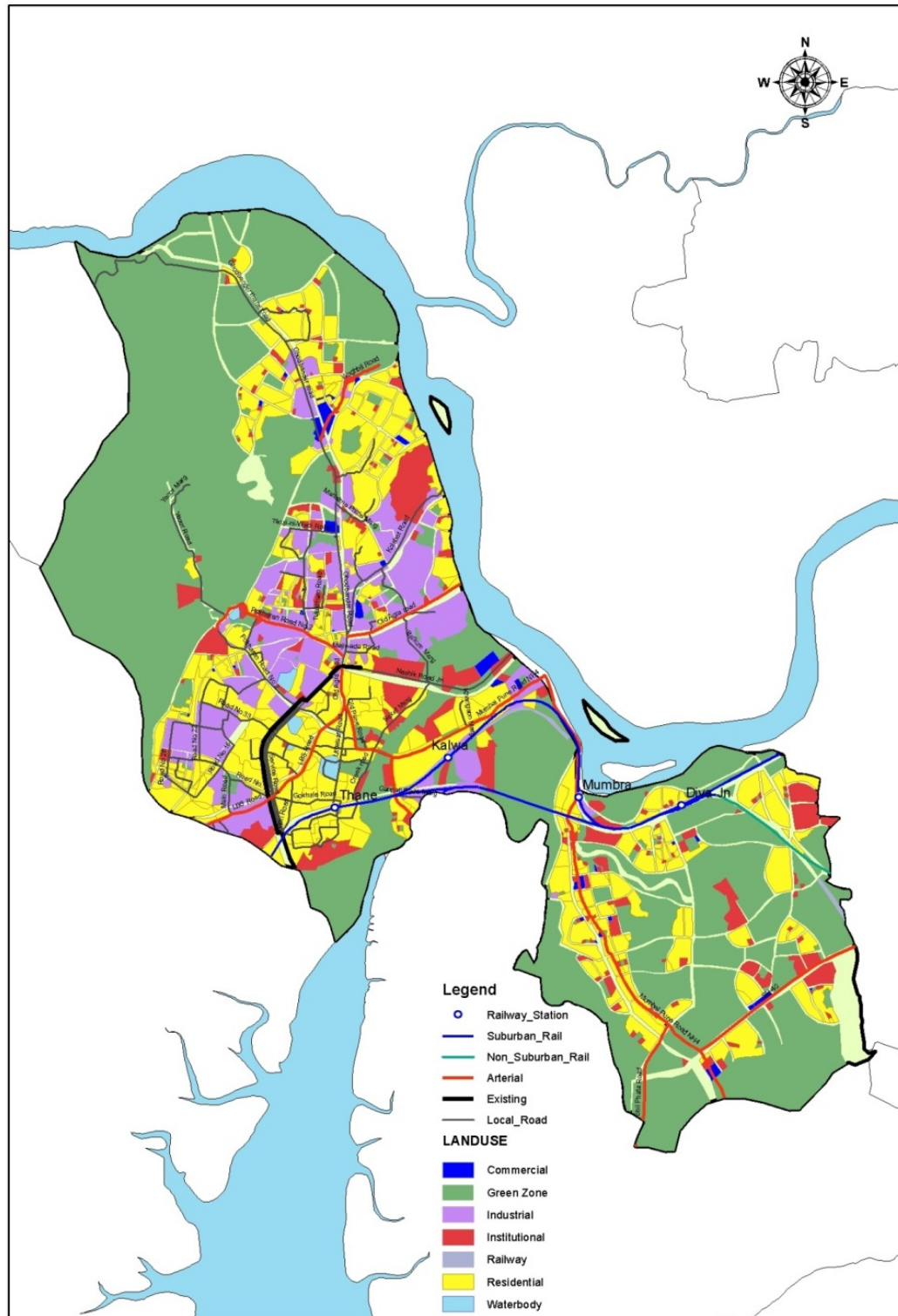
Year	Estimated Employment (In Lakh)
2001	4.2
2011	6.49

Source: Comprehensive Mobility Plan 2018

1.3.3 Area, Population Density, Migration and Spatial Pattern

The geographic area within the jurisdiction of Thane Municipal Corporation (TMC) is taken as the study area. The TMC study area comprise of about 147.0 Sq. km. The study area map has been shown in **Figure 1.3**.

FIGURE 1.3 : STUDY AREA MAP THANE



Population density of the city is 12527 persons per km². The city is growing at a good rate in terms of population and it is expected that the city will continue to do so in the upcoming years. Thane being an industrial hub has significant migrant workers' population increase over the years. There are a large number

of people migrating here due to job opportunity and the city is turning into a satellite city.

1.4 URBAN LANDUSE STRUCTURE/ACTIVITY DISTRIBUTION

1.4.1 Landuse As Per City Development Plan -2007

Thane Municipal Corporation (TMC) came into existence on October 1, 1982, initiated the process of preparing the existing landuse map. The process of preparation of Draft Development Plan was initiated in the year 1988 and published in the year 1991. The revised development plan was submitted for the approval of the State Government in 1986 which was finally sanctioned by the DTP with some modifications on 14th May 2003. The sanctioned development plan of the city is divided in seven broad zoning areas reveals the actual land available for the specified development and the land which will not be available for the development. The Landuse breakup with percentage of Thane city is presented in **Table 1.3** and **Figure 1.4**.

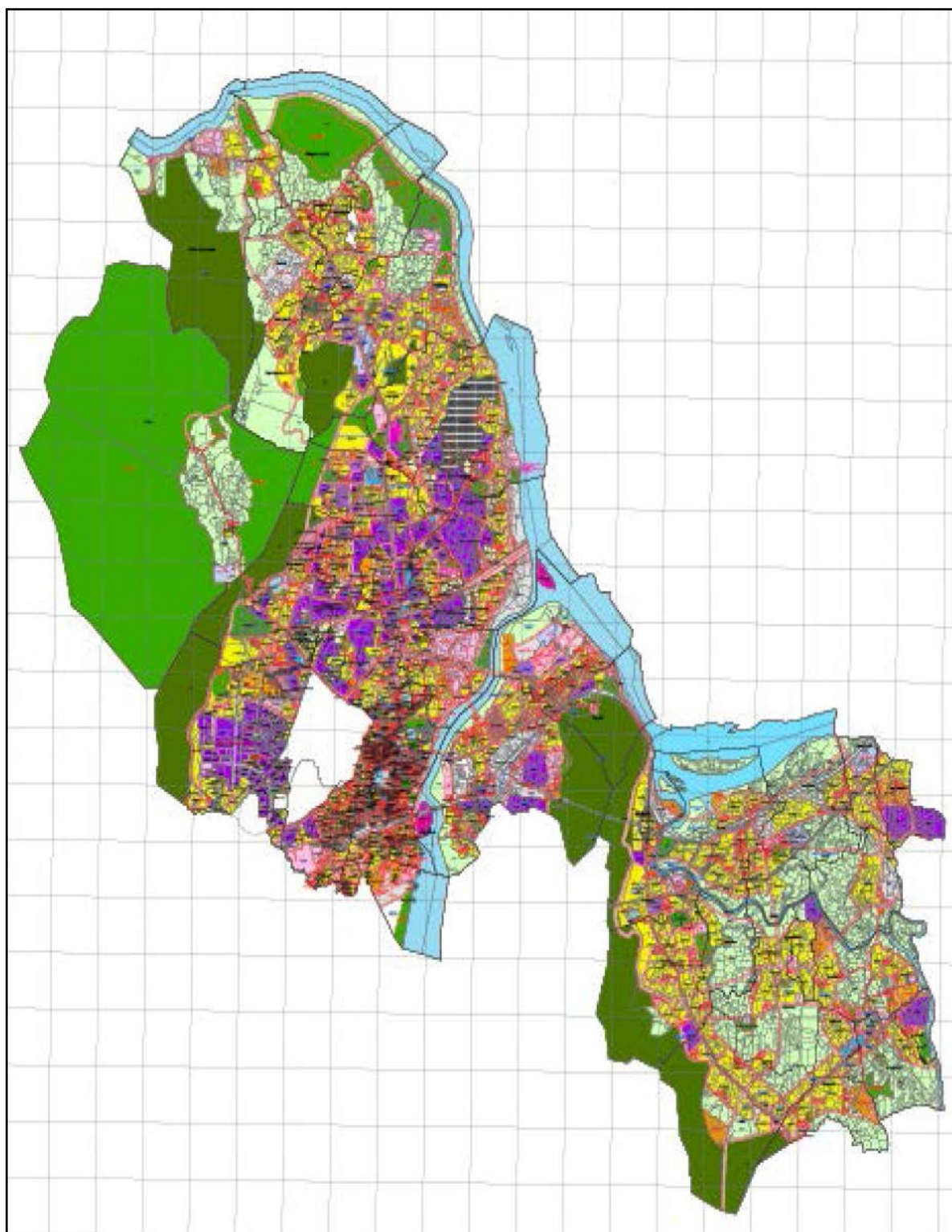
- The total area of corporation is 128.21 Sq Km. The broad categorization shows that 59.30 sqkm is developable, 36.82 sqkm is non-developable while 32.11 sqkm is under green zone.
- The area under road shown in the development plan is 7.42 sqkm. The area under residential zone is 26.65 sq km, while that under industrial zone is 12.54 sqkm.

TABLE 1.3: LANDUSE BREAKUP OF THANE CITY

Sno.	Zoning	Area (Sq Km)	Percentage
1.	Residential	26.65	20.80%
2.	Industrial	12.54	9.80%
3.	Reservation	12.67	9.90%
4.	Road	7.42	5.80%
5.	Defense Area	1.22	1.00%
6.	Forest Area	35.6	27.80%
7.	Green Zone	32.11	25.00%
8.	Total	128.21	100%

Source: City Development Plan, Thane 2007

FIGURE 1.4: DRAFT DEVELOPMENT PLAN FOR THANE-2007



Source: CDP 2007

1.4.2 Existing Land Use Pattern- As per CMP 2018

The Existing Land use map which was prepared on the basis of the Existing Land use Survey (ELU Survey) in CMP 2018. The ELU Survey was one of the key initial stages towards ELU Plan preparation. It has two main objectives, one, to determine current land uses, and, two, to assess the extent of implementation of the current DP.

The total area of Thane Municipal Corporation is 147 sq.kms as presented in **Table 1.4** and **Figure 1.5**. Most of this is covered by forests and greens and the rest is covered by residential, industrial and defense areas. According to city development plans 5930.23 hectares is development areas and 3682 hectares is non-development area. Around 742.97 hectares area has been used for roads.

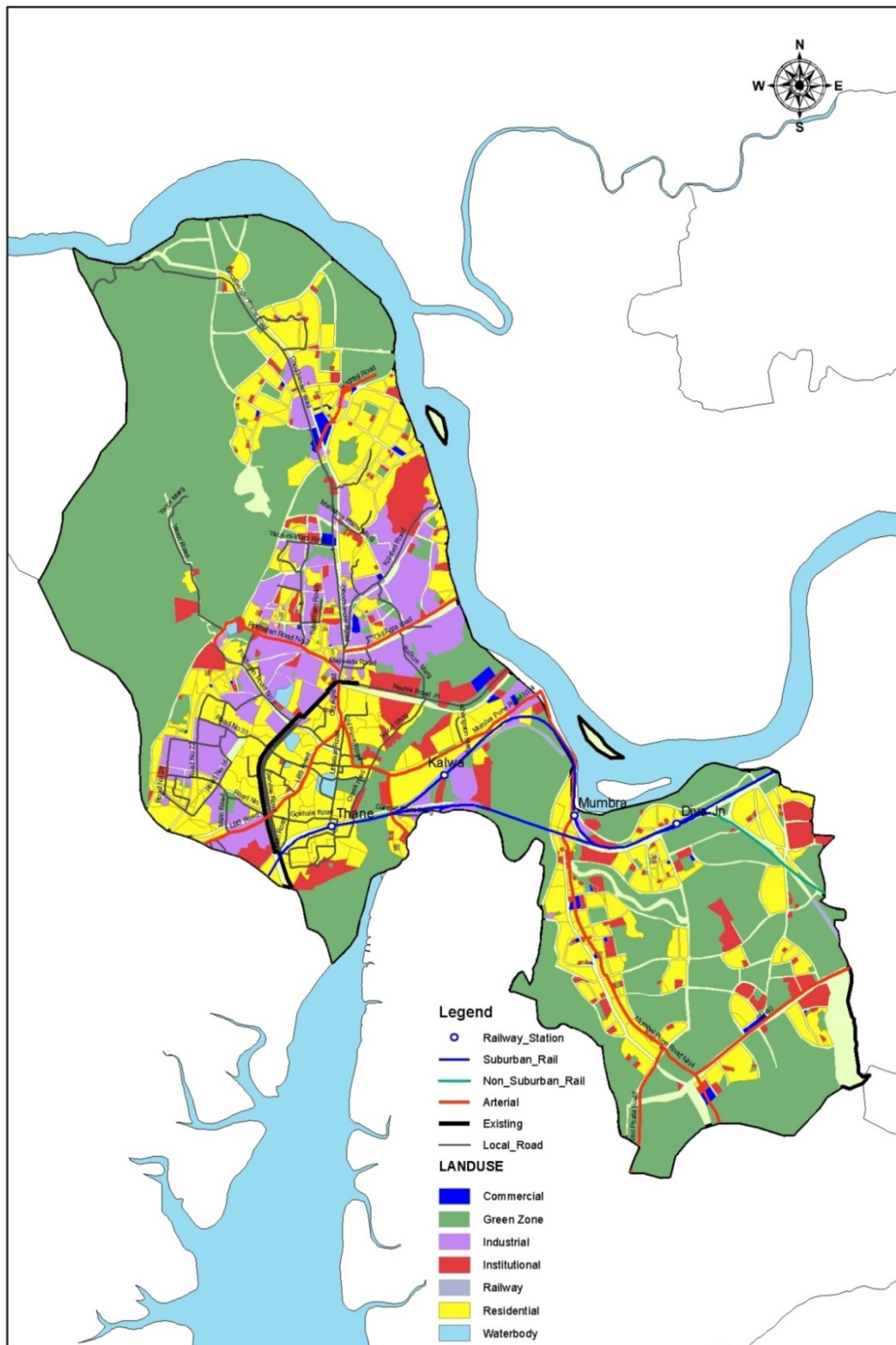
TABLE 1.4: LAND USE OF THANE CITY -CMP2018

Land area in TMC	Division Area(Hectares)
Residential	2665.61
Industrial	1254.67
Reservation	1267.67
Roads	742.97
Defense	122.0
Forest	3560.00
Greens	3211.77
Other	1875.31
Total	14700.00

Land use: Housing

The conversion of industrial areas into residential areas in recent years has boosted the real estate industry in Thane. Some of the biggest players in the real estate industry have set up their projects in Thane viz. Rustomjee, Lodha, Kalpataru, Runwal, Hiranandani and Akruti developers. The booming IT and BPO sector has also boosted the real estate industry.

FIGURE 1.5: EXISTING LAND USE PLAN OF THANE CITY (CMP2018)



Source: CMP 2018

a. Land use: Green & Open Area Allocation

The major land use category in Thane Municipal Corporation (TMC) is under forest and green zone (mangroves also fall under the green zone), together they occupy 46 % of the total within administrative boundaries, 3,211.77 Ha falls in green zone and 3560.0 Ha in forest zone.

b. Land Use: Industrial Areas

The manufacturing belt has been the economic driver of the city since 1961. However, due to a change in classification of industrial areas in TMC, Thane has seen a steady decline of manufacturing units and the trend is moving towards establishment of service industries and IT parks instead. TMC industrial area consists of Wagle Estate, Balkum and Kolshet. These industrial areas house mostly chemical, engineering, textile and electrical Industries and occupied area 8% of the total corporation boundary Area.

c. Land use: Reservation & Public Amenities

Thane city has 9 planning sectors and a total of 813 reserved sites covering an area of 1469.22 Ha. Thane Municipal Corporation has received reservation for 30.62 Hectares for entertainment facilities.

1.4.3 Zoning and Floor Space Index (FSI) Pattern

The land management and urban development initiatives within municipal jurisdiction are handled by Thane Municipal Corporation (TMC). As per Maharashtra Regional and Town Planning Act, 1966, TMC has formulated Development Control. the permissible FSI in Thane is presented in **Table 1.5**.

TABLE 1.5: PERMISSIBLE FSI IN THANE

Land Use	Permissible FSI
Residential	In R-1 zone, (a) for plots fronting on roads below 9 m. width, permissible FSI will be 1.5 only, (b) for plot fronting on road width of 9 m. above (existing or proposed) additional 0.5 FSI shall be allowed for commercial use only subject to condition that, margin and parking space as required under these regulations are provided and

Land Use	Permissible FSI
	separate access for residential and commercial users are provided.
Other Buildings	Maximum floor space index shall be 1.33
Educational Buildings	The maximum F.S.I shall be 1.00
Institutional Buildings	The maximum F.S.I. shall be 1.00
Public Entertainment Hall/Mangal Karyalaya Building	The maximum F.S.I. shall be 1.00
Commercial	The maximum F.S.I. shall be 1.00. For the purpose of F.S.I. net area of land excluding open space and area covered by internal roads shall only be considered.
Industrial	The maximum F.S.I. shall be 1.00

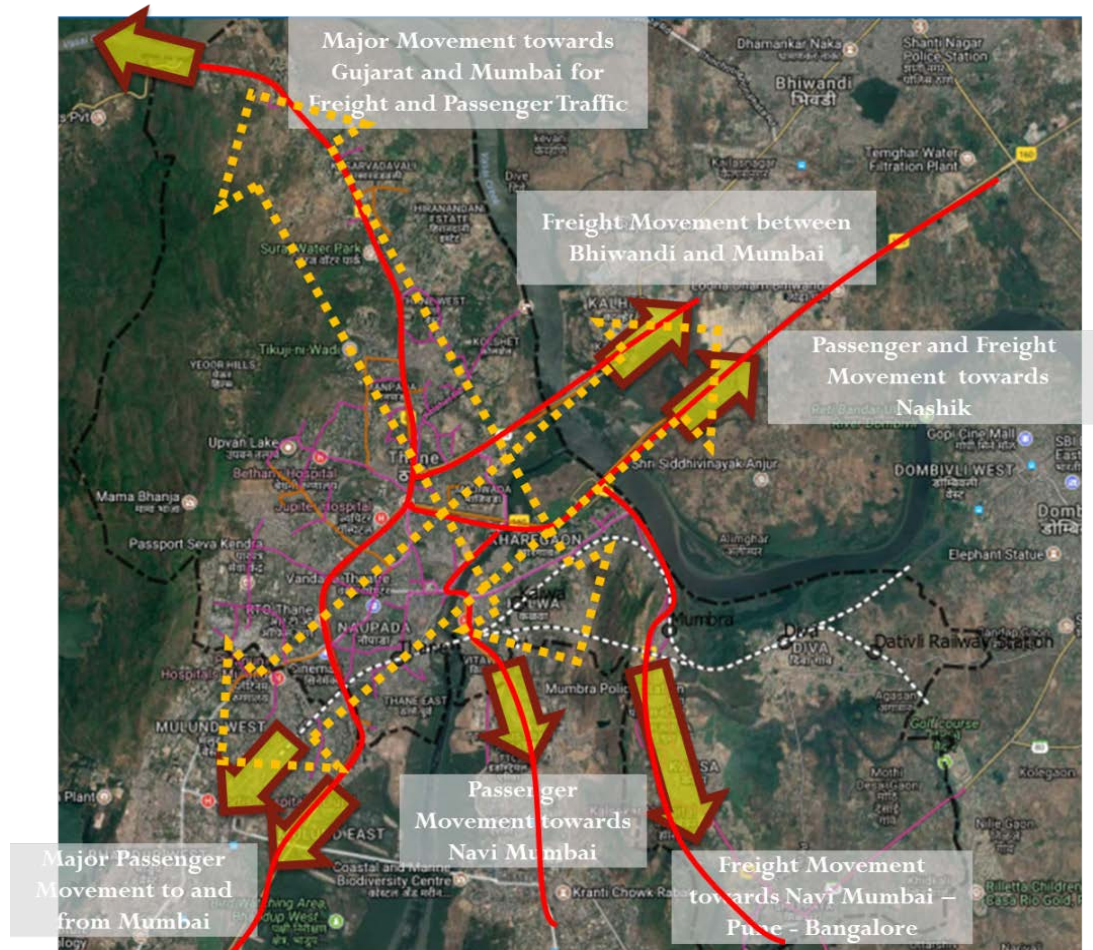
1.4.4 Development Pattern Of Thane - Existing

The existing development pattern revolves around three development nodes and axis-

- i. Development around the Thane Railway Station, Mumbra & Kalwa Railway Station: The area around the Thane railway station up till the Eastern Express Highway forms the Old city or the core city. Till the early 2000, the majority of the population and city growth was confined to the Core city. The core city is serviceable by the Railway Station with a maximum access distance of 2 to 3 km.
- ii. Development along the Wagle Estate Industrial (MIDC) Area: In the late 20th Century, Thane developed as an industrial town, with industries set up at the MIDC Industrial estate. A lot of worker housing and development took place around the Wagle estate area with development taking place along and between the Eastern Express Highway and the National park on the other side, till the Old Agra Road or Bhiwandi Road.
- iii. Development along Ghodbunder Road and Eastern Express Highway: In the first decade of 21st Century, with the opening up of Real estate sector and widening of Ghodbunder Road, large scale township and high rise residential development started to take place on both sides of the Ghodbunder road in a ribbon like pattern. The growth velocity of development occurring near to the Ghodbunder Road and Eastern Express Highway has been very high with a

large cosmopolitan mix of people, who have migrated from other regions of MMR, state and India. Today Ghodbunder Road has become a go to destination in Thane due to wider roads and new age amenities and developments.

FIGURE 1.6: THANE AS A TRANSIT HUB OF MMR



The location of Thane within MMR and the geomorphic formations across the MMR makes Thane a transit hub due to the following reasons

- It falls in the midst of the Route from Bangalore/Goa to Ahmedabad and Nasik. All vehicles which have to travel from Gujarat direction to Goa/Karnataka have to pass necessarily through Thane.
- Bhiwandi, much precisely the Kalher – Kasheli Belt which forms the largest warehousing and storage centre for all kind of goods in Mumbai Metropolitan Region is accessible through Thane, thus all goods vehicles transporting goods from and to these warehousing centres have to travel through Thane.

- For all vehicles travelling from Mumbai to Nasik and further to Madhya Pradesh have to pass through Thane.

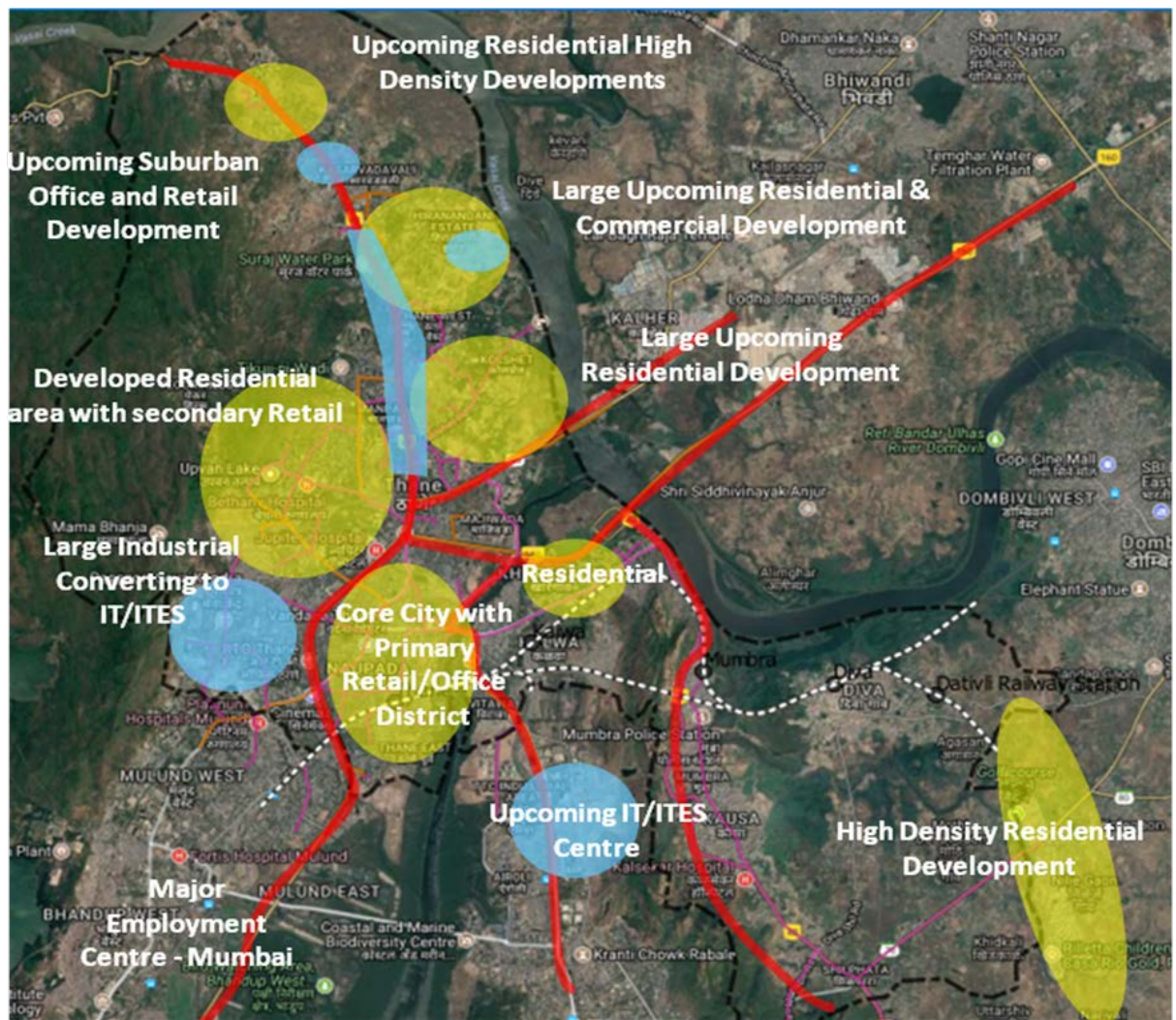
Thus Thane is affected by problems of transportation not only due to its internal travel needs, but also due to the larger regional needs and also due to large through traffic.

1.4.5 Development Pattern Of Thane - Future

Some of the important development initiatives that can impact the development pattern are listed below.

- a. Further growth and densification along the Ghodbunder Road up till Gaimukh, as many multi-storeyed complexes and townships are getting developed along with the infrastructure development. Level of amenities is of higher grade with a cosmopolitan environment making it a high growth area for the medium to long term.
- b. Development of Retail and Office (specifically IT/ITES) employment centres along Ghodbunder Road.
- c. Development and conversion of Wagle estate and Trans Thane Creek area including Airoli Knowledge Park into an IT/ITES park and a major employment centre of MMR as per the promotional scheme of Government of Maharashtra.
- d. Cluster Redevelopment Scheme with higher floor space index which will result in re-densification of older city areas including core city, but at the same time leading to development of road infrastructure and other components.
- e. Development of Thane Creek length as a Recreational zone which will impact recreational movement across the city
- f. Further development of Kalher, Kasheli into a storage and warehousing zone for MMR
- g. Development of Kharbav area into residential development in the long term.

FIGURE 1.7: MAJOR AREAS AND LANDUSE ACTIVITIES



1.5 SCOPE OF WORK

DPR for Thane Metro has been prepared as per Metro Policy, 2017 of MoHUA, Government of India. The scope covers the following:

1.5.1 Assessment of City Profile with Existing Transport Characteristics

Task 1: A brief overview of the city in terms of its growth, economy, spatial structure and trends, perspectives on the future growth. Overview of study areas and existing plans with land use distribution, review of zoning Regulations, employment distribution by Traffic Zones, land use plan proposals shall be done.

Task 2: Brief review of previous transport studies like City Master Plan, Comprehensive Mobility Plan and proposed Metro Rail Plan and other urban

transport proposals will be carried out. A brief showing interconnection among City Master Plan, Comprehensive Mobility Plan and proposed metro rail plan should be given.

1.5.2 Travel Characteristics and Demand Estimates

Task 3: Describes the components of urban transport system in terms of status, trends and gaps based on primary survey data, present travel patterns and forecast for the future travel demand will be described.

Task 4: Based on primary survey data and various traffic and transportation studies undertaken for the city, the present travel patterns and forecast for future travel demand should be done.

Task 5: Travel demand analysis, model framework, model calibration, summary of travel demand patterns and ridership assessment for horizon year should be done.

The data and analysis for this section has been taken from the CMP of Thane prepared in 2018 by MAHA Metro through another consultant.

1.5.3 System and Technology Selection

Task 6: Identification of suitable transit technology and the system specification to be adopted for the corridor including the rationale for choosing a particular technology as per the prescribed specification as issued by MoHUA from time to time. The technology chosen should not be a proprietary technology of any vendor.

1.5.4 Corridor Alignment Description

Task 7: Alignment description of approved alignment, with details about site conditions specifying road geometrics, utilities available along the corridor.

Task 8: Detailed analysis of corridor options with grade selection for construction shall be carried out. Design norms for track geometry, fixed structure clearance, geotechnical details with new innovative techniques to be used for implementation in civil works, track system etc

Task 9: Identification of existing services/utilities, if any

Task 10: Detailed estimation regarding land requirement for the corridor, depots, stations, parking, multi modal stations etc. with land ownership

1.5.5 Station Planning

Task 11: Station planning with preparation of general layouts based on type of station and site specific conditions focusing on:

- Station Area planning for non-motorized vehicles and pedestrians' facilities, multi modal integration with existing modes, feeder service planning.
- Accessibility for differently abled persons including specifying parking at stations for private and para transit facilities.
- Platform widths based on Station loadings and the minimum width to be provided.

1.5.6 Intermodal Integration

Task 12: Preparation of an Intermodal Integration Plan focusing on how the Metro Rail will integrate with the existing transportation systems/proposed transit system and introduction of a feeder system, integrated with the proposed Metro Rail project for improving last mile connectivity. This will include not only preparation of an operational plan for feeder system but also infrastructure that need to be upgraded/ improved or introduced for improving the intermodal integration with other modes of public transport to improve the viability of the project. Recommendations for institutional integration, physical integration, fare integration, operational integration and technology integration would also need to be elaborated in the report.

1.5.7 Train Operation Plan

Task 13: System operation approach, station yard planning, trains operation plan including system frequency, timetabling, rolling stock requirement, stabling details.

1.5.8 Signaling and Telecommunication

Task 14: Identification of Signaling and System control, Operation Control Centre (OCC), maintenance requirement, technology selection and choice of automation

Task 15: Identification of Telecommunication System, System Traffic Control, maintenance and emergency communication and Passenger Information System (PIS)

1.5.9 Fare Collection System

Task 16: Detailing the specifications for Automatic fare collection system, Ticketing and pass system, Fare System integrated with other transport Systems including integration of fares of all available modes with the metro system planned as per the guidelines issued by MoHUA.

1.5.10 Rolling Stock

Task 17: Technology selection, identification of rolling stock adopted as per Guidelines laid by MoHUA. Rationale for deviations, if any in choice of rolling stock parameters from the prescribed specifications and standards prevailing and rolling stock requirement for various horizon years should be specified.

1.5.11 Power Supply and Traction System

Task 18: Choice of electric traction system. Projected power demand, Source of power supply, Traction and Auxiliary Supply and supervisory control and data acquisition system. Number of tractions and their locations are also to be detailed out.

1.5.12 Ventilation and Air Conditioning System

Task 19: Need for Ventilation and Air Conditioning, design parameters and design concepts for VAC System with details on tunnel ventilation, station ventilation and air conditioning of ancillary spaces including specifications for control and monitoring facilities.

1.5.13 Depots

Task 20: Identification of Depot locations, approach to maintenance of depot

facilities and workshop along with detailed designs and layout plans.

1.5.14 Environmental and Social Impact Assessment

Task 21: Existing scenario, with analysis on water quality, noise level, land environment, biological environment etc.

Task 22: Environmental norms and regulations, detailed Environment Impact Assessment (EIA), Environment Management Plan (EMP), formation of an Environmental Management System (EMS) and costs estimates for Environment Impact mitigation measures.

Task 23: Detailed Social Impact Assessment (SIA) including R&R assessment, Resettlement Impacts, Resettlement Assistance Plan (RAP) and Monitoring and Evaluation Framework

1.5.15 Disaster Management and Security Measures

Task 24: Disaster Management, Disaster Management imperatives, Objectives of Disaster Management Plan, Systems to cater for disasters and Security Systems recommended for MRTS and Safety and Security Measures.

1.5.16 Cost Estimation

Task 25: Detailed project cost estimates shall include

- Capital cost estimates including taxes and duties
- Innovations proposed to reduce the cost of system
- Estimation of Operations and Maintenance Cost and the assumptions made thereof

1.5.17 Transit Oriented Development Plan

Task 26: The potential for transit oriented development along the metro corridor based on the guidelines issued by MoHUA to be developed including densification of corridor by increasing FSI and land value capture as per the guidelines issued by MoHUA. Guiding List of lands/areas amenable for change in near future e.g. vacant land, low rise development relocation, used type etc.

1.5.17 Financial Analysis and Non Fare Box Revenue Assessment

Task 27: Estimations and inputs for the corridor, estimation for O & M, overheads, phasing of construction and lease of built up area (BUA), operational viability of the project.

Task 28: Means of finance, revenue from different sources, fare box revenue, non-fare box revenue, like advertisement, taxes and property development etc, possible ways of funding the project using different approaches. Alternative means of funding the project using different approaches Like PPP, BOT, DBFOT, DFBOT Etc. The proposed funding /implementation model will be identified in line with the Metro Policy 2017.

Task 29: Financial Return: FIRR with 30 year time horizon, Sensitivity analysis should be done based on scenario building with variation in ridership estimates scenarios, costs estimates and Time overrun. Alternative scenarios based on the different options for funding / implementation of the project should be evaluated. A project should be able to meet its financial requirement for cost recovery and under a set of plausible assumptions be able to self-finance its activities. State Governments will have to ensure the financial sustainability of the project through financial assistance.

1.5.18 Economic Analysis

Task 30: The economic analysis shall include economic cost and benefit analysis of the project and estimation of the EIRR for a period of 30 years.

1.5.19 Implementation Plan

Task 31: Project implementation structure, if proposed to be implemented under various alternatives such as public or PPP model, role, responsibility and involvement (including financial stake) of the city government along with other government agencies in metro rail project, needs to be elaborated in the report.

1.5.20 Institutional Arrangement and Stakeholders Consultation

Task 32: Legal and Institutional Framework for implementation of the project based on the identified implementation plan shall be included in the DPR. Stakeholders' consultation shall be held at each major stage of the project

such as the Draft DPR stage.

1.6 COMPOSITION OF THE REPORT

This 'Draft Final Report' consists of following 21 chapters:

Chapter 1: Profile of the City covers background, demographic characteristics and urban landuse structure of the study area.

Chapter 2: The chapter gives existing transport system covering existing road network, traffic characteristics status of IPT and PT systems.

Chapter 3: Existing traffic and travel characteristics, development of base year transport demand model and future travel demand estimates have been covered in the Chapter.

Chapter 4: System and Technology Selection covering traction system etc. are part of the Chapter.

Chapter 5: This chapter gives the details about civil engineering components covering alignment planning, geometric design parameters, geotechnical investigations, utilities and land requirements.

Chapter 6: Station Planning Chapter gives the typical stations, facilities for differently-abled, parking planned for metro corridor

Chapter 7: Intermodal integration - the interchange possibilities of existing and proposed modes of transport are summarised in this Chapter.

Chapter 8: Train operation plan gives operation plan for trains and frequency of operation for the proposed corridor

Chapter 9: Signalling and Telecommunication Chapter covers the types of signaling and telecommunication systems and standards

Chapter 10: The Chapter on Fare Collection System covers the proposed ticketing system for passenger fare collection

Chapter 11: The chapter gives the requirement of rolling stock for operation

Chapter 12: This Chapter gives power supply requirements, sources of power supply, substations and related infrastructure facilities

Chapter 13: Ventilation and Air Conditioning Systems Chapter covers the need for ventilation and standards adopted

Chapter 14: Maintenance depot facilities, rolling stock maintenance and depot layouts are covered in this Chapter

Chapter 15: This Chapter details the Environmental & Social Impact Assessment characteristics covering environmental and social components

Chapter 16: Disaster Management and Security Measures Chapter covers types of disaster, preparedness and security measures

Chapter 17: Detailed Cost Estimates chapter includes details on capital and O&M cost

Chapter 18: This chapter covers the revenue potential along the corridor from Transit Oriented Development

Chapter 19: Financial Analysis and Non-Fare Box Revenue chapter covers revenue estimates and estimation financial internal rate of return

Chapter 20: Economic Analysis chapter gives economic benefits and estimation of Economic Internal Rate of Return

Chapter 21: Implementation Plan chapter provides the project implementation options

Chapter – 2

EXISTING TRANSPORTATION SYSTEM IN THE CITY

2. EXISTING TRANSPORTATION SYSTEM IN THE CITY

2.1. INTRODUCTION

Urbanization and rapid growth of vehicles population has laid severe stress on the urban transport system in Thane. Increase in vehicular traffic and limited augmentation road infrastructure facilities have been observed in the City. Private modes have gained more usage due to limited public transport facilities with poor level of service. This necessitates the assessment of existing transportation infrastructure in the City.

2.2. VEHICULAR GROWTH AND COMPOSITION

The registered vehicles in Thane have increased significantly over the years. The numbers of vehicle registration per year have climbed from 13.9 lakh to 19.4 lakh in the about six years. This high density and rapid growth of vehicles have affected the existing transport situation to a significant extent. The share of two wheelers is highest at about 56%. It is significant to note that 24.4% of the vehicles in Thane are cars and jeeps. The sharp increase of two-wheelers and cars could be attributed to the improved economic status of people and lack of city wide good public transport system. The increase of private modes demands more road space and has resulted in dense concentration of traffic on roads. The growth of registered vehicles for last six years is presented in **Table 2.1**.

TABLE 2.1: GROWTH OF REGISTERED VEHICLES IN THANE (IN LAKH)

SN	Vehicle Type	2011	2012	2013	2014	2015	2016	2017
1	Two Wheelers	7.22	7.86	8.51	8.89	9.53	10.11	10.89
2	Car/Jeep	3.51	3.72	4.01	4.05	4.16	4.36	4.55
3	Luxury Cabs /Tourist Cabs/Taxis meter fitted	0.28	0.30	0.29	0.31	0.31	0.34	0.41
4	Three-Wheeler (Auto-rickshaws)	0.87	0.87	0.88	0.86	0.87	0.91	0.95
5	Stn. Wagons/ Contract carriages/ Mini Bus/ Ambulances	0.14	0.15	0.16	0.17	0.17	0.18	0.20

SN	Vehicle Type	2011	2012	2013	2014	2015	2016	2017
6	Stage carriages/School Buses	0.02	0.02	0.02	0.01	0.02	0.02	0.03
7	Buses (Articulated/Multi.)	0.04	0.05	0.09	0.11	0.11	0.11	0.11
8	LCV (Delivery Van 4W/3W)	0.96	1.09	1.21	1.20	1.21	1.24	1.28
9	Trucks/Lorries/Tanker	0.80	0.83	0.81	0.87	0.87	0.85	0.90
10	Tractor & Trailers	0.08	0.09	0.10	0.10	0.10	0.10	0.10
11	Others	0.02	0.02	0.03	0.03	0.03	0.03	0.03
	Total	13.93	14.99	16.10	16.60	17.38	18.25	19.44

Source: Thane RTO Office, 2017 Statistics

2.3. ROAD NETWORK CHARACTERISTICS

The road network inventory was carried out along all arterial and major roads in the study area. The data collected as part of this survey include the right of way, carriageway details, footpath, median, street lighting and abutting land use. The survey has been conducted for a total length of about 366 km.

The distribution of the road network as per right of way (ROW) is presented in **Table 2.2**. It can be observed from the table that about 67% of road network has less than 20m ROW, 21% has ROW between 20-30m and merely 12% of the road has ROW more than 30m

It was observed from the field surveys that about 92% of the road network has footpath available along the road. The details footpath availability is presented in **Table 2.3**

TABLE 2.2: DISTRIBUTION OF ROAD NETWORK AS PER RIGHT OF WAY

S. No.	Right of Way (m)	Length (km)	Percentage (%)
1	< 10	190.74	52.11
2	10 – 20	54.46	14.88
3	20 – 30	76.70	20.96
4	30 – 40	27.94	7.63
5	>40	16.16	4.42
	Total	366.00	100.00

Source: CMP Thane -2018

TABLE 2.3: AVAILABILITY OF FOOTPATH

S. No.	Footpath	Road Length (km)	Percentage (%)
1	Present		
	<i>One-side</i>	25.0	6.83
	<i>Both-sides</i>	312.50	85.38
2	Absent	28.50	7.77
Total		366.00	100.00

Source: CMP Thane -2018

2.4. MAJOR TRANSPORT NODES

There are five major bus terminals in the City, namely, SATIS Thane West, Lokmanya Nagar, Thane Station East, Wagle Agar and Chendani. The total Boarding and Alighting figures are observed to be 1,12,633 (SATIS Thane West Bus Terminal), 20,027(Wagle Agar Bus Terminal) 7883 at Chendani Bus Terminal, 15010(Thane Station East) and 14,326 Lokmanya Nagar Bus Terminal.

The study area is served majorly by four Railway Stations, namely, Thane Station, Kalwa Station, Mumbra Station and Diva Station which provide connectivity to major cities. . The total Boarding and Alighting figures are observed to be 612637 (Thane), 245967(Diva), 2,02811 (Mumbra) and 183031 (Kalwa).

2.5. PEDESTRIAN AND NMV FACILITIES

The pedestrian volume counts were carried at major junctions throughout the study area. The survey was carried out continuously for a period of 12 hours (8 a.m. to 8 p.m.) for along and across pedestrian movements. The daily and peak hour pedestrian flows at various survey locations are presented in **Table 2.4**.

The maximum daily pedestrian volume in across direction is observed as 2613 pedestrians at EE Highway – Teen Hath Naka on approach road towards Mulund. Similarly, maximum morning and evening peak hour pedestrian across the road is observed at EE Highway – Teen Hath Naka on approach road towards Mulund with 392 pedestrians in morning and 314 pedestrians in evening.

TABLE 2.4: DAILY & PEAK HOUR PEDESTRIAN TRAFFIC AT SURVEY LOCATIONS

S. No.	Name of Location	Approach	Daily Pedestrian Vol. (12 hours)		Peak Hour Pedestrian Vol. (Morning Peak) (Evening Peak)			
			Across	Along	Across	Along	Across	Along
1	GB Road – Hypercity junction	Thane	765	-	107	-	138	-
		Borivali	578	-	69	-	69	-
		Kasarvadavali Road	356	-	36	-	36	-
2	GB Road – Dmart	Thane	862	-	103	-	103	-
		Parkwood Society	256	-	26	-	31	-
		Borivali	675	-	74	-	101	-
		Vijay Garden Rd	402	-	48	-	56	-
3	GB Road – Patlipada	Thane	265	-	32	-	32	-
		Borivali	198	-	30	-	20	-
		Hiranandani Estate	452	-	63	-	50	-
4	GB Road – Manpada	Thane	302	-	36	-	33	-
		Tikujiniwadi Road	498	-	50	-	80	-
		Borivali	398	-	44	-	60	-
		Manorama Nagar	278	-	31	-	28	-
		Manorama Nagar	307	-	49	-	34	-
5	GB Road – Tulsidham Junction	Thane	275	-	41	-	28	-
		Tulsidham	405	-	41	-	41	-
		Borivali	198	-	22	-	22	-
6	GB Road – Kapurbawdi	Thane	168	-	20	-	20	-
		Borivali	207	-	35	-	25	-
		Old Agra Road	845	-	101	-	101	-
7	GB Road – Pokhran Road No 2	Thane	246	-	39	-	30	-
		Pokhran Road No. 2	745	-	75	-	112	-
		Majiwada	304	-	33	-	43	-
8	EE Highway – Teen Hath Naka	Mulund	2,613	-	392	-	314	-
		LBS Marg	1,295	-	155	-	130	-
		Majiwada	1,846	-	185	-	203	-
		LBS Marg	957	-	96	-	105	-
		Gokhale Road	956	-	96	-	153	-
9	EE Highway – Wagle Estate Road Junction	Teen Hath Naka	1,576	-	173	-	236	-
		Kamgar Hospital Road	869	-	104	-	87	-
		Cadbury Jn.	1,486	-	178	-	163	-
		Almeda Road	1,205	-	157	-	121	-
10	EE Highway – Cadbury Junction	Nitin Company	1,256	-	188	-	138	-
		Pokhran Road No. 1	645	-	103	-	97	-
		Majiwada	1,006	-	151	-	121	-
		Khopat Road	948	-	104	-	171	-
11	GB Road – Majiwada	Nitin Company	456	-	55	-	46	-
		Majiwada	386	-	58	-	42	-
		Bhiwandi	245	-	34	-	27	-
		Thane Station Rd	789	-	95	-	95	-
12	EE Highway – Saket Road Junction	Balkum	349	-	35	-	42	-
		Saket Road	256	-	28	-	31	-
		Estern Express Highway	-	-	-	-	-	-

S. No.	Name of Location	Approach	Daily Pedestrian Vol. (12 hours)		Peak Hour Pedestrian Vol. (Morning Peak) (Evening Peak)			
			Across	Along	Across	Along	Across	Along
13	Station Road – Uthalsar Naka	LBS Marg	645	-	103	-	97	-
		Prabhakar Hegde Marg	256	-	38	-	36	-
		Thane Station Rd	306	-	31	-	37	-
		LBS Marg	549	-	60	-	55	-
		Runwal Nagar	245	-	29	-	27	-
14	Kalwa Bridge Thane Side	Old Pune Road	765	-	115	-	84	-
		Saket Kalwa Road	461	-	65	-	74	-
		Kalwa Bridge	675	-	81	-	101	-
		Chendani Bunder Road	478	-	48	-	48	-
15	Kalwa Bridge Kalwa side	Kalwa Bridge	561	-	62	-	62	-
		Pune Mumbai Highway	1,256	-	138	-	126	-
		Thane Belapur Road	1,475	-	236	-	162	-
16	Old NH-4 Retibhander	Pune Mumbai Highway	498	-	75	-	75	-
		Pune Road	512	-	51	-	82	-
		Mumbra Bypass Road	376	-	41	-	45	-
17	Old NH-4 Shilphata	Mumbra	781	-	86	-	78	-
		Diva Shil Road	451	-	54	-	50	-
		Kalyan	1,245	-	149	-	187	-
		Mahape Road	987	-	118	-	99	-
18	Pokhran Road – Gladis Alwaris Marg Jn	Gladis Alwaris Marg	645	-	77	-	71	-
		Pokhran Road No. 2	612	-	92	-	110	-
		Pokhran Road No. 2 Upwan	456	-	64	-	46	-
19	Gladis Alwaris Marg – Hiranandani Meadows Jn	Pawar Nagar	612	-	73	-	67	-
		Gladis Alwaris Marg	519	-	52	-	57	-
		Hiranandani Meadows	456	-	50	-	55	-
		Gladis Alwaris Marg	598	-	66	-	72	-
20	Khopat Jn on old Agra Road	Khopat Road	675	-	108	-	81	-
		LBS Marg	845	-	127	-	152	-
		Ambedkar Road	410	-	41	-	57	-
		LBS Marg	562	-	62	-	90	-
21	Jail Rd – Near Jail Lake	Prabhakar Hegde Marg	498	-	50	-	50	-
		Jail Road	425	-	47	-	47	-
		Prabhakar Hegde Marg	562	-	67	-	67	-
		Shankar Rao Pendekar Marg	356	-	53	-	43	-
22	Wagle Estate Road No.22	SG Barve Road	351	-	49	-	42	-
		Pokhran Road No. 2	459	-	55	-	69	-
		SG Barve Road	348	-	35	-	56	-
		Kisan Nagar	561	-	62	-	67	-
23	Naupada Jn – Near Malhar Cinema	Gokhale Road	465	-	51	-	47	-
		M.G. Road	598	-	96	-	66	-
		Gokhale Road	615	-	92	-	86	-
		M.G. Road	542	-	54	-	98	-
24	Pokhran Rd no – 1, Kores	Upwan	845	-	93	-	101	-
		Bhim Nagar	783	-	78	-	78	-

S. No.	Name of Location	Approach	Daily Pedestrian Vol. (12 hours)		Peak Hour Pedestrian Vol.			
					(Morning Peak)		(Evening Peak)	
			Across	Along	Across	Along	Across	Along
	Junction	Cadbury Jn.	541	-	60	-	87	-
		Acharya Atre Marg	625	-	75	-	63	-
		Saket Road	512	-	77	-	61	-
25	Saket Road Jn – On Old Agra Road	Old Agra Road - Thane	615	-	86	-	62	-
		Old Agra Road - Bhiwandi	698	-	84	-	77	-
		Almeda Road	641	-	64	-	96	-
26	Mahapalika Bhavan Rd – on LBS Marg	LBS Marg	725	-	80	-	102	-
		Lazarus Road	695	-	76	-	90	-
		LBS Marg	452	-	72	-	45	-

Source: Primary Survey (CMP-2018)

The CMP has also recommended some proposed measures to develop facilities for pedestrians and bicyclists on the streets as mentioned below:

- Rental cycle scheme has been introduced with cycle stands at seven locations.
- Dedicated cycle tracks have been proposed on all major arterial where sufficient width is available.
- On all new links proposed, dedicated cycle track has been proposed.
- Cycle stands have been proposed at all metro stations.

2.6. TRAFFIC MANAGEMENT INCLUDING PARKING MANAGEMENT

Traffic Management proposals in CMP consists of development of a parking strategy, junction improvement, planning of ITS systems, removal of encroachment at various locations etc. in order to shape the frame work for the future provision, management and maintenance of traffic.

Traffic Management proposals in CMP includes:

- Removal of encroachments on major roads.
- Substantial improvements in junctions by providing proper signages and markings - Creek Junction, Gokhale Road Junction, Shivaji Chowk, Kasarvadavli Junction and Shil Phata Junction etc.

- Education & Enforcement - Overall awareness of the traffic discipline and compliance with the traffic rules by road users in Thane is far below the desired level.
- Installation of ITS systems at major junctions for easy flow of traffic.
- Other Traffic Management Measures
 - Bus stops should be at least 60 m away from the junctions
 - Bus bays should be considered at all possible bus stop locations
 - Auto parking should be banned near all junctions and moved at least 50m away from junctions.
 - On street parking should be banned at critical locations on all major roads. To curb the menace of haphazard and illegal parking on main roads-measures like restricted parking, time limit parking and metered parking should be thought.

The development of Parking Strategy has been based on understanding of the parking supply and demand position in Thane City. The parking strategies that would be considered for Thane include:

- Thane Municipal Corporation prepared Parking Policy and Plans to cater for on-street parking of about 6,800 for 2-wheeler, 2,600 for 3-wheeler, 4,100 for 4-wheeler and 630 for heavy vehicles including buses. This is free of cost.
- Off-street paid parking's has been developed at Ashar Complex, Kacharali Talao and Gaodeo Market for 300 for 2-wheeler, 150 for 3-wheeler and 80 for 4-wheeler.
- Core city experiences very high parking demand with no land available for creation of off-street parking infrastructure.
- Existing bus terminals have been utilized to create parking in core city area.
- Specific areas for ambulance parking have been identified.

As per CMP, to encourage the use of off street parking facility, the on street parking charges should be kept higher than off street parking fees. The pricing should be based on three aspects viz type of parking, location and demand management.

2.7. TRAFFIC CHARACTERISTICS

2.7.1 Traffic Volumes and Composition

The daily traffic volumes total vehicles in terms of numbers of vehicles and Passenger Car Units (PCUs) have been computed at various mid-block locations. The counts observed at different locations varies from varies from 32,520 Vehicles (27,931 PCU's) at Gokhale Road near Navpada to 1,09,102 Vehicles (2,25,220 PCU's) along Bhiwandi Bypass Near Thane Creek Bridge throughout a normal working day.

2.7.2 Speed and Delay Characteristics

It is observed that about 52% of the total road network has journey speed upto 20 kmph during peak hours. About 24% of surveyed network has journey speed between 21-30 kmph and only 24% of road network has journey speed more than 30 kmph. Average Journey Speed during peak is observed to be 20 kmph.

The delays are caused mostly by traffic signal which account for about 39% in the peak hour, while traffic signal with congestion account for about 25%. Whereas in the off peak period, traffic signal accounts for 49%.

2.8. TRAFFIC SAFETY

The increase in number of private vehicles and inter mixing of slow and fast moving vehicles on road has led to increase in number of accidents on roads in Thane, which is a cause of concern. Considering the urban expanse, population growth and increased trends of vehicles on city roads; the safety of commuters is equally vital.

There are many reasons for the growth in the number of accidents in Thane such as increase in population and rise in vehicle ownership. They are also caused due to the casual approach of road users in observing driving rules, adhering to safety precautions and regulations. Over-speeding and negligent driving have proved to be a frequent cause of serious and fatal accidents. Similarly, poor road geometry has also increased the incidence of accidents on urban roads. One of major causes of pedestrian safety is endangered by extended trading activities of shops and commercial activity on footpaths and sidewalks. This compels the pedestrians to clog the road space, hence give a

chance to accidents.

Table 2.5 shows the number of accidents in recent years along-with the number of fatalities and series/ minor injuries occurred.

TABLE 2.5: ROAD ACCIDENT STATISTICS IN MUMBAI

Year	Fatal Accidents	Total Accidents	Killed	Injured
2013	481	23,512	502	4,250
2014	534	23,490	557	4,140
2015	586	23,468	611	4,029
2016	529	3379	562	3517

Source: Year-wise Statistics on Road Accidents in Mumbai, India, MoRTH, 2013-16

2.9. INTERMEDIATE PUBLIC TRANSIT (IPT) SYSTEM

Intermediate Public Transport (IPT) modes i.e. Taxi and Auto in Thane city plays an important role in meeting unstructured travel demands of users. It performs as feeder service to the main mass transport system (Both rail and road based) and provides accessible movement in predefined areas. The services provided by the IPT are intermittent in nature and this has complete flexibility in destination which is determined by the passengers. Private taxis, On demand taxi and cabs are also available by Coolcabs, Meru Cabs, Ola Cabs, Uber Cabs, Mega Cabs, Easy Cabs, etc. They provide services from Railway Station, Major business & commercial centres of Thane and also to nearby cities like Mumbai, Navi Mumbai, Raigad, Pune, Khopoli, etc.

2.10. PUBLIC TRANSPORTATION SYSTEM

Public transport offers economies of scale with minimised road congestion and low per capita road usage. Cheaper and affordable public transport systems world over have proved to promote mobility – move people more efficiently and safely with increased opportunities for education, employment, social development etc.

The Thane Municipal Transport Service, operating under the name "Thane Municipal Transport (T.M.T.)" is the transport wing of Thane Municipal Corporation, which operates a large number of bus lines in the Thane metropolitan area. These buses are called Thane Municipal Transport or T.M.T

bus. TMT bus serves the entire Thane City. It also has operation outside city limits into neighbouring Mumbai, Bhiwandi, Navi Mumbai, Kalyan Dombivali, Mira-Bhayandar and Vasai Virar, where it provides regional connectivity to Thane (**Table 2.6**).

Thane Municipal Corporation started its own transport service on 9 February 1989, known as TMT. TMT is the major bus service provider in Thane. TMT has all its bus depots in Thane and numerous bus stops. There are various kinds of bus in services right from ordinary, Mini, Midi, AC, Non AC etc to cater to different needs. The largest depot is at Wagle Estate. TMT operates its buses inside Thane city and also towards Kalwa & Mumbra. TMT buses ply from Thane to Bhiwandi, Mira Road, Mulund, Borivali, Andheri, Nalasopara, BKC and Dombivali. Thane TMT Bus Service the best connectivity of Mumbai western suburban like Borivali, Andheri, Bandra B.K.C., Mira Road, Nalasopara.

TABLE 2-6: DETAILS OF TMT TRANSPORT SYSTEM

Sr. no.	Description	Remarks
1	Total number of buses operational on road (No.)	472
2	Total number of buses under ownership of TMT	472
3	Average daily number of TMT operating in the city (No.)	297
4	Total number of Bus stations BRTS	472
5	Total No. of Bus terminals , Metro stations having Passenger Information System	12
6	No. of public transport vehicles & IPT with functional on board GPS/GPRS and connected to common control centre.	195

Other Bus Transport Systems connects the major locations of Thane to other MMR regions of more frequency. Navi Mumbai Municipal Transport (NMMT), Mira Bhayandar Municipal Transport (MBMT), Vasai Virar Municipal Transport (VVMT) & Brihan Mumbai Electric Supply and Transport (BEST) and State Transport Corporation (ST) ply through or from/to Thane.

2.11. REVIEW OF PAST STUDIES

The major studies carried out in the past by various organizations for transport system improvements in TMC area are as follows:

- Comprehensive Mobility Plan for the city of Thane, 2018
- Detailed Project Report for Mumbai Metro Line 5, 2016
- Detailed Project Report for Mumbai Metro Line 4, 2016
- New Suburban railway station on central line between Thane and Mulund railway stations, 2015
- LRT for Thane, 2014
- Comprehensive Transportation Study for MMR, 2008
- City Development Plan, 2006
- MRTS for Thane, 1998-2002

Brief descriptions of the above studies are presented as follows:

1.7.1 Comprehensive Mobility Plan for the city of Thane, 2018

Comprehensive Mobility Plan (CMP) has been prepared in 2018 for Thane. CMP envisions a need for a mass rapid system is felt where long distance trips within the City are conveniently addressed and are complimented by safe efficient and economical services.

Comprehensive Mobility Plan has been prepared for a planning period of 20 years with a vision for transport in Thane to ensure that the city has a planned, best performing transport systems to address the needs and concerns of the City. The objectives of CMP is to develop specific actions in form of short, medium and long term improvement proposals that will achieve the transportation vision for the area.

a. Mass Transit Proposals:

Based on estimated peak hour travel demand, the following public transport proposals have been assessed for Thane city.

- Mass Rapid Transit System of about 27.5 Kms identified HCMTR in Phase 1.
- Mass Rapid Transit System of about 33.5 Kms connecting Thane to Navi Mumbai in Phase 2.
- Sub-urban Proposals Thane-Bhiwandi Line – 12.5 km;
- Metro proposals Ghatkopar-Mulund-Thane (M5) and Thane-Ghodbunder-Dahisar (M12) – 40 km;
- Metro/ Monorail proposals Thane-Bhiwandi-Kalyan Dombivali – 32 kms

Development of the new sub-urban railway corridors, metro and mono-rail corridors connecting Thane with other sub-regions of MMR as mentioned above, have been assessed holistically using the analysis of travel demand of entire MMR in different horizon years.

b. Landuse Transport Integration Plan:

The urban sprawl in Thane has taken place in almost all the directions. One of the strategies of integrating land use and transport is consideration of Transit Oriented Development (TOD) strategy. This concept can be applied along the major identified mobility corridors that have the potential to carry higher order mass transit systems.

c. Non-Motorized Transport (NMT) Plan:

In view of high share of pedestrian and NMT trips, CMP has proposed certain measures and proposals to improve non motorised transport which include footpath and cycle tracks in primary and secondary road networks, pedestrian phase signals at identified intersections, Covered Walkways for pedestrian, grade separated pedestrian crossing facilities and cycle rickshaw management.

d. Traffic Management Plan:

Junction improvement plans has been considered as a part of short term improvement plan. As a part of traffic management strategy, it is recommended to remove the encroachments along road, installation of traffic signals, Setting up of a Road Accident Analysis System (RAAS), Provision of anti-crash barrier railing, Provision of adequate street lighting

on all arterials, sub-arterials, collectors, and local roads etc.

1.7.2 Detailed Project Report for Mumbai Metro Line 4, 2016

Detailed Project Report for Mumbai Metro Line 4 (Wadala – Ghatkopar – Mulund – Thane – Kasarvadavali) Metro corridors was prepared by DMRC in year 2016. The salient features of the recommended metro rail system and engineering are summarized below:

- Gauge (Nominal): 1435 mm
- Maximum operating speed 80 kmph, Scheduled speed for this corridor has been taken as 35 Kmph.
- 6 Car rake with 25 KV AC, Overhead Catenary Current Collection System
- Automatic Fare collection system with POM and Smart card etc.
- the traffic projection and the train operation plan is presented in **Table 2.7** and **Table 2.8**

TABLE 2.7 TRAFFIC PROJECTION FOR HORIZON YEAR

Year	Total Trip	Average Lead (KM)	Maximum PHPDT
2021	870198	10.1	28107
2031	1213177	10.25	33417

TABLE 2.8 TRAIN OPERATION

Particulars	2021	2031
Cars/trains	6	6
Head way (Minutes)	3.75	3
No. of Rakes	36	44
No. of Coaches	216	264
Max. PHPDT Demand	28107	33417
PHPDT Capacity Available	28096* (35904**)	35120* (44880**)

* @ 6 persons per square meter of standee area

** @ 8 persons per square meter of standee area

Maintenance Depot has been proposed near Kasarvadavali Station (main depot) and near Ghatkopar (stabling depot). Total land area proposed for maintenance facilities is 30.00 Ha.

1.7.3 Detailed Project Report for Mumbai Metro Line 5, 2016

Detailed Project Report for Mumbai Metro Line 5 corridors was prepared in year 2016.

- Thane Bhiwandi Kalyan corridor has been assessed as 18000 PHPDT for 2021 and this is likely to increase to 26000 PHPDT by the year 2031
- Proposed peak hour headway for 2021 is 5 minutes and Train capacity is 1756 passengers.
- Proposed Thane – Bhiwandi – Kalyan corridor is 24.9 km long and have 17 stations. All stations are elevated stations and are located at an average distance of 1.5 km apart. Average station length would be 180 m.

1.7.4 New Suburban railway station on central line between Thane and Mulund railway stations, 2015

There is four sub-urban railway stations in TMC limits viz. Thane, Kalwa, Mumbra and Diva. Since Thane railway station is used for sub-urban as well as inter-city train travel. Thane emerged as the most crowded station followed by heavy weight junctions like CST and Dadar in MMR. TMC intends for implementation of additional sub-urban station (proposed as part CTS MMR Study) between Mulund and Thane as the distance between the stations is about 2.5 km. The new sub-urban station is Kopri planned at Dharamveer Nagar near the Mental hospital about 1.5 km from Thane station in between Thane and Mulund stations.

About 2.6 lakh passengers per day were anticipated and considering that Passenger density will increase at the rate of 4% per annum and escalating this percentage upto 2041. It is expected that this traffic will approach the station by means of public transport system, private transport or as pedestrians in the ratio of 50, 30 and 20 respectively. The Road network connectivity will have to be planned to cater for these modes of traffic.

1.7.5 LRT for Thane, 2014

Thane's Comprehensive Mobility Plan, developed in 2009, outlined many scheme to tackle transport challenges Due to emerging growth in and around Thane. These schemes were further detailed out in this study into strategic

level interventions by developing short term, mid-term and long term plans as well as identifying several suitable projects to provide a sustainable transport solution to not only support but also augment Thane's rapid development and transformation.

The proposed at-grade BRTS was one among the many schemes for developing the city which later on converted to LRTS. In view of the increasing transit demand, the first project viz. at grade BRTS, was later converted to a Light Rail Transit by Thane Municipal Corporation.

1.7.6 Comprehensive Transportation Study for MMR, 2008

The Government of Maharashtra through MMRDA with technical assistance from the World Bank under MUTP has embarked on preparing the Comprehensive Transportation Study (CTS) for MMR known as TRANSFORM (Transportation Study FOR the region of Mumbai) with prime objective of identifying travel pattern of residents in MMR and recommend long term comprehensive transportation strategy for MMR up to 2031.

Brief summary of the study findings and recommendations for 2016, 2021 and 2031 are presented as follows:

- The length of metro network for the horizon year 2016 and 2021 is 208 km and 318 km respectively, which further expands to 435 km by 2031. Most of the metro network proposed by 2016 is located in MCGM and Navi Mumbai.
- Total length of new suburban rail network is approximately 248 km. The majority of the new suburban rail network corridors are required by 2016, with minimal addition thereafter. Only twin track corridors have been proposed, with one track per direction.
- The highway network, which includes higher order transport network (fully access controlled) and arterial corridors for the horizon year 2016, 2021 and 2031 is 982 km, 1,229 km and 1,740 respectively. It is recommended that, all major sea-links and bridges will have the lane configuration reflecting 2031 requirements.

- Exclusive Bus Lanes (EBL), Passenger Water Transport (PWT) on the west coast, east coast have been proposed for the horizon years where the travel demands were insufficient.
- Inter-State bus terminals, inter-city/ intra regional bus stations, major/ minor truck terminals, inter-city rail terminals have been proposed as part of transport plan for the horizon years .
- Road safety measures, traffic management measures include intersection improvements, flyovers/ interchanges, pedestrian facilities, ROBs/ RUBs, footpath improvements, traffic signal installation/ Area Traffic Control Systems, etc are being recommended.
- Alternative institutional arrangements have been examined such as “Reinforcing the coordinating role of MMRDA” and “Establishing a new Unified Metropolitan Transport Authority (UMTA)”.

1.7.7 City Development Plan for Thane, 2006

CDP was prepared in 2006 in line with goals and objectives of JnNURM, focusing on major aspects like provide equitable and sustainable infrastructure to the city. The study area extends over 128.23 Sqkm of Thane Municipal Corporation (KMC) comprising of 11 sectors and 95 wards with a population of 12.61 Lakh in 2001.

The Vision and CDP Thane focuses on –

- a) Identification of thrust areas and effective exploitation of cities growth engines.
- b) Initiation of financial reforms to achieve desired strength
- c) Efficient and equitable development by accommodating urban poor for sustainable city development.
- d) Promoting means of livelihood of urban poor.
- e) Enhancement in governance by implementing various models.

1.7.8 MRTS for Thane, 1998-2002

GOM and Thane Municipal Corporation (TMC) had carried out preliminary studies through RITES (1989) and CIDCO (1994) and reservation for the proposed ring railway was made in the development plan of Thane city.

Considering the urgency of implementation of the proposed MRT system, Government of Maharashtra has appointed Maharashtra State Road Development Corporation Ltd. (MSRDC) as the nodal agency for carrying out necessary studies and implementing the MRT system in public private partnership. The MSRDC in association with Thane Municipal Corporation (TMC) and Ministry of Urban Development (MoUD), Government of India accordingly initiated the necessary program of action by inviting offers for consultancy services and appointed the Consortium led by M/s.Consulting Engineering Services (India) Limited (CES) with PBK&D (UK), LPT Consultants (Malaysia) as associates and UTI Securities Exchange Limited (UTISEL), and Architects (USA) as consortium members, to prepare Detailed Project Report (DPR) for the proposed MRTS for Thane City.

The base year daily travel demand (excluding intra - zonal trips) assessed was 17.6 lakhs trips. Four stage transport planning model was used for forecasting the ridership on MRT system. The travel demand estimated for the years 2006 and 2031 are 23.1 and 33.8 lakhs trips respectively including walk trips.

A master plan of MRTS Network to serve the future development pattern of Thane (2031) has been formulated. It includes the Ring, North-South Axial and West-East Axial corridors. These corridors were named as Green, Red and Blue corridors pass through and intersect at the envisaged Town Centre providing high accessibility. The Thane MRTS Network integrates with the suburban railway system at Thane, Mumbai and Diva Stations. A number of transfer station amongst the corridors were also envisaged. The car depot is proposed at Balkum. The details are as under.

Corridor	Length(Km)
Ring (Green)	16.05
North South Axial (Red)	11.20
West East Axial (Blue)	18.50

2.12. ISSUES AND PROSPECTS

1.12.1. Existing Traffic Characteristic and Related Issues

The existing traffic and transport issues and concerns in the study area are listed as follows and are presented in **Figure 2.1**.

- Lack of citywide good and quality public transport system
- Encroachment of footpaths / Unorganized On-street parking causing reduction in efficient roadway width
- Lack of pedestrians facilities like footpath along major roads resulting in pedestrian spill over on right of way
- un-organised operations of shared auto services
- Absence of necessary infrastructure such as bus stop, lighting etc.

The said issues and concerns are widespread in the Thane City which reduces the efficiency of road carriageway leading to congestion and causes vulnerability to road users. Other reasons for congestion include encroachment of road space by street vendors, unauthorized movement of auto-rickshaws and tempos which have not been regularized. With increase in population and dependence on personalized modes of transport, increase in road accidents the transport system requires expansion and augmentation for safe, efficient, convenient travel and further to reduce the pollution level in the City.

FIGURE 2.1: EXISTING ISSUES AND CONCERNS

 1. Absence of Footpath near Vijay Nagari	 2. Roadside Encroachment near Kasinath Ghanekar
 3. Lack of pedestrian facilities around Medulla Chowk	 4. On-street parking near Juna S T Stop

1.12.2. Air Pollution Levels

The pollution levels in the City are determined by the existing Ambient Air Quality Index (AQI). The AQI considers three main pollutants (PM₁₀, NO₂ and SO₂). There are four AQI categories, namely Low (L), Moderate (M), High (H) and Critical (C). The pollution level classification is presented in **Table 2.9**. the pollution level in Thane for last five years is presented in **Table 2.10**

TABLE 2.9: POLLUTION LEVEL CLASSIFICATION

Pollution level	Annual Mean Concentration Range (µg/m ³)		
	SO ₂	NO ₂	PM ₁₀
Low (L)	0-25	0-20	0-30
Moderate (M)	26-50	21-40	31-60
High (H)	51-75	41-60	61-90
Critical (C)	>75	>60	>90

Source: Central Pollution Control Board, Annual reports

TABLE 2.10: AMBIENT AIR QUALITY TREND OF THANE

Year	SO ₂	NO ₂	PM ₁₀
2013-14	20	12	70
2014-15	16	33	110
2015-16	28	58	117
Average	21	34	99
Pollution level	Low	Moderate	Critical

Source: Central Pollution Control Board, Annual reports

Chapter – 3

TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

3. TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

Maharashtra Metro Rail Corporation has appointed another consultant for preparation of traffic and travel database, travel demand modelling and CMP. The data and analysis from CMP 2018 has been used for the preparation of this Chapter.

3.1 TRAFFIC AND TRANSPORTATION STUDIES UNDERTAKEN

3.1.1 Study Area and Zoning

The geographic area within the jurisdiction of Thane Municipal Corporation (TMC) is taken as the study area. The TMC study area comprise of about 147.0 Sq. km. For the purpose of analysis and development of travel demand forecasting model, the study area is subdivided into smaller areas known as Traffic Analysis Zones (TAZs) . A traffic zone system is developed for the Study Area based on the existing ward boundaries and natural physical barriers. It is sufficiently detailed to capture inter zonal trips. The study area for Thane has been divided into 95 Zones. The traffic zones of the study area is presented in **Table 3.1**.

TABLE 3.1: TRAFFIC ZONES IN STUDY AREA

TAZ No	TAZ Name	TAZ No	TAZ Name
1201	Wagbil	1249	Azad Nagar
1202	Patlipada	1250	Panchsheel Nagar
1203	Kolshet	1251	Vrindavan
1204	Chitalsar	1252	Saket Complex
1205	Dokali	1253	Amrut Park
1206	Balkum	1254	Bhudhaji Nagar
1207	Balkumpada	1255	Mukund Staff Colony
1208	Sainath Nagar	1256	Samrat Nagar
1209	Kharegaon	1257	Chatrapati Shivaji Hospital
1210	Goutam Nagar	1258	M. G. Garden
1211	Rana Nagar	1259	Shivaji Nagar
1212	Rehemani Colony	1260	Vadgholkar Hospital
1213	Bombay Colony	1261	Sambhaji Nagar
1214	Diva	1262	Louis Wadi
1215	Sabe	1263	Regional Transport Office

TAZ No	TAZ Name	TAZ No	TAZ Name
1216	Shil	1264	Ambica Nagar 2
1217	Sanjay Nagar	1265	Kisan Nagar
1218	Shanti Nagar (Mumbra)	1266	Railadevi Tank
1219	Thakurpada	1267	Hindustan Breweries
1220	Samrat Nagar	1268	Jaibhawani Nagar
1221	Parsik Tunnel	1269	Patil Nagar
1222	Mafatlal Colony	1270	Runwal Plaza
1223	Vitava	1271	Laxmi Market
1224	United Sports Club	1272	Samatha Garden
1225	Valmiki Nagar	1273	Shashtri Nagar
1226	Kopri	1274	Joshi School
1227	Kopri Colony	1275	J K Gram
1228	Thane Railway Stn (E)	1276	Khopat
1229	Siddharth Nagar	1277	Rabodi
1230	Bara Bungalow	1278	Kranti Nagar
1231	Dharamveer Nagar	1279	District Court
1232	St. Lawrence School	1280	D K Stadium
1233	Vaishali Nagar	1281	Shivaji Path
1234	Kisan Nagar 2	1282	Vartak Hospital
1235	Padwal Nagar	1283	Mahavarkar Nursing Home
1236	Bhat Wadi	1284	SIES Jr College
1237	Kisan Nagar 3	1285	Jeejamata Nagar
1238	Suraj Hospital	1286	Ramchandra Nagar 2
1239	Shanti Nagar	1287	Sundarvan Park
1240	Kailash Nagar	1288	Ramabai Ambedkar Ngr
1241	Ram Nagar	1289	Runwal Nagar
1242	Hanuman Nagar	1290	Uthalsar
1243	Savarkar Nagar	1291	Charai
1244	Lokmanya Nagar	1292	Vaidya Hospital
1245	Tikuji Ni Wadi	1293	Tekdi Bungalow Road
1246	Kisan Nagar 4	1294	Namdeo Wadi
1247	Manpada	1295	Chandan Wadi
1248	Subhash Nagar		

Source: Comprehensive Mobility Plan, 2018

3.1.2 Landuse Surveys

The distribution of the road network with respect to abutting land use is presented in **Table 3.2**. It is seen that the road network is abutted by residential land use upto an extent of about 28%, commercial about 8% and Institutional landuse about 1.7%.

TABLE 3.2: DISTRIBUTION OF ROAD NETWORK AS PER ABUTTING LANDUSE

S. No	Type	Left		Right		Average
		Road length (Km)	%	Road length (Km)	%	
1	Residencial	54.28	29.66%	47.02	25.69%	27.68%
2	Commercial	14.12	7.72%	15.56	8.50%	8.11%
3	Mixed	61.88	33.81%	67.44	36.85%	35.33%
4	Institutional	2.80	1.53%	3.50	1.91%	1.72%
5	Industrial	24.44	13.36%	22.56	12.33%	12.85%
6	Forest	14.28	7.80%	6.12	3.34%	5.57%
7	Agricultural	11.20	6.12%	20.80	11.37%	8.75%
Total		183.00	100.00	183.00	100.00	100.00

Source: Primary Survey (CMP-2018)

3.1.3 Traffic and Transportation Surveys

A number of traffic & travel surveys were conducted to appreciate and quantify the characteristics of commuter travel within the Study Area. This data analysis has helped us in developing the Travel Demand Model.

3.1.4 Classified Traffic Volume Counts

Classified traffic volume surveys were carried on average weekday to quantify the volume of traffic moving along various road sections in the study area. The counts were carried out for 16-hour at mid block/screen line and Intersection locations and for 24 hour at outer cordon locations. The survey locations were selected in a manner that would cover the entire study area and assist in understanding the traffic pattern within the study area as well as with adjacent urban settlements. These surveys help in assessing the existing traffic problems in the study area as well as to validate the transport demand models.

i. Screen Line/Mid-Block Survey

The quantum and temporal variation of daily vehicles and trips moving in the study area has been carried out in the following sections.

Traffic Volume (Average Daily Traffic)

The traffic counts both in terms of numbers of vehicles and Passenger Car Units (PCUs) have been computed at various screen line/mid-block locations as presented

in **Table 3.3**. It is observed that the traffic at different locations varies from 32,520 Vehicles (27,931 PCU's) at Gokhale Road near Navpada to 1,09,102 Vehicles (2,25,220 PCU's) along Bhiwandi Bypass Near Thane Creek Bridge throughout a normal working day.

TABLE 3.3: DAILY TRAFFIC VOLUME AT SCREEN LINE/MID-BLOCK LOCATIONS

S. No	Name of Mid-Block/Screenline Location	Total Vehicles	Total PCU's
1	Bhiwandi Bypass Near Thane Creek Bridge	1,09,102	2,25,220
2	Hutatama Maruti kumar Marg, Near Khopat	65,807	60,331
3	Gokhale Road near Navpada	32,520	27,931
4	Kalwa Bridge	99,612	1,14,825
5	LBS Marg Near Teen Hath Naka	39,316	37,208
6	Mahapalika Marg Near Nitin Company	64,967	54,951
7	Thane Godbhundr Raod near Patlipada	84,884	1,40,356
8	Mumbra Panvel Road	66,214	90,448

Source: Primary Survey (CMP-2018)

Peak Hour Traffic Characteristics

The peak hour traffic at the Screen Line/Mid-Block locations is presented in **Table 3.4**. The morning peak hour volume varies from 3,631 PCUs (4,878 vehicles) on Gokhale Road near Navpada to 27,026 PCUs (17,456 vehicles) along Bhiwandi Bypass Near Thane Creek Bridge & evening peak hour volume varies from 2,793 PCUs (3,902 vehicles) on Gokhale Road near Navpada to 27,026 PCU's (18,547 vehicles) along Bhiwandi Bypass Near Thane Creek Bridge.

Directional Distribution of Traffic

It can be observed that peak hour peak directional traffic at Screen Line/Mid-block locations generally varies from 50.8% at Kalwa Bridge to 56.5% at Thane Godbhundr Raod near Patlipada. The details are presented in **Table 3.4**.

TABLE 3.4: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT SCREEN LINE/MID-BLOCK LOCATIONS

S. No.	Location of Mid-Block/Screen Line	Total Traffic		Morning Peak				Evening Peak				Directional Distribution	
		Veh.	PCU's	Veh.	% of Total Traffic	PCU's	% of Total Traffic	Veh.	% of Total Traffic	PCU's	% of Total Traffic	Peak Direction %	Off Peak Direction %
1	Bhiwandi Bypass Near Thane Creek Bridge	1,09,102	2,25,220	17,456	16%	27,026	12%	18,547	17%	27,026	12%	56.2	43.8
2	Hutatama Maruti kumar Marg, Near Khopat	65,807	60,331	8,555	13%	6,636	11%	7,239	11%	6,636	11%	52.1	47.9
3	Gokhale Road near Navpada	32,520	27,931	4,878	15%	3,631	13%	3,902	12%	2,793	10%	51.5	48.5
4	Kalwa Bridge	99,612	1,14,825	11,953	12%	11,483	10%	9,961	10%	13,779	12%	50.8	49.2
5	LBS Marg Near Teen Hath Naka	39,316	37,208	5,504	14%	4,093	11%	4,325	11%	3,349	9%	53.5	47.5
6	Mahapalika Marg Near Nitin Company	64,967	54,951	10,395	16%	7,144	13%	7,796	12%	7,144	13%	52.4	47.6
7	Thane Godbhundr Raod near Patlipada	84,884	1,40,356	9,337	11%	16,843	12%	7,640	9%	14,036	10%	56.5	43.5
8	Mumbra Panvel Road	66,214	90,448	9,270	14%	9,045	10%	7,284	11%	10,854	12%	53.2	44.8

Source: Primary Survey (CMP-2018)

ii. Turning Movement Counts at Intersections

Classified traffic volume count surveys have been conducted at selected intersections locations. The output provides total daily traffic, hourly traffic variations and peak hour traffic flow/composition for all directional movements and individual arms at each intersection.

Classified turning movement count surveys were carried out on weekday to quantify the volume of traffic moving along various road sections in the study area. The survey locations were selected in a manner that would cover the entire study area and assist in understanding the traffic pattern within the study area as well as with adjacent urban settlements.

Traffic Volume (Average Daily Traffic – 16 hours)

The intensity of traffic at intersection locations is given in **Table 3.5**. It can be seen that EE Highway – Teen Hath Naka handles the maximum daily traffic of 5,68,122PCUs (4,74,813 vehicles) followed by GB Road – Pokhran Road No 2 with 3,18,625 PCUs (2,68,974 vehicles) while the least daily traffic is observed on Old NH-4 Retibhandar with 64,108 PCUs (48,053 vehicles). The survey involved 15 minutes' interval direction wise classified traffic volume counts for each movement at the intersection-continuously for 16 hours (0600 hours to 2200 hours) on a typical working day.

TABLE 3.5: DAILY TRAFFIC VOLUME AT INTERSECTION SURVEY LOCATIONS

S. No.	Junction/Intersection Name	Total Vehicles	Total PCUs
1	GB Road – Hypercity junction	1,56,971	1,58,025
2	GB Road - Dmart	1,08,100	1,39,449
3	GB Road – Patlipada	58,800	80,556
4	GB Road – Manpada	87,245	1,03,081
5	GB Road- Tulsidham Junction	72,460	95,647
6	GB Road – Kapurbawdi	1,50,146	1,60,063
7	GB Road – Pokhran Road No 2	2,68,974	3,18,625
8	EE Highway – Teen Hath Naka	4,74,813	5,68,122

S. No.	Junction/Intersection Name	Total Vehicles	Total PCUs
9	EE Highway- Wagle Estate Road Junction	1,05,855	1,25,598
10	EE Highway - Cadbury Junction	1,01,905	1,35,166
11	GB Road – Majiwada	1,76,280	1,71,796
12	EE Highway – Saket Road Junction	1,40,528	1,66,285
13	Station Road – Uthalsar Naka	46,478	1,61,381
14	Kalwa Bridge Thane Side	1,97,131	2,56,946
15	Kalwa Bridge Kalwa side	1,00,159	1,35,400
16	Old NH-4 Retibhander	48,053	64,108
17	Old NH-4 Shilphata	1,08,929	1,40,178
18	Pokhran Road – Gladis Alwaris Marg Jn	1,64,824	2,14,376
19	Gladis Alwaris Marg – Hirandani Meadows Jn	1,18,272	1,56,119
20	Khopat Jn on old Agra Road	65,450	83,122
21	Jail Rd – Near Jail Lake	75,654	94,568
22	Wagle Estate Road No.22	49,568	1,32,041
23	Naupada Jn – Near Malhar Cinema	1,05,662	1,42,821
24	Pokhran Rd no – 1, Kores Junction	1,06,044	1,32,699
25	Saket Road Jn – On Old Agra Road	50,223	65,289
26	Mahapalika Bhavan Rd – on LBS Marg	49,568	1,32,041

Source: Primary Survey (CMP-2018)

Peak Hour Traffic Characteristics

The peak hour traffic characteristics and composition of total traffic at each intersection is presented in **Table 3.6**. The maximum morning and evening peak hour traffic varies at EE Highway – Teen Hath Naka with 59,653 PCUs to 4,552 PCUs at Old NH-4 Retibhander. The maximum share of buses is observed to be 6.6 % at GB Road – Hyper city junction while the share of slow modes varies from 0% (GB Road – Dmart) to 3.4% (Pokhran Rd no – 1, Kores Junction). Goods vehicles comprise about 2.3% at Wagle Estate Road No.22 to 42% at GB Road – Kapurbawdi.

TABLE 3.6: INTENSITY AND PEAK HOUR TRAFFIC AT INTERSECTIONS

S. No.	Name of Intersection	Total (Nos.)	Total (PCU's)	Morning Peak				Evening Peak			
				(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
1	GB Road – Hypercity junction	1,56,971	1,58,025	12,558	8%	14,696	9.30%	11,616	7.40%	12,326	7.80%
2	GB Road – Dmart	1,08,100	1,39,449	8,324	7.70%	11,714	8.40%	8,918	8.25%	11,853	8.50%
3	GB Road – Patlipada	58,800	80,556	5,527	9.40%	7,733	9.60%	4,057	6.90%	5,961	7.40%
4	GB Road – Manpada	87,245	1,03,081	7,241	8.30%	8,865	8.60%	6,456	7.40%	8,040	7.80%
5	GB Road- Tulsidham Junction	72,460	95,647	5,797	8%	8,034	8.40%	4,710	6.50%	6,600	6.90%
6	GB Road – Kapurbawdi	1,50,146	1,60,063	10,510	7%	11,845	7.40%	11,561	7.70%	12,805	8%
7	GB Road – Pokhran Road No 2	2,68,974	3,18,625	22,863	8.50%	27,720	8.70%	25,284	9.40%	30,907	9.70%
8	EE Highway – Teen Hath Naka	4,74,813	5,68,122	37,035	7.80%	46,586	8.20%	48,906	10.30%	59,653	10.50%
9	EE Highway- Wagle Estate Road Junction	1,05,855	1,25,598	8,998	8.50%	10,927	8.70%	8,363	7.90%	10,425	8.30%
10	EE Highway - Cadbury Junction	1,01,905	1,35,166	9,477	9.30%	12,841	9.50%	8,764	8.60%	12,165	9%
11	GB Road – Majiwada	1,76,280	1,71,796	14,808	8.40%	15,462	9%	12,868	7.30%	13,056	7.60%
12	EE Highway – Saket Road Junction	1,40,528	1,66,285	13,491	9.60%	16,629	10%	9,696	6.90%	12,305	7.40%
13	Station Road – Uthalsar Naka	46,478	1,61,381	4,648	10%	16,461	10.20%	3,904	8.40%	14,202	8.80%
14	Kalwa Bridge Thane Side	1,97,131	2,56,946	17,742	9%	23,896	9.30%	15,770	8%	21,583	8.40%
15	Kalwa Bridge Kalwa side	1,00,159	1,35,400	7,011	7%	10,290	7.60%	6,610	6.60%	9,478	7%
16	Old NH-4 Retibhander	48,053	64,108	3,316	6.90%	4,616	7.20%	3,268	6.80%	4,552	7.10%
17	Old NH-4 Shilphata	1,08,929	1,40,178	8,714	8%	11,635	8.30%	8,388	7.70%	11,495	8.20%
18	Pokhran Road – Gladis Alwaris	1,64,824	2,14,376	12,856	7.80%	17,364	8.10%	11,043	6.70%	15,221	7.10%

S. No.	Name of Intersection	Total (Nos.)	Total (PCU's)	Morning Peak				Evening Peak			
				(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
	Marg Jn										
19	Gladis Alwaris Marg – Hirandani Meadows Jn	1,18,272	1,56,119	9,935	8.40%	13,582	8.70%	10,881	9.20%	14,831	9.50%
20	Khopat Jn on old Agra Road	65,450	83,122	4,843	7.40%	6,400	7.70%	5,629	8.60%	7,481	9%
21	Jail Rd – Near Jail Lake	75,654	94,568	6,733	8.90%	8,700	9.20%	5,901	7.80%	7,755	8.20%
22	Wagle Estate Road No.22	49,568	1,32,041	4,659	9.40%	12,808	9.70%	4,164	8.40%	11,356	8.60%
23	Naupada Jn – Near Malhar Cinema	1,05,662	1,42,821	8,136	7.70%	11,569	8.10%	7,925	7.50%	11,426	8%
24	Pokhran Rd no – 1, Kores Junction	1,06,044	1,32,699	9,968	9.40%	13,137	9.90%	6,787	6.40%	9,156	6.90%
25	Saket Road Jn – On Old Agra Road	50,223	65,289	4,169	8.30%	5,615	8.60%	3,666	7.30%	5,027	7.70%
26	Mahapalika Bhavan Rd – on LBS Marg	49,568	1,32,041	3,965	8%	11,012	8.34%	4,070	8.21%	11,356	8.60%

Source: Primary Survey (CMP-2018)

iii. Classified Traffic Volume Counts at Outer Cordon Survey

The classified traffic volume counts and origin destination surveys were carried out at 7 outer cordon locations to know the intensity and trip making characteristics of the traffic entering and leaving the study area.

Traffic Volume (Average Daily Traffic – 24 hours)

The traffic counts both in terms of numbers of vehicles and Passenger Car Units (PCUs) have been computed for the total daily (24 hour) traffic at 7 Outer Cordon locations (**Table 3.7**). It is observed that the traffic at different locations varies from 72,820 PCUs at Old Agra road, near Kasheli Bridge to 2,09,507 PCUs at Bhiwandi Bypass Near Toll Naka on a normal working day.

TABLE 3.7: DAILY TRAFFIC VOLUME (24 HOURS) AT OUTER CORDON LOCATIONS

S. No.	Location of Outer Cordon	Grand Total (No.s)	Grand Total (PCU's)
1	Thane Godbhunder Road near Octroi Naka	66,794	1,32,778
2	Old Agra road, near Kasheli Bridge	49,350	72,820
3	Bhiwandi Bypass Near Toll Naka	1,01,490	2,09,507
4	Mumbra Panvel road near bharat Gears	38,788	75,294
5	Thane Bealpur Road Near near TMC Octroi Naka	48,825	94,733
6	Eastern Expresshighway , Near Anand Nagar Checknaka	1,19,629	1,60,870
7	LBS Marg Mulund Checknaka	68,964	95,451

Source: Primary Survey (CMP-2018)

Peak Hour Traffic Characteristics

The peak hour traffic at the Outer cordon locations is presented in **Table 3.8**. The morning peak hour volume varies from 6554 PCUs at Old Agra road, near Kasheli Bridge to 23046 PCUs at Bhiwandi Bypass Near Toll Naka & evening peak hour volume varies from 8010 PCUs at Old Agra road, near Kasheli Bridge to 20,951 PCU's at Bhiwandi Bypass Near Toll Naka.

It can be observed that peak hour peak directional traffic at Outer Cordon generally varies from about 50.8% at Bhiwandi Bypass Near Toll Naka to 56.5% at Eastern Expresshighway, Near Anand Nagar Checknaka. The details are presented in **Table 3.8**.

TABLE 3.8: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT OUTER CORDON LOCATIONS

SN	Name of Outer Cordon Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution	
		(Veh.)	(PCU's)	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	Peak Direction %	Off Peak Direction %
1	Thane Godbhunder Road near Octroi Naka	66,794	1,32,778	7347	11%	13278	10%	9351	14%	15933	12%	52.6	47.4
2	Old Agra road, near Kasheli Bridge	49,350	72,820	4935	10%	6554	9%	5922	12%	8010	11%	51.5	48.5
3	Bhiwandi Bypass Near Toll Naka	1,01,490	2,09,507	9134	9%	23046	11%	11164	11%	20951	10%	50.8	49.2
4	Mumbra Panvel road near bharat Gears	38,788	75,294	4655	12%	9788	13%	4655	12%	9035	12%	53.5	47.5
5	Thane Bealpur Road Near near TMC Octroi Naka	48,825	94,733	6347	13%	9473	10%	4394	9%	8526	9%	52.4	47.6
6	Eastern Expresshighway , Near Anand Nagar Checknaka	1,19,629	1,60,870	13159	11%	19304	12%	19141	16%	20913	13%	56.5	43.5
7	LBS Marg Mulund Checknaka	68,964	95,451	6896	10%	7636	8%	7586	11%	9545	10%	53.2	44.8

Source: Primary Survey (CMP-2018)

3.1.5 Road Side Origin and Destination Interviews at Outer Cordon Locations

It is observed from **Table 3.9** that the share of work and business purpose trips is about 62.6%. The other purpose trips contribute to about 29.10% at outer cordon location.

TABLE 3.9: DISTRIBUTION OF OUTER CORDONPASSENGERS BY TRIP PURPOSE

Mode	Trip Purpose						Total
	Work	Business	Education	Social	Others	Tourist	
Car	54.50%	5.75%	2.50%	5.20%	26.90%	5.20%	100%
2-Wheeler	54.60%	10.40%	2.40%	2.70%	29.90%	-	100%
Auto	47.80%	14.80%	1.80%	4.90%	30.50%	-	100%
Avg. Composition %	52.30%	10.32%	2.23%	4.27%	29.10%	5.20%	100

Source: Primary Survey (CMP-2018)

It is observed from **Table 3.10** that about 63% of passengers travel on daily basis, 7% Weekly, 11% Monthly and 19% Occasionally.

TABLE 3.10: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL FREQUENCY

Mode	Travel Frequency				Total
	Daily	Weekly	Monthly	Occasionally	
Car	58.60%	2.40%	15.00%	23.90%	100%
2-Wheeler	61.20%	11.40%	12.60%	15.00%	100%
Auto	68.60%	7.20%	6.20%	18.00%	100%
Avg. Composition %	62.80%	7.00%	11.27%	18.97%	100

Source: Primary Survey (CMP-2018)

It is observed from **Table 3.11** that travel time of about 35% of total passengers is upto 30 minutes. About 64% of total passengers' travel time ranges between 31-90 minutes and about 2% of total passengers' travel time are found to be more than 90 minutes at outer cordon locations.

Distribution of Passengers by trip length is presented in **Table 3.12**. It is observed that about 70% of passengers have trip length less than 20 Km.

TABLE 3.11: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME

Mode	Travel Time (In Mins.)							Total
	<15	16-20	21-30	31-45	46-60	61-90	>90	
Car	0%	2%	24%	27%	22%	20%	5%	100%
2-Wheeler	0%	3%	29%	37%	23%	8%	0%	100%
Auto	0%	6%	39%	40%	13%	1%	1%	100%
Avg. Composition %	0.0%	4%	31%	35%	19%	10%	2%	100%

Source: Primary Survey (CMP-2018)

TABLE 3.12: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP LENGTH

Mode	Travel Distance (In Kms.)								Total
	<5	5-8	9-10	11-15	16-20	21-25	26-30	>30	
Car	0%	2%	8%	16%	27%	22%	20%	5%	100%
2-Wheeler	0%	3%	12%	17%	37%	23%	8%	0%	100%
Auto	2%	6%	16%	22%	40%	13%	1%	0%	100%
Avg. Composition %	1%	4%	12%	18%	35%	19%	10%	2%	100

Source: Primary Survey (CMP-2018)

3.1.6 Willingness to Pay/Use Surveys

This section focused on the opinion of users with respect to various characteristics of a new mass transit system in Nagpur. The respondents at various bus terminals, rail terminals and airport were queried with regard to preference for the quantum of extra fare they are willing to pay.

i. Willingness to Pay Survey at Rail Terminals

Opinion survey was carried out at rail terminals to obtain preference of commuters about shifting to good and efficient public transport system. The respondents were asked willingness to pay extra fare and time saving with respect to their existing transport used. **Table 3.13** presents willingness to shift to good public transport system among other existing modes of transport to reach rail terminal. It is observed that about 90% of passengers have willingness to shift to MRTS System.

TABLE 3.13: WILLINGNESS OF TO SHIFT TO MRTS FOR REACHING TERMINAL

Willingness	Yes	No	Other	Total
Rail Passengers Composition (%)	90%	7.9%	2.1%	100%

Source: Primary Survey (CMP-2018)

The acceptable time saving in reaching rail terminal to shift to MRTS is presented in **Table 3.14**. It indicates that 20% respondents would choose MRTS if the time saved is upto 10 minutes. About 80% of passengers would choose MRTS if the time saved ranges between 10-20 minutes.

TABLE 3.14: WILLINGNESS TO CHOOSE METRO FOR REACHING RAIL TERMINAL WITH RESPECT TO TIME SAVINGS

Time Saved (minutes)	<5	5-10	10-15	15-20	>20	Total
Rail Passengers Composition (%)	2%	18%	38%	42%	0	100

Source: Primary Survey (CMP-2018)

The willingness to pay extra fare to reach rail terminal by MRTS System is presented in **Table 3.15**. The result indicates that about 25% respondents want the existing fare for new public transport as same as existing fare, 41% are willing to pay upto Rs.5 as extra fare. About 34% are willing to pay in the range of Rs.6– Rs.20 as extra fare for good MRTS system in comparison to existing fare.

TABLE 3.15: WILLINGNESS TO PAY EXTRA FARE FOR REACHING RAIL TERMINAL

Parameters	Same as Existing Mode Fare	Extra as compared to Existing Mode Fare (Rs.)						Total
		Upto 2	3-5	6-10	11-12	13-15	>15	
Rail Passengers Composition (%)	25%	8%	33%	19%	15%	NA	NA	100%

Source: Primary Survey (CMP-2018)

i. Opinion, Willingness to Pay Survey at PT/IPT Stops

Opinion survey was carried out at PT/IPT stops to obtain preference of commuters about shifting to MRTS system. The respondents were asked willingness to pay extra fare and time saving with respect to their existing transport used. **Table 3.16**. presents willingness to shift to good public transport system among other existing modes of transport. It is observed that about 73% of surveyed passengers have willingness to shift to MRTS System.

TABLE 3.16: WILLINGNESS OF PT/IPT PASSENGERS TO SHIFT TO MRTS

Willingness	Yes	No	Other	Total
PT/IPT Passengers Composition (%)	72.5%	25%	2.5%	100%

Source: Primary Survey (CMP-2018)

The acceptable time saving to shift MRTS is presented in **Table 3.17**. It indicates that about 20% respondents would choose metro if the time saved is less than or equals to 10 minutes. 80% would choose metro if the time saved is ranging between 11-20 minutes. 0% would choose metro if the time saved is more than 20 minutes.

TABLE 3.17: WILLINGNESS TO CHOOSE METRO WITH RESPECT TO TIME SAVINGS

Time Saved (Min)	<5	5-10	11-15	16-20	>20	Total
PT/IPT Passengers Composition (%)	2%	18%	38%	42%	0%	100%

Source: Primary Survey (CMP-2018)

The willingness to pay extra fare for MRTS System is presented in **Table 3.18**. The result indicates that 25% respondents want the existing fare for new public transport as same as existing fare, about 41% are willing to pay upto Rs.5 as extra fare and about 34% are willing to pay Rs.10 to Rs.12 as extra fare. Only about 0% of respondents are showing their willingness to pay Rs.15 or more as extra fare for MRTS system in comparison to existing fare.

TABLE 3.18: WILLINGNESS TO PAY EXTRA FARE FOR MRTS SYSTEM

Parameters	Same as Existing PT/IPT Fare	Extra as compared to Existing PT/IPT Fare (Rs.)					Total
		2	5	10	12	15	
PT/IPT Passengers Composition (%)	25%	8%	33%	19%	15%	0%	100%

Source: Primary Survey (CMP-2018)

3.1.7 Speed and Delay Survey

The speed and delay survey was conducted along the network using the running car method during peak and off-peak periods. The results of the survey with respect to the journey and running speed and delays are presented in the following paragraphs.

i. Journey Speed

The journey speed characteristics during peak period are presented in **Table 3.19**. It is observed that about 52% of the total road network has journey speed upto 20 kmph during peak hours. About 24% of surveyed network has journey speed between 21-30 kmph and only 24% of road network has journey speed more than 30 kmph. Average Journey Speed during peak is observed to be 20 kmph.

TABLE 3.19: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED

S. No.	Journey Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	6.1	7.1 %
2	10--20	39.55	45.5 %
3	21-30	20.7	23.8%
4	> 30	20.5	23.6%
Total		86.85	100.00

Source: Primary Survey (CMP-2018)

ii. Running Speed

The distribution of road length by Peak hour running speed is given in **Table 3.20**. It can be observed that about 70% of the road network has running speed less than 30 kmph during peak hours. Average running speed for peak is found as 30 Kmph.

TABLE 3.20: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR RUNNING SPEED

S. No.	Running Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<=20	6.25	7.2
2	21-30	54.80	63.1
3	31-40	5.30	6.1
4	>40	20.5	23.6
Total		86.85	100.00

Source: Primary Survey (CMP-2018)

iii. Delays

The distribution of causes of delays & their duration during peak hours and off-peak hours is presented in **Table 3.21**. The analysis of causes of delays reveal that the delays are caused mostly by traffic signal which account for about 39% in the peak hour, while traffic signal with congestion account for about 25%. Whereas in the off peak period, traffic signal accounts for 49%.

TABLE 3.21: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK & OFF PEAK HOURS

S. No.	Causes and Delays	Peak Hour		Off Peak Hour	
		No. of Points	%	No. of Points	%
1	Traffic Signals	32	38.56	18	48.65
2	Traffic Congestion	29	34.94	11	29.73
3	Traffic Signal + Congestion Signal	21	25.30	8	21.62
4	Animal	1	1.20	0	0.00
Total		83	100	37	100.00

Source: Primary Survey (CMP-2018)

3.1.8 Parking Characteristics

The Parking surveys have been conducted at various locations at identified on-street parking stretches on major arterial and sub-arterial roads and at major existing off-street parking lots in the study area for 12 hours (8 a.m. to 8 p.m.) on fair weather working day.

i Parking Accumulation

The observed peak parking accumulation along the surveyed locations is presented in **Table 3.22**. The Maximum peak hour parking accumulation was observed about 855 E.C.S. at Railadevi (Road No 22).

ii Parking Demand

The total parking demand at the surveyed locations is presented in **Table 3.23**. The table indicates that parking demand is high at many locations. Many locations have on street parking provisions which in turn reduces the effective carriageway width and affects the smooth movement of the traffic. The total parking demand over the day at the main parking stretches was observed to be about 7545 E.C.S. with maximum demand of 550 E.C.S. being observed at Railadevi (Road No 22).

iii Parking Duration

The composition of parking demand by parking duration is presented in **Table 3.24**. About 25.5% of cars are parked for short-term (0-60 min) 69% for medium-term (60-120 min) and only 5.5 % for long-term (> 2hrs). Two-wheeler parking of about 32%, 66% and 2% for short-term, medium-term and long-term duration respectively.

TABLE 3.22: PEAK HOUR PARKING ACCUMULATION

S. No	Name of Location	Side	Peak Accumulation				Equivalent Car Spaces	Parking Type
			Car	Auto	2-W	bus		
a	Railadevi							
1	Wagle To ITI	Both	220	70	95	14	362	parallel
2	Road No 16A	Both	88	61	52	5	174.75	parallel
3	Road No 22	Both	327	406	447	0	855	Perpendicular
4	MTNL TO Lokmany Nagar Last Stop	Both	24	59	259	0	197.75	parallel
5	Road No 21	Both	22	87	15	0	94.75	Perpendicular
6	Road No 25	Both	24	0	49	0	48.5	parallel
7	Road No 23	Both	11	0	40	0	31	parallel
8	Shree Nagar	Both	169	22	48	0	209.5	Perpendicular
b	Naupada							
1	Ram Maruti Road	Both	126	12	189	0	229.5	parallel
2	Sane Guruji Road	Both	90	58	213	0	240	Perpendicular
3	Bajiprabhu Road	Both	112	38	105	0	193	parallel
4	LBS Road	Both	173	25	292	0	337.75	Perpendicular
5	Veer Savarkar Path	Both	74	9	36	0	98.75	Perpendicular
6	Almeda Road	Both	161	62	258	0	336.5	parallel
7	TMC Marg	Both	141	35	252	0	293.25	Perpendicular
c	Vartak Nagar							
1	Pokharan Road No1	Both	289	151	398	18	655.25	parallel
2	Pokharan Road No2	Both	274	188	353	41	714.5	parallel
3	E.S.I.S Road	Both	153	247	260	0	468.25	parallel
4	Tuslidham Road	Both	75	5	57	21	170.25	parallel
d	Majiwada							
1	Majiwada Road	Both	5	30	13	0	34	Perpendicular
2	Bhiwandi Road	Both	64	67	19	31	216.75	parallel
3	Kolshet Road	Both	166	59	208	37	425.25	Perpendicular
4	Bhranand Road	Both	134	20	110	13	243	parallel
5	Hirananda-Ni Road	Both	49	8	48	8	103	Perpendicular
6	Wagbil Road	Both	97	19	92	4	169.25	Perpendicular
e	Kalwa Prabhag							
1	New Thane Belapur Road	Both	9	13	15	0	26.25	Perpendicular
2	Juna Mumbai Pune Road	Both	47	25	45	0	88.25	parallel
3	Juna Belapur Road	Both	89	10	5	4	111	Perpendicular
4	Juna Mumbai Pune Road	Both	231	34	217	27	446	parallel

S. No	Name of Location	Side	Peak Accumulation				Equivalent Car Spaces	Parking Type
			Car	Auto	2-W	bus		
f	Uthalsar							
1	Jambhalinaka To Civil Hospital To Minatai Thakre Chowk	Both	110	22	116	0	184.5	Perpendicular
2	Nitin Co. To Khopat Rd To Golden Dyse Naka	Both	306	72	423	10	601.5	parallel
3	Khopat Rd To Gavdevi Chowk	Both	95	65	165	0	226.25	Perpendicular
4	Rutupark Nalla Bridge To Golden Dyse Naka	Both	118	4	201	0	221.5	Perpendicular
5	Golden Dyse To Minatai Thakre Chowk To Almieda Chowk	Both	144	136	386	0	439	Perpendicular
6	Dr.Babasaheb Ambedkar Road Bridge To Gaondevi	Both	44	27	117	0	122.75	parallel
7	Khopat Rd To Singnagar To TMC Office	Both	134	34	244	0	281.5	Perpendicular
8	Panchganga To Nalla Culvert To Saket Road	Both	36	64	141	0	154.5	parallel
9	Holly Cross To Bape House To Shrirange Police Chowki	Both	62	55	122	0	164.25	Perpendicular

Source: Primary Survey (CMP-2018)

TABLE 3.23: PARKING DEMAND

S. No	Name of Location	Car	2-Whlr	Parking Demand (ECS)
a	Railadevi			
1	Wagle To ITI	220	95	267.5
2	Road No 16a	88	52	114
3	Road No 22	327	447	550.5
4	MTNL To Lokmany Nagar Last Stop	24	259	153.5
5	Road No 21	22	15	29.5
6	Road No 25	24	49	48.5
7	Road No 23	11	40	31
8	Shree Nagar	169	48	193
b	Naupada			
1	Ram Maruti Road	126	189	220.5

S. No	Name of Location	Car	2-Whlr	Parking Demand (ECS)
2	Sane Guruji Road	90	213	196.5
3	Bajiprabhu Road	112	105	164.5
4	LBS Road	173	292	319
5	Veer Savarkar Path	74	36	92
6	Almeda Road	161	258	290
7	TMC Marg	141	252	267
c	Vartak Nagar			
1	Pokharan Road No1	289	398	488
2	Pokharan Road No2	274	353	450.5
3	E.S.I.S Road	153	260	283
4	Tuslidham Road	75	57	103.5
d	Majiwada			
1	Majiwada Road	5	13	11.5
2	Bhiwandi Road	64	19	73.5
3	Kolshet Road	166	208	270
4	Bhranand Road	134	110	189
5	Hirananda-Ni Road	49	48	73
6	Wagbil Road	97	92	143
e	Kalwa Prabhag			
1	New Thane Belapur Road	9	15	16.5
2	Juna Mumbai Pune Road	47	45	69.5
3	Juna Belapur Road	89	5	91.5
4	Juna Mumbai Pune Road	231	217	339.5
f	Uthalsar			
1	Jambhalinaka To Civil Hospital To Minatai Thakre Chowk	110	116	168
2	Nitin Co. To Khopat Rd To Golden Dyse Naka	306	423	517.5
3	Khopat Rd To Gavdevi Chowk	95	165	177.5
4	Rutupark Nalla Bridge To Golden Dyse Naka	118	201	218.5
5	Golden Dyse To Minatai Thakre Chowk To Almieda Chowk	144	386	337
6	Dr.Babasaheb Ambedkar Road Bridge To Gaondevi	44	117	102.5
7	Khopat Rd To Singnagar To Tmc Office	134	244	256
8	Panchganga To Nalla Culvert To Saket Road	36	141	106.5
9	Holly Cross To Bape House To Shrirange Police Chowki	62	122	123
	Total			7545

Source: Primary Survey (CMP-2018)

TABLE 3.24: PARKING DURATION

S. No	Name of Location	Mode	Duration (Hours)										Total
			0-30 (min)	30-60 (min)	60-90 (min)	90-120 (min)	Total	2-4 (Hrs)	4-6 (hrs)	6-8 (hrs)	Total	>8 (hrs)	
1	Railadevi Prabhag	Car	71	150	221	398	840	27	18	0	45	0	885
		%	8%	17%	25%	45%		3%	2%	0%		0%	100%
		2-W	151	221	281	342	995	10	0	0	10	0	1005
		%	15%	22%	28%	34%		1%	0%	0%		0%	100%
2	Naupada Prabhag	Car	88	158	193	368	807	53	18	0	71	0	877
		%	10%	18%	22%	42%		6%	2%	0%		0%	100%
		2-W	188	269	350	498	1305	40	0	0	40	0	1345
		%	14%	20%	26%	37%		3%	0%	0%		0%	100%
3	Vartak Nagar Prabhag	Car	79	111	182	356	728	40	24	0	64	0	791
		%	10%	14%	23%	45%		5%	3%	0%		0%	100%
		2-W	150	192	320	395	1057	11	0	0	11	0	1068
		%	14%	18%	30%	37%		1%	0%	0%		0%	100%
4	Majiwada Prabhag	Car	52	82	139	237	510	5	0	0	5	0	515
		%	10%	16%	27%	46%		1%	0%	0%		0%	100%
		2-W	59	83	113	225	480	5	5	0	10	0	490
		%	12%	17%	23%	46%		1%	1%	0%		0%	100%
5	Kalwa Prabhag	Car	30	64	105	165	364	11	0	0	11	0	376
		%	8%	17%	28%	44%		3%	0%	0%		0%	100%
		2-W	31	51	68	116	266	11	6	0	17	0	282
		%	11%	18%	24%	41%		4%	2%	0%		0%	100%
6	Uthalsar Prabhag	Car	94	178	273	451	996	31	21	0	52	0	1049
		%	9%	17%	26%	43%		3%	2%	0%		0%	100%

S. No	Name of Location	Mode	Duration (Hours)										Total
			0-30 (min)	30-60 (min)	60-90 (min)	90-120 (min)	Total	2-4 (Hrs)	4-6 (hrs)	6-8 (hrs)	Total	>8 (hrs)	
		2-W	211	364	479	843	1897	19	0	0	19	0	1915
		%	11%	19%	25%	44%		1%	0%	0%		0%	100%
Total Cars		Car	414	743	1113	1975	4245	167	81	0	248	0	4493
		%	9.21%	16.54%	24.77%	43.96%	94.48%	3.72%	1.80%	0.00%	5.52%	0.00%	
Total Two wheelers		2-W	790	1180	1611	2419	6000	96	11	0	107	0	6107
		%	12.94%	19.32%	26.38%	39.61%	98.25%	1.57%	0.18%	0.00%	1.75%	0.00%	
Total Car & Two Wheelers			1204	1923	2724	4394	10245	263	92	0	355	0	10600
		%	11.36%	18.14%	25.70%	41.45%	96.65%	2.48%	0.87%	0.00%	3.35%	0.00%	

Source: Primary Survey (CMP-2018)

3.1.9 Public Transport & IPT Characteristics

The following public transport surveys were conducted as part of the study:

- Bus Passenger Survey
- Rail Passenger Survey
- PT/IPT Passenger Survey

The data collected through the field surveys have been analysed to assess the various public transport characteristics of commuters for different modes.

i. Bus Terminal Characteristics

A total of 5 Bus terminals were selected to conduct in-out, Origin-Destination and willingness to pay surveys within study area. It is observed from **Table 3.25** that SATIS Thane West caters to the maximum number of passengers with 61,949 Boarding & 50,684 Alighting.

Distribution of passenger trips by purpose is presented in **Table 3.26**. It is observed that work trips contribute about 82% of total trips. The share of other trips which include Education, Social contributes to about 10%.

TABLE 3.25: DISTRIBUTION OF PASSENGERS AT BUS TERMINALS

S. N o.	Name of Bus Terminal	Total Boarding	Total Alighting	Total B+A	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour B+A
1	SATIS Thane West	61,949	50,684	1,12,633	19.00 to 20.00	14,554	11,908	26,462
2	Lokmanya Nagar	7,880	6,446	14,326	9.00 to 10.00	1,851	1,515	3,366
3	Thane Station East	8,256	6,754	15,010	19.00 to 20.00	1,939	1,586	3,525
4	Wagle Aagar	11,015	9,012	20,027	9.00 to 10.00	2,589	2,119	4,708
5	Chendani	9,636	7,883	17,519	9.00 to 10.00	2,263	1,851	4,114

Source: Primary Survey (CMP-2018)

TABLE 3.26: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
Bus Passengers Composition (%)	68%	14%	8%	2%	8%	100%

Source: Primary Survey (CMP-2018)

ii. Rail Passengers Characteristics

A total of 4 Rail terminals were selected to conduct terminal survey spread over the entire study area. It is observed from **Table 3.27** that Thane railway station caters to the maximum number of passengers with 3,08,633 boarding & 3,04,004 alighting.

It is observed from **Table 3.28** that share of other purpose trips is about 11% and trips for service and business purpose together contributes to about 83%. Educational trips are about 5% followed by social trips which contribute to about 1%. Distribution of passenger trips by purpose.

TABLE 3.27: DISTRIBUTION OF PASSENGERS AT RAIL TERMINALS

S. No.	Name of Railway Station	Total Boarding	Total Alighting	Total B+A	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour B+A
1	Thane	3,08,633	3,04,004	6,12,637	8.30 to 9.30	47,124	46,417	93,541
2	Kalwa	93,346	89,685	1,83,031	8.30 to 9.30	14,002	13,453	27,455
3	Mumbra	1,03,434	99,377	2,02,811	8.30 to 9.30	15,515	14,907	30,422
4	Diva	1,25,443	1,20,524	2,45,967	8.30 to 9.30	18,816	18,079	36,895

Source: Primary Survey (CMP-2018)

TABLE 3.28: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
Rail Passengers Composition (%)	71%	12%	5%	1%	11%	100%

Source: Primary Survey (CMP-2018)

3.2 SOCIO- ECONOMIC CHARACTERISTICS

The household travel survey has been conducted to bring out socio-economic and travel characteristics of the study area like household size, income, and vehicle ownership, per capita trip rates for various purposes viz. Work, education and other

trips, expenditure on transport, modal split and origin-destination characteristics. To ensure that the sample was representative, the households interviewed during the survey were distributed throughout the study area in the same proportion as the distribution of population.

About 5000 household surveys were interviewed in the study area representing 95 traffic zones. A random sampling technique was used to identify the sample. Further, care was taken that the representative households of all socio-economic strata i.e. High Income Groups (HIG), Middle Income Groups (MIG) and Lower Income Groups (LIG) were covered in the sample.

3.2.1 Socio Economic Characteristics

i. Household Size

The distribution of households by size is presented in **Table 3.29**. It can be observed that about 53% of the households fall under the category of to 3-4 persons per household and about 19% of household's falls under category of 5-6 persons' group.

TABLE 3. 29: DISTRIBUTION OF HOUSEHOLDS BY SIZE

S. No.	Household by Size	Number of Households	Percentage (%)
1	Upto 2	1,050	21%
2	3-4	2,668	53.36%
3	5-6	927	18.54%
4	7-8	265	5.3%
5	>8	90	1.8%
Total		5,000	100.00%

Source: Primary Survey (CMP-2018)

ii. Occupation

The occupational structure of the surveyed household members is presented in **Table 3.30**. It is observed that about 54% samples are non-workers comprising of students, housewives, retired and unemployed people. About 12% are engaged in business sector. Among the service class, majorly about 23% are in private sector and about 9% in government services.

TABLE 3.30: DISTRIBUTION OF HOUSEHOLD MEMBERS BY OCCUPATION

S. No.	Occupation	No. of Sampled Household Members	Percentage (%)
1	Govt. Service	1,946	9.20%
2	Pvt. Service	4,814	22.76%
3	Business	2,612	12.35%
4	Student	5,076	24.00%
5	House Wife	4,429	20.94%
6	Retired	825	3.90%
7	Unemployed	1,005	4.75%
8	Others	444	2.10%
Total		21,150	100.00%

Source: Primary Survey (CMP-2018)

iii. Monthly Household Income

The average monthly household income in the study area is about Rs. 26,300. **Table 3.31** presents the distribution of Households by monthly income. It is observed that about 46% of the households earn Rs.5000 to Rs. 20,000. About 44% between Rs.20,00 to Rs. 50,000. A small percentage of about 2% households are earning even less than or equal to Rs.5000 per month. Only, about 7% of the households has monthly income more than Rs. 50,000.

TABLE 3.31: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME

S. No.	Income Group (Rs.)	No. of Households	Percentage
1	<5000	128	2.57
2	5000-10000	220	4.40
3	10000-15000	1,000	20.0
4	15000-20000	1,100	22.0
5	20000-25000	1,101	22.01
6	25000-50000	1,103	22.05
7	>50000	348	6.97
Total		5,000	100.00

Source: Primary Survey (CMP-2018)

3.2.2 Travel Characteristics

i. Per Capita Trip Rate

The total daily trips, as derived from the household survey, in the study area is about 30.6 lakh. Distribution of trips according to mode of travel is given in **Table 3.32**. About 68% of these are vehicular trips while 32% are walk trips. Per capita trip rate including walk is 1.48, excluding walk is 1.01 and for motorised trips is 1.01.

TABLE 3.32: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)

Mode		No. of Trips	Percentage
Vehicular Trips	Car	68,704	2.24%
	2- Wlrs	1,70,719	5.58%
	Auto	1,74,883	5.71%
	Bus	4,97,584	16.25%
	Cycle	2,082	0.07%
	Train	11,67,968	38.15%
Walk Trips	Walk	9,79,736	32.00%
Total Trips		30,61,676	100.00%
PCTR Including Walk		1.48	
Total Trip without walk		20,81,939	
PCTR Excluding Walk		1.01	
Total Motorised Trip		20,79,858	
PCTR Motorised		1.01	

Source: Primary Survey (CMP-2018)

ii. Trip Purpose

Purpose wise distribution of daily vehicular and walk trips is presented in **Table 3.33**. It is observed that about 35% vehicular and 19% walk trips have been performed daily for work and business purpose. Among the Education trips, 26% are vehicular and 8% are walk trips.

The detailed distribution is presented in **Table 3.34**. Among the total trips, government and private work trips account for about 40%, education about 34%, business trips for about 14%, shopping trips about 3.5% and others account for about 7%.

TABLE 3.33: DISTRIBUTION OF VEHICULAR & WALK TRIPS BY PURPOSE

S. No.	Trip Purpose	Vehicle Trips		Walk Trips		Total Trips By Purpose
		Trips	%	Trips	%	
1	Work	8,26,652	27%	3,98,018	13%	11,17,512
2	Business	2,44,934	8%	1,83,701	6%	7,85,278
3	Education	7,96,036	26%	2,44,934	8%	10,87,309
4	Others	2,14,317	7%	1,53,084	5%	30,203
Total		28,08,881	68%	9,79,736	32%	30,61,676

Source: Primary Survey (CMP-2018)

TABLE 3.34: DISTRIBUTION OF TRIPS BY PURPOSE

S. No.	Trip Purpose	Onward Trips		Return Trips		Total	
		Trips	%	Trips	%	Trips	%
1	Govt. Service	1,85,538	6.06%	1,81,864	5.94%	3,67,401	12.00%
2	Pvt. Service	4,37,207	14.28%	4,20,062	13.72%	8,57,269	28.00%
3	Business	2,25,033	7.35%	2,03,601	6.65%	4,28,635	14.00%
4	Education	5,20,485	17.00%	5,20,485	17.00%	10,40,970	34.00%
5	Shopping	53,579	1.75%	53,579	1.75%	1,07,159	3.50%
6	Medical	19,135	0.63%	19,135	0.63%	38,271	1.25%
7	Social / Others	1,22,084	3.99%	99,887	3.26%	2,21,971	7.25%
Total		15,63,062		14,98,614		30,61,676	100%

Source: Primary Survey (CMP-2018)

iii. Trip Length

Table 3.35 represent the detailed distribution of trips by the distance covered for each mode. It is observed that an average trip length of 1.1km is being covered up by walk. Cars travel an average trip length of 12.5 km, two wheelers 7.65 km while Auto rickshaws and cycles covers average trip distance of 7.15 km and 5.3 km respectively.

TABLE 3.35: DISTRIBUTION OF AVERAGE TRIP LENGTH BY MODE

Mode of Travel	Trip Length (In Kms.)							Total	Avg. trip length
	0-5	5-10	10-15	15-20	20-25	25-30	30-35		
Car	41%	16%	18%	11%	7%	5%	2%	100%	12.50

Two Wheeler	72%	14%	7%	4%	2%	1%	-	100%	7.65
Auto Rickshaw	69%	23%	5%	2%	1%	-	-	100%	7.15
Bus	53%	21%	11%	8%	4%	1%	2%	100%	10.00
Cycles	94%	6%	0%	-	-	-	-	100%	5.30
Train	10%	13%	19%	18%	13%	16%	11%	100%	17.65
Walk	100%	0%	-	-	-	-	-	100%	1.10

Source: Primary Survey (CMP-2018)

3.3 TRAVEL DEMAND ANALYSIS

3.3.1 APPROACH

The following steps are involved in traffic demand analysis towards estimation of ridership on public transit system:

Preparation of Database: Involves collection of secondary data (studies done earlier, census data, master plan, land use parameters etc) and primary surveys (traffic and travel surveys).

Development of Transport Demand Models: The process consists of development of formulae (or models) enabling forecast of travel demand.

Estimation of Land Use Parameters: Land use parameters (viz., population, employment) are estimated for the horizon years in order to assess the future travel demand.

Formulation & Evaluation of Public Transit Networks: The alignments for public transit corridor are identified and passenger loading on this alignment estimated along with the engineering feasibility.

Detailed traffic & travel studies and transport demand forecasting have been carried out by Maha Metro as part of the assignment to establish the existing and future transport demand in the study area. The same data and travel demand estimates has been used for this assignment and presented in subsequent

paragraphs.

The travel demand assessment in urban environment is a complex exercise involving a large number of parameters and warrants the development of a transport model.

The transportation modeling process consists of development of formulae (or models), enabling forecast of travel demand, and development of alternative strategies for handling this demand. It is not just one model, but a series of inter-linked and inter-related models of varying levels of complexity, dealing with different facts of travel demand. Through these models, the transportation study process as a whole is checked and calibrated before it is used for future travel predictions.

The standard 4 stage Urban Transport Planning System model consists of:

- Trip Generation and Attraction Sub Model
- Trip Distribution Sub Model
- Modal Split Sub Model
- Assignment Sub Model

The parameters involved in the model development are population, employment and transport systems (with their accessibility, speed & capacity) of the study area. A commuter decides on his/ her selection of travel mode considering a number of parameters including accessibility of travel mode from the house, total travel time, total cost of travel, convenience/ comfort of travel and cost/ convenience for reaching the destination at the other end of the main journey. The commuter evaluates the merits and demerits of all possible alternative modes and their combinations before deciding on the final selection of travel mode(s).

Transport demand is a function of landuse and the growth of demand in various years vary depending upon the interrelationship of various landuse and traffic intensity in future years. Some of the major inputs to an urban transport demand model are:

- Delineation of study area into smaller traffic zones
- Population (existing and proposed at traffic zone level)

- Employment (existing and proposed at traffic zone level)
- Transport network and system (alongwith their respective carrying capacity and speed of each type of network/ system)
- Speed and frequency of operation of the proposed System.
- Intermodal integration facilities available and time required for passengers to interchange from one mode to another. This will also include the walking time required to access a particular System.

3.3.2 Trip Generation

The analysis and the model building phase starts with the step commonly known as Trip Generation. This is the term used in the transportation planning process to estimate the number of trip ends in a given area (i.e., how much travel; for example either from homes or workplaces). The objective of the trip generation stage is to understand the reasons behind the trip making behavior and to produce mathematical relationships to synthesize the trip making behavior and to analyze the trip making pattern on the basis of observed trips, land use data and the household characteristics.

For this study:-

All the existing trips on the project stretch have been considered for the base year. This is arrived through the Household Survey (travel diary), Volume count survey and Road side interview conducted in the study area. All the proposed developments and their scale of developments have been captured to estimate future trip generations within the study area.

Trips are usually divided into two types i.e. home-based and non-home based trips. Home-based trips are those having one end of the trip either origin or destination at home, of the persons making the trip, The home based trips are further classified as home based work trips, home based education trips and Home based other trips. Non home based trips are those having neither end at home of the person making the trip.

The base year planning variables and Trip generated are presented in **Table 3.36**.

TABLE 3.36: BASE YEAR PLANNING VARIABLE AND TRIPS GENERATED

Base Year (2017) Planning Variables	
Population (2017)	20,68,700
Employment (2017)	5,15,364
Trips Produced in Base Year (2017)	
Home Based Work (HBW)	19,02,790
Home Based Education (HBE)	10,87,309
Home Based Others (HBO)	30,203

Source: CMP-2018

Based on the correlation between the Planning Variables and the trips produced, the trip production and attraction equations are developed and the regression exercise showed a good correlation between planning variables and trip generated.

3.3.3 Trip Distribution

Second stage is Trip distribution or interchange. In this stage the spatial interchange of trips is modelled (from where to where). Trip distribution modeling is done based on the observed travel pattern which was analyzed from the OD survey and passenger survey. OD matrix for the entire horizon year was developed at this stage.

The base year (2017) Productions and Attractions obtained from the corrected O-D matrices, skim matrices from network and the calibrated function parameters were used to generate synthetic matrices. The Trip length distributions from Observed/Corrected and Synthetic O-D matrices were calculated (**Table 3.37**).

TABLE 3.37: DISTRIBUTION OF AVERAGE TRIP LENGTH BY MODE

Mode of Travel	Trip Length (In Kms.)							Total	Avg. trip length
	0-5	5-10	10-15	15-20	20-25	25-30	30-35		
Car	41%	16%	18%	11%	7%	5%	2%	100%	12.50
Two Wheeler	72%	14%	7%	4%	2%	1%	-	100%	7.65
Auto Rickshaw	69%	23%	5%	2%	1%	-	-	100%	7.15
Bus	53%	21%	11%	8%	4%	1%	2%	100%	10.00
Cycles	94%	6%	0%	-	-	-	-	100%	5.30
Train	10%	13%	19%	18%	13%	16%	11%	100%	17.65
Walk	100%	0%	-	-	-	-	-	100%	1.10

Source: CMP-2018

3.3.4 Modal Split

Third stage is related to modal split (which modes are used). This depends upon the observed relationship between modes used in relation to personal characteristics, trip characteristics and mode characteristics.

- For base year model, the existing Modal share (as derived in Household Survey) has been used.
- For horizon year models, the modal share as derived from 'willingness to pay and shift', PT & IPT Stated Preference Surveys etc. have been used (**Table 3.38**).

TABLE 3.38:: TRIPS AND MODAL SPLIT FOR BASE YEAR (2017)

S. No.	Trip Purpose	Vehicle Trips		Walk Trips		Total Trips By Purpose
		Trips	%	Trips	%	
1	Work	8,26,652	27%	3,98,018	13%	11,17,512
2	Business	2,44,934	8%	1,83,701	6%	7,85,278
3	Education	7,96,036	26%	2,44,934	8%	10,87,309
4	Others	2,14,317	7%	1,53,084	5%	30,203
Total		28,08,881		9,79,736		30,61,676

Source: CMP-2018

3.3.5 Traffic Assignment

The test corridor was coded in the VISUM (Version 14) model with the network attributes as captured through road inventory surveys and traffic and transit details from primary and secondary sources. The traffic volume originating from every zone in the network in terms of PCUs are given as per the site survey. The other properties such as free flow speed, vehicular speeds, permitted network speeds, lane capacities etc were provided.

The calibrated model is validated by comparison of field results and model output results. The 'Multi criterion' approach was followed for model validation. The zone to zone travel time at aggregate level were analyzed in all the trials till the error of below 5% is achieved. The second criterion was traffic concentration at roads, quantitatively measured by flow at the mid blocks. This was validated by comparison of model outputs and field survey outputs (traffic volume survey at mid blocks).

3.3.6 Establishing Base Year Travel Pattern

As explained earlier, the travel pattern in the form of mode wise OD matrices were obtained following the process described. The sources used for arriving at the base year OD pattern are the home interview survey, cordon OD survey, screen line traffic volume counts and occupancies. The mode wise OD matrices obtained from these primary sources were then validated by assigning them on to the respective networks and comparing the assigned and observed flows from ground counts. As the cordon surveys give only the external commercial vehicle trips, the internal commercial vehicle trips have been estimated from link counts using standard matrix estimation procedure. Highway and public transport networks were coded in transportation planning software package. The details of the assignment procedure are discussed in the following section.

3.3.7 Highway And Public Transport Assignment

Peak hour public transport passenger matrix, which includes trips made by bus, Intermediate Public Transport (IPT) and train, was assigned on to the public transport network. Public transport network is prepared by coding all the bus and IPT routes on the road network. In addition, the public transport network consists of all the existing rail links with the suburban train route coded on the rail links. All the zone centroids were connected to the nearest road nodes by walk links. Road to rail node walk connections were also given appropriately.

Highway assignment has been carried out for peak hour, preloading the highway network with peak hour public transport flows. The peak hour public transport passenger trips were converted into PCUs by using appropriate PCU-passenger ratios. These peak-hour public transport (bus and IPT) flows in terms of PCUs were preloaded on to the highway network before loading the two-wheeler and car O-D matrices. The passenger matrices of car and two-wheeler were converted into peak hour PCU units by using appropriate K factors (proportion of daily flow occurring during peak hour) and passenger-PCU conversion factors based on observed occupancies. An equilibrium procedure based on generalized cost was used in loading these car and two-wheeler matrices. The Commercial Vehicle (CV) trips were taken as preloads on highway network.

The assignment of PT and private vehicle trips were done iteratively till an overall equilibrium was reached between PT and highway networks. After every step of this equilibrium assignment, the observed and assigned flows were compared and

the matrices were adjusted if required using O-D Matrix estimation procedure.

3.3.8 Validation of Base Year (2018) Travel Demand

For validation travel demand estimated for the Base Year (2017), Cordon Line locations and Screen Line locations identified for the Thane study area have been considered as analysis of flows within Thane area is more relevant in the present study.

Classified traffic count survey, occupancy survey and OD surveys were carried out at 7 cordon locations for 24 hours. Classified count surveys were carried out at 14 screen line locations for 16 hours.

It can be inferred in case of cordon line and screen line locations that, location wise the error is within acceptable range indicating the ability of the travel demand estimates to represent the observed travel pattern.

3.4 DEVELOPMENT OF TRANSPORT DEMAND MODEL

Using the planning variables and validated total O-D matrix for base year (2018), trip end models are calibrated for total internal passenger travel. A single gravity model is calibrated using the validated trip ends and skims (generalized cost) obtained from assignment process as the seed values. The revised skims obtained after successive modal split and traffic assignments will be used to calibrate the gravity model.

3.4.1. Horizon Year Travel Demand Forecasts

The developed Travel Demand Model is used to forecast the Horizon Year loadings on each mode on all the links. Future forecasts would be done for the Horizon years 2029, 2035 and 2045. Planning variables would be predicted for Horizon years based on demographics and also with inputs from respective planning agencies.

3.4.2. Forecast Of Planning Parameters

Estimation of planning parameters is one of the important aspects of traffic demand modelling exercise. Planning parameters include population and employment of the study area. The Landuse parameters have been taken into account while projecting the future years' population and employment. The estimation is done for both base year and horizon years.

3.4.3. Population – Trends and Forecast

The population in the study area in the base year 2017 is 20.68 lakh. Accordingly, the population in the study area for the horizon years 2029, 2035 and 2045 is presented in **Table 3.39**.

TABLE 3.39: FORECASTED POPULATION OF STUDY AREA FOR HORIZON YEARS

Year	Forecasted Population (lakh)
2029	27.34
2035	34.99
2045	39.45

Source: Comprehensive Mobility Plan, 2018

The distribution of population in horizon years amongst various traffic zones would be based on land use and population density as derived from Master Plan.

3.4.4. Employment – Trends and Forecast

WFPR as observed in the base year 2017 is 25%. The employment for year 2011 has been worked out from the census data figures and has been extrapolated to obtain base year 2017 employment figures. Keeping in view the economic profile of the study area. It has been estimated that 15.99 lakh workers would comprise the workforce in the study area by 2045. **Table 3.40** shows the growth trend in employment in the study area. **Table 3.41** gives the forecasted population and employment for the horizon years.

TABLE 3.40: WORK FORCE PARTICIPATION IN STUDY AREA FOR BASE AND HORIZON YEARS

Year	Workers (Lakh)	WFPR (%)
2029	7.60	28
2035	12.43	36
2045	15.99	41

Source: Comprehensive Mobility Plan, 2018

TABLE 3.41: ZONEWISE FORECASTED POPULATION AND EMPLOYMENT FOR HORIZON YEARS

TAZ No	Population			Employment		
	2025	2035	2045	2025	2035	2045
1201	133904	218115	293128	11991	19532	42168
1202	179879	293004	393772	28649	46665	100747
1203	30701	50009	67208	3951	6435	13893
1204	36573	59573	80061	2402	3913	8448
1205	51739	84277	113261	2300	3746	8087
1206	25660	41798	56173	2196	3577	7722
1207	24996	40716	54719	2014	3280	7081
1208	23652	38527	51777	2014	3280	7081
1209	52999	61508	71382	12736	14350	16168
1210	75916	88103	102247	9851	11099	12506
1211	11916	16014	16014	1773	3828	4853
1212	20139	27065	27065	2221	4795	6079
1213	21553	28965	28965	6421	13862	17572
1214	131355	176530	176530	24844	53637	67993
1215	180125	242073	242073	39086	84384	106970
1216	91375	122800	122800	26284	56746	71934
1217	90787	122010	122010	17121	36963	46856
1218	25667	34495	34495	4470	9650	12232
1219	19417	26094	26094	3008	6495	8233
1220	18561	24944	24944	1503	3246	4115
1221	30763	41342	41342	9560	20639	26163
1222	33199	38529	44714	7586	8547	9630
1223	24753	28727	33339	6635	7476	8423
1224	9935	9935	9935	3256	3256	3256
1225	9549	9549	9549	2589	2589	2589
1226	7081	7081	7081	2125	2125	2125
1227	6456	6456	6456	2036	2036	2036
1228	5475	5475	5475	3072	3072	3072
1229	10867	10867	10867	10035	10035	10035
1230	6932	6932	6932	2088	2088	2088
1231	46602	54083	54083	16017	34580	43835
1232	11147	12936	12936	5825	12575	15941

TAZ No	Population			Employment		
	2025	2035	2045	2025	2035	2045
1233	13169	15283	15283	3904	8428	10684
1234	20391	23664	23664	22290	48123	61003
1235	11331	13150	13150	3016	6511	8254
1236	13800	16016	16016	1883	4066	5154
1237	7645	8872	8872	2656	5735	7270
1238	8683	10077	10077	2728	5891	7467
1239	49343	57265	57265	7652	16520	20941
1240	13828	16047	16047	3482	7517	9529
1241	16098	18683	18683	18948	40908	51858
1242	40527	47033	47033	18269	39441	49997
1243	48782	56614	65703	9859	12497	15842
1244	73955	85828	99607	16369	20750	26304
1245	36754	49395	57325	6414	8130	10306
1246	18622	25026	29044	4967	6296	7982
1247	67740	91037	105652	24821	31464	39886
1248	21913	29450	34178	3040	3853	4884
1249	6654	6654	6654	2070	2070	2070
1250	10899	10899	10899	4718	4718	4718
1251	7096	7096	7096	1871	1871	1871
1252	22209	22209	22209	4074	4074	4074
1253	36172	41979	48718	4844	5457	6149
1254	29129	33805	39232	13117	14779	16651
1255	88173	102329	118757	21448	24165	27227
1256	31524	36585	42459	3932	4430	4991
1257	26035	30215	35065	5456	6148	6926
1258	9025	9025	9025	5181	5181	5181
1259	6091	6091	6091	4733	4733	4733
1260	6091	6091	6091	2588	2588	2588
1261	33307	33307	33307	17997	17997	17997
1262	38146	44270	44270	14914	32197	40815
1263	11216	13017	13017	3748	8091	10257
1264	12331	14311	14311	35977	77672	98461
1265	10962	12722	12722	4909	10598	13434

TAZ No	Population			Employment		
	2025	2035	2045	2025	2035	2045
1266	29076	33743	33743	10731	23168	29369
1267	8558	9932	9932	7582	16369	20751
1268	18344	21289	21289	24668	53257	67511
1269	26834	31142	36141	4266	5408	6855
1270	8974	10415	12087	2227	2823	3578
1271	9033	10483	12166	2296	2911	3690
1272	14926	17322	20103	7706	9769	12384
1273	7289	8459	9817	2164	2743	3477
1274	47212	54792	63588	2710	3435	4355
1275	27726	32178	37343	6777	8591	10891
1276	22968	22968	22968	13334	13334	13334
1277	10517	10517	10517	2718	2718	2718
1278	27777	27777	27777	12383	12383	12383
1279	7360	7360	7360	3870	3870	3870
1280	8515	8515	8515	3715	3715	3715
1281	4011	4011	4011	13514	13514	13514
1282	6711	6711	6711	3086	3086	3086
1283	5838	5838	5838	2387	2387	2387
1284	7541	7541	7541	3761	3761	3761
1285	25975	30145	30145	7513	16220	20562
1286	22211	25777	29916	7094	8993	11400
1287	8738	10141	11769	2163	2741	3475
1288	6346	6346	6346	2506	2506	2506
1289	9736	9736	9736	4775	4775	4775
1290	7542	7542	7542	1351	1351	1351
1291	8929	8929	8929	2994	2994	2994
1292	5869	5869	5869	2394	2394	2394
1293	6869	6869	6869	3316	3316	3316
1294	26881	26881	26881	15839	15839	15839
1295	8122	8122	8122	2961	2961	2961
Total	2733739	3499924	3944520	760335	1242733	1598635

Source: Comprehensive Mobility Plan for Thane, 2018

3.5 PROPOSED THANE MRTS CORRIDOR

The Thane Metro corridor starts from New Thane Station (Proposed Sub urban Station at Kopri) and ends at Thane junction Railway Station which traverses through city in a ring at the North of Thane junction Railway Station up to Kasarvadavali area. The Alignment Plan of the proposed Corridor with station and depot location are shown in **Figure 3.1**.

The proposed Metro corridor is about 29 Km long and have 22 stations. It passes through important areas like New Thane, Wagle Circle, Lokmanya Nagar, Pokhran Road No. 1, Nilkanth Terminal, Gandhi Nagar, Kashinath Ghanekar, Patlipada, Dongripada, Vijay Nagari, Wagbil, Waterfront (TCS, New Brahmand, Azad Nagar, Manorama Nagar, Kolshet Industrial Area, Balkum Naka, Balkum Pada, Saket, Shivaji Chowk and Thane Junction.

3.6 RIDERSHIP ASSESSMENT FOR HORIZON YEAR

3.6.1. Ridership on Proposed Metro Corridor

Daily ridership on the proposed metro corridor for the years 2029, 2035 and 2045 is expected to be 6.47 Lakh, 7.61 Lakh and 8.72 Lakh passengers respectively. The Section loads, Station loads and Maximum PHPDT for 2029, 2035 and 2045 are shown in **Table 3.42, 3.43 and 3.44** respectively.

TABLE 3.42 SECTION LOADS ON METRO CORRIDOR

From	To	2029		2035		2045	
		Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2
New Thane	Raila Devi	5,371	42	5,225	132	4,363	184
Raila Devi	Wagle Circle	7,943	10,743	7,619	17,011	6,837	13,725
Wagle Circle	Lokmanya Nagar Bus Depot	7,707	17,604	6,301	23,655	5,504	23,661
Lokmanya Nagar Bus Depot	Shivai Nagar	8,212	18,147	6,288	26,781	5,256	27,070
Shivai Nagar	Neelkanth Terminal	8,769	16,644	6,892	26,566	5,829	27,380
Neelkanth Terminal	Gandhi Nagar	9,366	14,319	7,599	23,962	6,467	24,846
Gandhi Nagar	Dr Kashinath Ghanekar Natyagraha	9,690	12,169	8,032	21,437	6,808	22,501

From	To	2027		2035		2045	
		Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2
Dr Kashinath Ghanekar Natyagraha	Manpada	9,314	9,151	7,636	17,767	6,372	19,148
Manpada	Dongripada	9,513	8,968	7,900	17,451	6,570	18,943
Dongripada	Vijay Nagari	6,178	8,192	9,288	16,489	9,438	18,133
Vijay Nagari	Wagbil	8,905	15,375	13,424	17,839	13,603	16,722
Wagbil	Waterfront	9,335	12,647	14,056	13,683	13,976	12,648
Waterfront	Patlipada	9,394	12,216	15,519	13,054	14,389	12,244
Patlipada	Azad Nagar Bus Stop	10,067	12,129	16,501	11,575	15,327	11,840
Azad Nagar Bus Stop	Manorama Nagar	11,526	11,754	18,776	10,972	17,772	11,277
Manorama Nagar	Kolshet Industrial Area	14,037	10,749	22,493	9,421	21,365	9,586
Kolshet Industrial Area	Balkum Naka	14,370	9,018	23,116	6,865	21,887	7,092
Balkum Naka	Balkum Pada	15,363	9,343	20,577	6,945	22,979	7,295
Balkum Pada	Rabodi	16,348	9,836	22,017	8,830	24,327	8,974
Rabodi	Shivaji Chowk	21,307	9,589	27,398	8,469	29,515	8,643
Shivaji Chowk	Thane Junction	23,320	9,037	29,489	7,873	31,393	8,073
Thane Junction	New Thane	62	9,071	278	7,842	367	8,104

Source: MAHA- Metro (CMP, 2018)

TABLE 3.43 STATION LOADS ON METRO CORRIDOR

Station	Peak Hour 2029		Peak Hour 2035		Peak Hour 2045	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
New Thane	5,371	10,701	5,225	16,879	4,363	13,541
Raila Devi	3,775	8,064	3,435	7,685	3,338	10,800
Wagle Circle	3,617	4,396	3,977	8,421	3,268	8,010
Lokmanya Nagar Bus Depot	6,650	4,642	7,222	7,020	6,263	6,821
Shivaji Nagar	4,041	1,159	4,507	1,299	4,397	1,290
Neelkanth Terminal	3,335	588	3,895	663	3,624	641
Gandhi Nagar	4,485	1,143	5,381	1,278	4,956	1,262
Dr Kashinath Ghanekar Natyagraha	1,054	1,247	1,274	1,354	1,094	1,325
Manpada	1,450	475	1,748	522	1,507	499
Dongripada	7,387	17,905	10,079	10,041	10,997	6,718
Vijay Nagari	5,995	540	9,070	778	9,535	1,296
Wagbil	1,403	542	2,041	780	2,033	1,256
Waterfront	5,609	5,463	8,198	5,256	8,161	7,344

Station	Peak Hour 2027		Peak Hour 2035		Peak Hour 2045	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Patlipada	1,197	149	1,748	163	1,742	241
Azad Nagar Bus Stop	2,642	178	4,080	254	4,559	423
Manorama Nagar	4,509	267	6,655	382	6,722	635
Kolshet Industrial Area	944	936	1,436	893	1,548	1,229
Balkum Naka	1,637	1,137	1,659	6,083	1,840	2,427
Balkum Pada	1,365	133	1,993	192	1,984	305
Rabodi	7,167	1,656	7,586	1,609	7,088	1,330
Shivaji Chowk	3,781	1,802	3,723	1,601	3,180	1,333
Thane Junction	9,071	23,258	7,842	29,211	8,104	31,026

Source: MAHA- Metro (CMP, 2018)

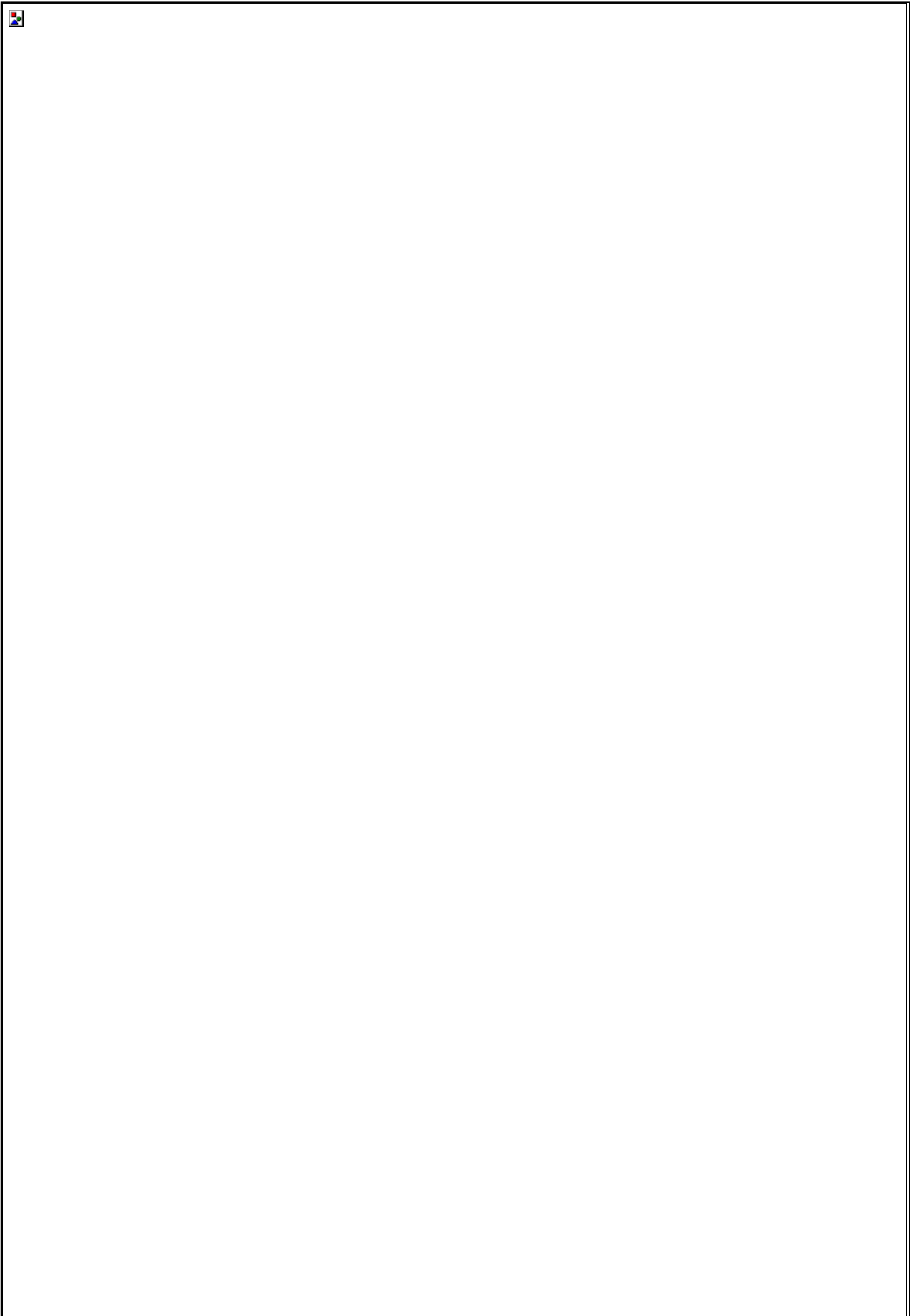
TABLE 3.44 MAXIMUM PHPDT AND DAILY RIDERSHIP

Year	Maximum PHPDT	Daily Ridership (in Lakh)
2029	23,320	6.47
2035	29,489	7.61
2045	31,393	8.72

3.7 DESIGN RIDERSHIP

Ridership realization however depends on a number of factors including the type/ intensity/ direction of development, various policies of the government and a number of unforeseen issues that could appear during next 20-40 years. The system will start operating with initial ridership estimated and the capacity will be increased depending on the development planned and actually achieved.

FIGURE 3.1: PROPOSED THANE METRO RING CORRIDOR



Chapter – 4

SYSTEM AND TECHNOLOGY SELECTION

4. SYSTEM & TECHNOLOGY SELECTION

4.1 TECHNOLOGY

Selection of a particular mass transit system largely depends on the characteristics of the city, its metropolitan area, the projected traffic demand and the availability of right-of-way (ROW). Mass Transit System is selected and planned to provide comfortable, safe, reliable and fast/high frequency connectivity across the cityscapes.

The urban transport requirements of Thane City have been evaluated based on projected traffic demand. Considering the city specific characteristics, traffic demand, availability of right of way, Medium Capacity Metro rail system, which can cater to Design capacity of 28000 PHPDT, is proposed to be adopted for Thane Metro corridor.

Metro Rail system is most prevalent mass transit system adopted worldwide. In India, MRTS is operational in various cities viz. Delhi, Chennai, Kolkata, Mumbai, Bangalore, Kochi, Jaipur etc. Metro rail technology offers the advantage of latest technology being available off the shelf with standardization, indigenization and has already stabilized for reliability, acceptance and availability of manufacturing infrastructure (for spare parts etc.) around the world and also in India. It is a grade separated system with exclusive right of way characterized by short distances of stations spaced at about 1 km and modern state of the art rolling stock having high acceleration and deceleration with maximum speed of 80-120 KMPH. Sharpest curve of 120m radius is permitted for MRTS. The system can be designed to meet the peak hour peak direction traffic (PHPDT) carrying capacity from 10,000 to up to 80,000 depending upon the type of system and infrastructure adopted such as rolling stock, train set configurations, signaling system, stations platform length etc. The capacities indicated for 6 car trains have been calculated by considering 1.5 minutes (90 seconds) headway which is achievable with advanced signaling system i.e. CBTC technology.

The maximum peak hour peak direction traffic (PHPDT) for the proposed Thane metro corridor is estimated to be about 28000 in year 2050. Considering the city specific characteristics, traffic demand, availability of right of way, 6 car train composition is proposed to be adopted for Thane Metro.

4.2 SYSTEM SPECIFICATIONS ADOPTED FOR THE CORRIDOR

Following system specification parameters are considered for the Thane Metro corridor. The rationale for choosing the particular technological parameter has been discussed in detail in the subsequent chapters.

TABLE 4.1: SYSTEM SPECIFICATION PARAMETERS

Parameters		System Specification
Traffic Handling capacity (PHPDT)		10000-60000
Alignment and Gauge	Minimum radius of curvature	Min. for elevated = 120m Min. for UG = 200m
	Gradient	4%
	Gauge	Standard gauge (1435 mm)
Traction System		25 kV AC Overhead Catenary
Signaling System		Communication Based Train Control (CBTC) System as per IEEE 1474.1
Telecommunication System		IP GE based
Rolling Stock	Coach Width	2.9 m wide coaches
	Basic Unit	One motor car and one trailer car
	Train Composition	3- Car :DMC-TC-DMC 6 –Car: DMC-MC-TC-MC-MC-DMC Capable of GoA4 operation Every coach should be fully interchangeable with any other coach of same type.
	Coach construction	Light weight stainless steel/Aluminum body
	Axle load	≤16 T
	Braking System	Regenerative Braking
	Propulsion system	3 phase drive system with VVVF control
	Performance Characteristics	Max. Design speed : 80 KMPH Max. Acceleration : 1.0 m/s² Max. Deceleration : 1.1 m/s² (Normal brake) , More than 1.3 m/s² (Emergency brake)

Chapter – 5

CIVIL ENGINEERING & ALIGNMENT DETAILS

5. CIVIL ENGINEERING& ALIGNMENT DETAILS

5.1 ALIGNMENT DESCRIPTION OF APPROVED ALIGNMENT, AVAILABILITY OF ROAD SPACE

5.1.1. Engineering Survey and Alignment Design

The Thane Ring Metro corridor was agreed upon for the study. Corridor starts from Kopriand ends at Thane junctionwhich traverses through city in a ring at the North of Thane junction Railway Station up to Kasarvadavali area.

Metro Route of the corridor was initially planned on Google Map. For detailed planning of the proposed metro route, ground survey was carried out with the help of DGPS, Total Station and Auto levels. Details of all the existing features falling in the proposed corridor were collected for proper planning of the alignment and Depot. Detailed Methodology of the Survey and other descriptions are given in subsequent paragraphs.

5.1.2. Survey Methodology

- i. Before starting the detailed topographical survey work, a team of expert in the field of alignment design and survey has conducted reconnaissance survey to familiarize withthe area and selection of control points along the proposed Metro Route.
- ii. Topographical survey of the Corridor has been carried out to collect all manmade and natural features like roads, building, drain, railway line telephone/electric pole etc., falling in the proposed metro corridor for better and accurate planning of the metro alignment.
- iii. Topographical survey was carried out in detail covering all the activities which are mentioned in Terms of Reference of the Contract using modern surveying instrument like DGPS, Total Station and Auto/Digital Level. Survey Drawings were prepared in AutoCAD format.
- iv. Topographical survey and alignment design have been carried out in following steps:
 - a. Establishment of Horizontal Control Points using DGPS

- b. Densification of Horizontal Control Points using Total station
- c. Establishment of Vertical Control Points
- d. Detailed survey of corridor
- e. Preparation of drawings
- f. Site verification of features and finalization of drawings
- g. Alignment design on basis of verified drawings

A. Establishment of Horizontal Control Points using DGPS

Before starting the GPS work, network has been planned and a pair of concrete pillars of 300x300x400mm size of M15 grade concrete has been fixed at every one Km along the corridor. A mild steel rod of 20mm diameter and 350mm long has been provided at the centre of pillar to mark location of GPS point. Location of these pillars has been selected such that these are obstruction free towards sky at an angle of 15 degree with Horizontal plane to achieve required degree of accuracy in GPS observation.



For carrying out GPS work, first control point (base point) was set-up at Saket Police ground. At this point, 24hrs GPS observation was done to achieve higher degree of accuracy and for other points, sufficiently long hours common period observation was carried out. Common period observation at three points have been carried out to form the triangle and to calculate the accuracy of the loop with the help of loop closer reports by solving these triangles with the help of data processing software.

In this survey, **Spectra Precision SP-800** GPS has been used for collecting GPS Data. Data was downloaded and processed with **Survey Pro office** software. In this processing UTM Projection system and WGS84 Datum has been used for horizontal controls whereas for vertical control Earth Gravitation Model 2008 (EGM 08) has been used. Grid Co-ordinates have been converted in Ground Co-ordinate by using

combined scale factor. These Ground Co-ordinates are used in total station during the traversing and topographical survey. Details of established GPS Control points (GCP) are provided in **Table 5.1**.

B. Densification of Horizontal Control Points using Total Station

For densification of Horizontal Control Points, nine to ten additional pillars of size (150x150x450) on traverse points have been fixed between GPS control points which were used during the detailed topographical survey of the corridor. Details of additional control points (Traverse Control Point) established are given in **Table 5.2**.



For densification of horizontal points, traversing was carried out by Nikon Total Station of 1" (one second) accuracy between GPS points which co-ordinates are already determined with help of GPS observation. Co-ordinates of intermediate points established with the help of total station have been determined by solving the traverse network between GPS control Points. Closing error of traverse network was calculated and errors which were within permissible limits, were adjusted by transit rule method after adjusting the angular error of the traverse. Total linear error in traverse after angular adjustment was permitted as 1 in 20,000 whereas angular error of traverse was permitted as $15''\sqrt{n}$ where n is the number of angle measured in the traverse network.

TABLE 5.1: LIST OF DGPS CONTROL POINTS

S. No.	Point ID	WGS 84 Co-ordinates		Ellipsoidal Height (m)	UTM Co-ordinates (WGS 84, Zone 43)		Elevation (m)	Description
		Longitude	Latitude		Easting (m)	Northing (m)		
1	GPS-1	72d58'00.35660"	19d10'48.71442"	-50.932	286198.662	2122013.321	13.275	Railway bridge near Dattaji salvi Udyan
2	GPS-1A	72d58'04.47705"	19d10'40.87831"	-56.078	286316.229	2121770.986	8.142	Copri Village Road
3	GPS-2	72d58'26.18324"	19d10'27.99867"	-59.914	286945.764	2121367.605	4.394	On Football Ground, Hari On Nagar
4	GPS-2A	72d58'29.36780"	19d10'29.62879"	-60.455	287039.384	2121416.644	3.828	On Football Ground, Hari On Nagar
5	GPS-3	72d59'03.24122"	19d11'50.50944"	-57.288	288057.76	2123891.945	6.964	Kalwa bridge
6	GPS-3A	72d58'57.06381"	19d11'50.07468"	-58.28	287877.157	2123880.666	5.938	Police station Near Kalwa Naka
7	GPS-4 (BASE)	72d59'16.65342"	19d12'11.69404"	-59.632	288457.068	2124538.759	4.614	Saket Police Ground
8	GPS-4A	72d59'16.49958"	19d12'17.23837"	-59.263	288454.534	2124709.237	4.919	Saket Police Ground
9	GPS-5	72d59'51.46151"	19d13'15.40729"	-59.967	289496.342	2126485.967	4.256	Pipe road,Fishing Pond near Dadlani Park
10	GPS-5A	72d59'53.46982"	19d13'20.27193"	-59.734	289556.719	2126634.86	4.525	Pipe road,Fishing Pond near Dadlani Park
11	GPS-6	72d59'14.91333"	19d13'57.67053"	-56.158	288443.929	2127797.719	7.947	Kolshet Road
12	GPS-6A	72d59'16.50411"	19d14'01.49054"	-55.324	288491.746	2127914.632	8.761	Kolshet Road chowk
13	GPS-7	72d58'38.31475"	19d14'51.35297"	-51.12	287394.287	2129460.664	12.763	On Patlipada T Point/ Opp. Kolshet Sub Station
14	GPS-7A	72d58'33.82700"	19d14'48.38647"	-48.9	287262.172	2129370.981	15.04	On Patlipura Road
15	GPS-8	72d58'11.65860"	19d14'05.29985"	-25.813	286599.328	2128053.77	38.096	Opp. Orbit Interior Near khewra cricle

S. No.	Point ID	WGS 84 Co-ordinates		Ellipsoidal Height (m)	UTM Co-ordinates (WGS 84, Zone 43)		Elevation (m)	Description
		Longitude	Latitude		Easting (m)	Northing (m)		
16	GPS-8A	72d58'11.77869"	19d13'59.37158"	-26.272	286600.706	2127871.456	37.638	NearValley Tower,Kewra Circle
17	GPS-9	72d57'10.57416"	19d13'07.35266"	-7.106	284794.406	2126293.003	56.675	On Road Shivai Nagar
18	GPS-9A	72d57'13.65694"	19d13'03.17866"	-15.791	284882.938	2126163.608		On Road Shivai Nagar
19	GPS-10	72d56'57.73778"	19d11'47.12328"	-26.526	284390.428	2123830.628	37.35	Near Weltech Fectory
20	GPS-10A	72d56'57.66319"	19d11'41.15487"	-29.805	284386.088	2123647.145	34.084	In side of Wagle circle
21	GPS-11	72d57'19.22651"	19d11'12.98807"	-46.968	285005.829	2122773.707	17.009	On S G Barve Road,near MIDC Colony
22	GPS-11A	72d57'20.84242"	19d11'07.90131"	-48.081	285051.201	2122616.753	15.971	On Medulla Chowk

C. Establishment of Vertical Control

Establishment of vertical control was started from a known GTS benchmark situated on Pillar top at office of the Junior Engineer office (Jail Jalkumbh). The value of this benchmark is 6.280m. From this location bench mark was transferred along the corridor using three stadia method of leveling with Digital Auto levels. Every loops of level has been closed and closing error of leveling loops has been worked with the formula given below:

$$\sum BS - \sum FS = \sum RISE - \sum Fall = \text{Last R.L} - \text{First R.L.}$$



TABLE 5.2: LIST OF TRAVERSE POINTS

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
1	T1	286356.343	2121606.423	4.218	Service Road Median End, Shrima Bal Niketan High School
2	T2	286383.763	2121406.439	5.411	on Median Near Sainath Heght
3	T3	286349.849	2121129.726	5.073	on Median Near Toll Tax
4	T4	286598.074	2121124.174	7.81	Open Ground Near Pylon (BMC Land)
5	T5	286839.465	2121266.972	5.1	on Cart Track Back Side of Kaveri Co-oprative Housing Society Ltd.
6	T6	286927.504	2121295.193	5.817	Hariom Nagar View Ground
7	T7	287146.416	2121576.146	3.709	Near Water Pipe Line
8	T7A	287278.009	2121521.085		Near Water Pipe Line
9	T7B	287487.058	2121663.449		on Stone Near Water Pipe Line
10	T8	287518.092	2121771.32	3.348	on Pillar Near Pond
11	T8A	287530.992	2121815.326		Near Water Pipe Line
12	T8B	287448.043	2122044.713		Peoples Education Society High School & Jr. Collage Wall Corner
13	T8C	287515.534	2122016.629		Near Peoples Education Society High School & Jr. Collage.
14	T8D	287542.859	2122079.165		Near Peoples Education Society High School & Jr. Collage.
15	T8E	287565.923	2122087.215		Near Peoples Education Society High School & Jr. Collage. Gate
16	T8F	287616.322	2122086.497		Swami Samarth Chowk
17	T8G	287662.315	2122232.403		Neil Top
18	T8H	287625.717	2122245.043		on Footpath
19	T9	287599.891	2122270.614	4.34	Astvinayak Chowk
20	T10	287516.193	2122440.868	4.054	Astvinayak Chowk
21	T10A	287524.013	2122509.62		Near Piau
22	T11	287552.035	2122585.153	3.492	ICICI Bank ATM Right Side
23	T12	287596.071	2122756.102	3.641	Opposite Side Sunanda General Store
24	T13	287689.172	2122794.813	3.24	Railway Underpass
25	T14	287680.394	2122838.667	2.772	Railway Underpass
26	T15	287572.329	2122862.578	3.441	Sudco Bus Statnd Near High Mask

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
27	T16	287527.262	2122924.295	3.685	Left Side Turning Tea Shop
28	T17	287570.458	2123002.289	4.108	Right Side Police Booth & Park
29	T17A	287578.471	2123050.458		Maharashtra Matan Shop
30	T18	287609.509	2123098.361	4.194	Near TMC Toilet, (Josho Bedekar Canteen)
31	T19	287671.414	2123272.039	3.797	Near SR Bhosle Krida Sankul Stadium
32	T19A	287755.765	2123412.518		Near Ambedkar Socity
33	T19B	287796.02	2123429.749		Near Laxmi Apartment
34	T20	287828.468	2123435.231	4.038	Near Laxmi Apartment
35	T20A	287835.26	2123455.943		Near Laxmi Apartment
36	T21	287899.335	2123534.297	3.966	Near Hari Niwas
37	T21A	287942.576	2123642.437	6.114	Right Side Near Culvert (Rahul Tailor)
38	T21B	287973.369	2123720.815		Footpath Front of Commissnor Office Gate
39	T22	288014.884	2123857.287	6.11	on Median Kalwa Chowk
40	T22A	288062.939	2123990.859	5.319	Near Thane Jail
41	T22B	288145.522	2124088.963	5.145	Near Thane Jail
42	T23	288211.223	2124158.649	4.819	on Median Near Rabodi Vahan Police Tiraha
43	T24	288264.262	2124317.489	4.847	on Footpath Near Nallah Culvert
44	T25	288365.71	2124440.976	5.019	on Footpath Near Nallah Culvert
45	T25A	288410.753	2124533.413		on Saket Police Ground
46	T25B	288460.721	2124730.71		on Road Near Toilet at Saket Police Ground
47	T26	288453.21	2124901.941	4.447	Rustom Ji Cambridge Internation School
48	T27	288383.596	2125072.442		Front of Rustom Ji Acura
49	T28	288367.967	2125286.074		on Drain Top Near T-Junction (Rustom Ji Atelier)
50	T29	288478.398	2125261.239	6.323	Near Rustom Ji Azzikno
51	T29A	288492.528	2125314.695		on Median Mumbai Nasik Road
52	T30	288471.936	2125318.512	5.494	on Median Mumbai Nasik Road
53	T30A	288470.913	2125363.671	4.979	on Pipe Line Road
54	T30B	288643.763	2125331.825	5.038	on Pipe Line Road
55	T33	288874.067	2125313.231		on Pipe Line Road

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
56	T34	288955.58	2125488.597		on Pipe Line Road
57	T35	289057.652	2125715.558		Near Balkumb Saket Road
58	T36	289118.708	2125850.27		on Pipe Line Road
59	T37	289192.683	2126014.575		on Pipe Line Road
60	T38	289324.961	2126204.054		on Pipe Line Road
61	T39	289469.767	2126408.569		on Pipe Line Road
62	T40	289596.434	2126921.713	4.431	on Pipe Line Road
63	T41	289606.435	2127022.517	9.908	on Agra Highway
64	T42	289689.249	2127059.111	10.092	on Agra Highway
65	T43	289632.088	2127139.632	8.403	on Road
66	T44	289481.152	2127300.772	7.976	on Platform
67	T44A	289523.564	2127339.787		Neil Top
68	T45	289524.883	2127617.118		on Pipe Line Road
69	T46	289527.527	2127827.188		on Pipe Line Road
70	T47	289529.924	2128048.362		on Pipe Line Road
71	T47A	289505.359	2128032.003		on Pipe Line Road
72	T47B	289374.544	2127989.28		on Pipe Line Road
73	T47C	289298.666	2127961.287		on Pipe Line Road
74	T47D	289196.622	2127976.148		Mariai Nagar Kolshet
75	T47E	289211.994	2128101.963		
76	T47F	289209.15	2128241.482		on Tank
77	T47G	288951.626	2128329.253		
78	T47H	288843.623	2128425.547		
79	T47I	288769.994	2128429.452		on Main Road Dhanlaxmi Jewelors (on Neil Top)
80	T47J	288625.709	2128140.151		
81	T47K	288529.776	2127970.616		
82	T48	288476.67	2127871.528		on Median Kolshet Majiwada Road
83	T49	288469.466	2127978.701	11.136	
84	T50	288436.465	2128101.223	16.948	

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
85	T51	288387.672	2128264.133	19.23	
86	T52	288226.01	2128227.641	15.626	Maruti Suzuki on Footpath
87	T53	288141.287	2128267.351	13.899	
88	T54	288099.48	2128510.291	18.845	Near Hanuman Temple
89	T55	288046.444	2128533.274	20.597	Right Side of Gali Near Junction Box
90	T56	287899.734	2128538.44	26.95	Left Side of Sai Kripa Hair Traders
91	T57	287819.329	2128581.339	32.118	on Neil Top Left Side of Bhoomi Property Solution
92	T58	287802.025	2128609.558	34.1	More Vegetable Shop
93	T59	287762.789	2128739.847	33.949	on Pillar Left Side of Near Police Booth
94	T60	287854.015	2128739.211	28.645	Neil Top Metro Tolis Shop
95	T61	287946.359	2128818.191	28.651	Kosmos arcade orchids International School
96	T62	287986.351	2128991.051	22.123	Near Temple
97	T63	287931.547	2129119.356	19.079	on Median Near Opollo Pharmecy
98	T64	287928.027	2129265.102	14.703	Right Side of Axis Bank
99	T65	287794.358	2129327.715	11.244	Front of Gate Near Amita Apartment
100	T66	287733.784	2129425.341	10.288	Neil Top Perfect Aotu Garage
101	T67	287606.32	2129486.386	10.294	Patlipada
102	T68	287480.101	2129558.941	10.65	Near Park T-Point Opposite DJ 5 Bsahkarj Building
103	T69	287226.557	2129323.687		on Neil Flyover Bottam 220Kv. Kolshet Substation
104	T70	287221.5	2129107.638	17.611	Flyover End on Neil Top
105	T71	287220.605	2128879.921	26.518	Neil Top on Red Light
106	T72	287189.898	2128637.969		Neil Top
107	T73	287192.299	2128479.415		on Service Road Near Hill Crest Apartment
108	T74	287201.066	2128335.363		on Road Near Thane Steel Shop
109	T75	287214.239	2128206.12		Maanpada Chitarsar Titan Hospital
110	T76	287059.001	2128207.069		on Median Art Sera
111	T77	286879.072	2128215.859	35.062	on Road Near Sahyog Complex
112	T78	286798.4	2128224.637	35.242	on Road Near Krishna Family Restourent
113	T79	286601.819	2128253.174	38.09	Neil Top Near Median End

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
114	T80	286596.486	2128133.354		Neil top Near Wine Shop
115	T81	286605.566	2127760.687	36.638	Khewara Circle
116	T82	286610.231	2127671.279	33.814	on Road Near SBI Bank
117	T83	286598.495	2127641.616	33.921	on Footpath Near Magnoia Building
118	T84	286611.089	2127457.159	34.583	on Median Near Oak House
119	T85	286575.437	2127326.675	33.59	Milog Circle
120	T86	286617.222	2127155.409	32.136	on Neil Titan Egeplus
121	T86A	286618.998	2127080.78	31.588	on Road Near Regal Plaza Shopping Centre
122	T87	286592.945	2126994.73	29.992	on Median Niharka Tower
123	T88	286592.828	2126906.738	26.361	on Road Near Indusland Bank
124	T89	286586.414	2126584.018	17.827	on Median Near Lok Upvan Complex
125	T90	286635.842	2126438.231	18.17	on Road Near Ashar Residency
126	T91	286584.557	2126223.851	23.381	Near T-Point Gandhi Nagar OHT
127	T92	286410.872	2126280.144	26.188	on Footpath Near Galaxo Smith Kline
128	T93	286181.654	2126343.075	31.076	on Footpath Opposite Hanuman Temple
129	T94	285933.016	2126406.426	32.078	on Median End Galaxo Smith Kline
130	T95	285776.868	2126450.43	35.651	on Median Near Dethane Hospital
131	T96	285539.359	2126562.926	46.078	on Road Near Nilkhant Terminal
132	T97	285363.614	2126600.819	44.521	on Road Near Anand Furniture
133	T98	285327.484	2126770.816	53.959	on Median End Near Upvan Lake
134	T98A	285325.93	2126796.257	54.603	on Median End Near Upvan Lake
135	T99	285084.082	2126718.47	45.962	on Road Near Upvan Lake
136	T100	284977.495	2126586.161	47.204	Near Bus Stop Upvan Lake
137	T101	284886.829	2126500.289	55.316	on Median Cosmos Hill Gate
138	T102	284768.353	2126408.811	63.565	on Road Near Junction Box
139	T103	284763.9	2126319.914	59.664	on Median End Near Darus Sakina Gate
140	T104	284922.867	2126150.072	45.913	on Median Front Side of Hotel Annpurna
141	T105	285065.766	2126014.787	39.106	on Road Near Sailyam Society Shivai Nagar
142	T106	285057.014	2125951.378	47.274	on Stone Top Miletry Ground
143	T107	285047.14	2125894.263	46.372	on Stone Top Miletry Ground

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
144	T108	284998.755	2125706.913		on Road Near Junction Box Shastri Nagar
145	T109	284969.438	2125672.627	33.015	on Road Opposite Vihang Park
146	T110	285030.678	2125560.08	31.25	on Road Near Pipal Tree & Laxmi Park Gate
147	T111	285178.215	2125304.835	31.093	Gali & Real Baites
148	T111A	285059.676	2125309.535	31.556	Near Shankar Mandir
149	T111B	285003.152	2125309.239	33.843	Opposite Mobile Shop
150	T111C	284933.341	2125324.672	34.698	Sobhagya Jewelors
151	T111D	284890.427	2125316.833		Nanji Kirana Store
152	T112	284849.381	2125346.47	35.423	Shri Swami Samarth Full Mart
153	T113	284813.169	2125333.673	35.359	opposite Shri Mahavir Jewelors
154	T114	284792.012	2125334.501	36.014	Gali
155	T115	284792.574	2125313.629	36.855	Shiv Darshan Apartment
156	T116	284763.361	2125316.789	37.501	
157	T117	284745.73	2125207.875	37.22	
158	T118	284683.176	2125253.968	41.097	on Road Near Lokmanya Bus Depot
159	T119	284659.275	2125253.57	42.452	on T-Point Lojmanya Nagar Chowk
160	T120	284551.476	2125081.796	46.818	on Median Opposite Balaji Enterprises
161	T121	284512.956	2124945.909	47.002	on Median & Sai Traders
162	T122	284476.741	2124773.092	42.953	on Road Near Baba Saheb Ambedkar Chowk
163	T123	284432.806	2124621.478	41.735	on Median Raja Febrication
164	T124	284399.637	2124435.987	44.363	on Road Edge Near Shankar Electronics
165	T125	284362.009	2124348.236	45.641	on Neil Andabhau Chowk
166	T126	284378.276	2124213.54	43.918	on Road JB Savan Engineering
167	T127	284373.902	2124075.519	39.891	on Median Near Dosti Tinnacle (Near Nallah Crossing)
168	T128	284492.357	2123629.318	33.473	on Road Median Kotak Mahindra Bank
169	T129	284593.949	2123605.264	29.656	on Neil Millennium Toyota
170	T130	284670.563	2123592.669	28.856	on Median End Shri Engineering Corporation
171	T131	284824.616	2123530.424	28.856	on Median End Lokshaheer Andabhau Chowk
172	T132	284855.971	2123521.683	29	Near Toilet Lokshaheer Andabhau Chowk

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
173	T133	284927.579	2123442.145	28.719	on Median Near Pipe Line Crossing
174	T134	284977.585	2123357.439		on Neil in Front of EPFO Office
175	T135	285036.89	2123177.759	20.133	on Road Edge in Front of Opal Square
176	T136	285031.867	2123063.421	20.046	on Road Opposite of Khandelwal Laboratories
177	T137	285004.994	2122896.623	17.336	on Median End Near Radha Krishna Restaurant
178	T138	285147.737	2122628.482	14.751	on Road Opposite Bus Stop on LBS Marg
179	T139	285332.441	2122642.609	14.345	on Neil top Near the Residency Vastusilp Gate
180	T140	285579.063	2122731.323	12.719	on Median Near Foot Over Bridge
181	T141	285557.227	2122631.286	12.068	
182	T142	285602.684	2122431.611	11.02	Near Gali
183	T143	285642.858	2122376.927	10.797	on Circle Near Mental Hospital
184	T144	285937.159	2122371.783	9.503	Near Sai Temple & Gali
185	T145	286023.651	2122409.986	9.622	on Neil Near Foot Over Bridge
186	T146	286073.77	2122271.095	13.028	on Neil Near Foot Over Bridge
187	T147	286119.717	2122201.808	14.962	on Neil Top Kopari Bridge Near High Mask
188	T148	286156.633	2122093.183	15.147	on Road Near Foot Over Bridge
189	T149	286179.16	2122323.663		on Median Near Under Construction Flyover
190	T150	286249.034	2122470.307		Left Side of Dr. Neha Gupta (Narvi Tanaji Chowk)
191	T151	286320.578	2122433.661		Near Anmol Height
192	T152	286395.426	2122450.012		Near Manodutt Building
193	T153	286403.144	2122532.72		Opposite Temple
194	T154	286485.259	2122523.776		Kamla Smarti Building
195	T155	286565.306	2122608.964		Near Dental Clinic
196	T156	286641.551	2122697.192		B-Cabin Police Station
197	T157	286714.114	2122752.587		Opposite Yashwant Vichal Marathe
198	T158	286817.984	2122788.996		Near Tjsb Sehkari Bank
199	T159	286906.639	2122859.646		on Footpath Near ICICI Bank
200	T160	287093.902	2122859.748		Near Subhsagar Restaurant
201	T161	287150.985	2122852.953		Flyover Bottam

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Easting	Northing		
202	T162	287243.757	2122848.502		Opposite Side Womens World
203	T163	287293.793	2122840.886		Neil Top Near Ashok Cinema
204	T164	287307.598	2122860.377		Attitude Apartment
205	T165	287375.907	2122853.059		Near Rajesh Apartment
206	T166	287386.777	2122875.271		Near Shanti Temple
207	T167	287419.484	2122871.811		Near Saideep Apartment
208	T168	287431.349	2122883.277		Johri Bhaugo Poly Chowk
209	T169	287556.483	2122880.508		Near Axix Bank ATM
210	C1	287208.134	2129471.464	18.899	in Front of Riddhi Siddhi Plywood
211	C2	287091.278	2129654.97	21.517	on Drain Top Near Transformer
212	C3	287061.258	2129734.361	23.946	Near Ansh Traders
213	C4	287006.207	2129819.627	27.833	Near Manas Anand Socity
214	C5	286932.944	2129979.152	19.67	on Service Road Near Toilet
215	C6	286896.804	2130076.257	18.442	on Footpath Near Wagbil Naka
216	C7	287000.276	2130282.397	14.832	Near Road Edge Green Acres
217	C8	287077.001	2130546.297	12.368	Near T-Junction Vijay Anaxi Building-18
218	C9	287202.251	2130707.692	11.147	Near Road Edge Vijay Anaxi Building-31
219	C10	287299.763	2130707.128	11.186	Opposite Swastik Bhojnalaya
220	C15	287457.855	2130603.789	12.057	on Drain Top
221	C16	287629.125	2130477.652	17.12	on Footpath
222	C17	287746.703	2130382.908	10.045	on Footpath Near Avon Coprative Socity
223	C18	287911.487	2130240.356	4.831	on Circle
224	C19	288123.018	2130085.762	3.841	Near Bend
225	C20	288237.4	2129960.911	4.974	on Road
226	C21	288112.841	2129773.565	7.87	Near Bend (Near TMC Land)
227	C22	288188.419	2129705.028	11.722	on Road in Front of Shriji Splender
228	C23	288061.436	2129526.093	13.092	on Road in Front of Shriji Splender
229	C24	287947.388	2129303.792	16.383	on Footpath in Front SBI ATM (Khbra Galaxy)

Closing error within permissible limit has been adjusted. Permissible error in leveling is $6\sqrt{K}$ mm where K is length of the loop in Km. The Leveling was carried out by a precision auto level with accuracy of $\pm 6\sqrt{K}$. Reduced levels of all traverse stations and permanent control points were taken by Double territory method. Bench mark has been established at interval of 500m along the corridor or as per instruction of site in- charge. Details of benchmarks are given in **Table 5.3**.

D. Detailed Survey of the Corridor

Based on Easting & Northing co-ordinates arrived by the traversing and Elevation by Precise Leveling, Detailed survey was carried out along the proposed metro route for 100m wide corridor (50m either side of the centre line of the road) or upto Built up line using total stations of desired accuracy. At some places instrument having reflector-less facilities has been used for collecting details of features due to inaccessibility of the area.

Survey covered picking up of relevant details like roads, footpaths, dividers/central verges, railway tracks, trees, manholes and other structures, H.T., L.T., Transmission lines, bridges, ROBs / RUBs, ponds, streams, major drains, level crossing, religious structures such as Temples, Gurudwaras, Mosques, Churches, Monuments, tombs etc. Spot/ Ground levels were taken at 25 m intervals in longitudinal as well as traverse direction and at sudden change of levels.

E. Preparation of Drawings

Drawings were prepared in Auto CAD format in 1: 1000 scale as per project requirement showing all the manmade and natural features. Different features are shown in different layers. Attributes of all the features like name of the road its width, name of railway line, name of the building and its number of stories, width of drains and its HFL, Type of overhead crossings (Electric and Telephone lines) and its rating have been provided in this drawing.

Details of all the religious structure such as Temple, Mosque, Gurudwara, Church, Monuments, Tomb, etc have been shown in the drawing as per standard legend.

Spot levels have been shown in drawing to access the terrain of the area along with trees falling in said survey corridor of 100m. Control points, established during conducting the survey work, have been also shown in the drawings.

TABLE 5.3: LIST OF TBM'S

S. No.	TBM No	Ground Coordinate		RL (m)	Description
		Easting	Northing		
1	Bench Mark-1	-----	-----	6.280	on Pilar in Jailkumbh Sub-Engineer Office.
2	Bench Mark-2	-----	-----	3.655	Main gate No.1 Dadoji Kondke stadium
3	Bench Mark-3	287599.891	2122270.614	4.34	Astvinayak Chowk
4	Bench Mark-4	288014.884	2123857.287	6.11	on Median Kalwa Chowk
5	Bench Mark-5	288457.068	2124538.759	4.614	Saket Police Ground
6	Bench Mark-6	289606.435	2127022.517	9.908	on Agra Highway
7	Bench Mark-7	287946.359	2128818.191	28.651	Kosmos arcade orchids International School
8	Bench Mark-8	286611.089	2127457.159	34.583	on Median Near Oak House
9	Bench Mark-9	286575.437	2127326.675	33.59	Milog Circle
10	Bench Mark-10	284922.867	2126150.072	45.913	on Median Front Side of Hotel Annpurna
11	Bench Mark-11	284659.275	2125253.57	42.452	on T-Point Lojmanya Nagar Chowk
12	Bench Mark-12	284476.741	2124773.092	42.953	on Road Near Baba Saheb Ambedkar Chowk
13	Bench Mark-13	284824.616	2123530.424	28.856	on Median End Lokshaheer Andabhau Chowk
14	Bench Mark-14	284386.088	2123647.145	34.084	In side of Wagle circle

F. Site Verification of Features

Details of features shown in the drawings were verified at site and additional details were collected and incorporated in the drawing wherever needed.

G. Preparation of Alignment Drawing

Based on the finalized topographical survey drawing, the alignment design was done using MX-Road software.

5.1.3. Route Alignment

The proposed Thane Metro - Ring corridor has been finalized for implementation in this Phase as shown in **Figure 5.1**. Corridor starts as New Thane station adjacent to Sub urban Station Kopri and traverses through city in a ring via Dongripada, Kasarvadavali areas and Thane junction Railway Station at the North of Thane junction Railway Station.

a. Alignment Description

Considering km 0/000, centre line of New Thane Station near proposed Kopri sub-urban station as starting of alignment, this corridor ends at the same location and forms a Ring. The length of Ring Alignment is 27400.172 m. A connection of length 1177.7 m is planned from Waghbil to Kasarvadavali area as depot connectivity. This corridor consists of elevated and underground stretches along with Switch over Ramps (SOR).

Total of 22 stations, in which 20 stations are elevated and 2 stations are underground, have been proposed in the entire corridor.

Two Mumbai Metro lines, namely Line-4 (Wadala–Ghatkopar–Mulund– Teen Hath Naka–Kasarvadavali) and Line-5 (Thane–Bhiwandi–Kalyan) intersect Thane Ring Metro corridor at three locations Modella Chowk, Dongripada and Balkum Naka.

The corridor is summarised as under in **Table 5.4**.

TABLE 5.4: ALIGNMENT DESCRIPTION

Alignment Type	From (m)	To (m)	Length (m)
Underground	0.0	317.0	317.0
Switch over Ramp (-)8.0m to(+)7.5m	317.0	1181.0	864.0
Elevated	1181.0	24917.0	23736.0
Switch over Ramp (+)7.5m to (-)8.0m	24917.0	25342.0	425.0
Underground	25342.0	27400.2	2058.2
Depot Entry	0	1177.7	1177.7
Total			28577.8

The Alignment of the Ring Corridor is described in detail in following sub sections:-

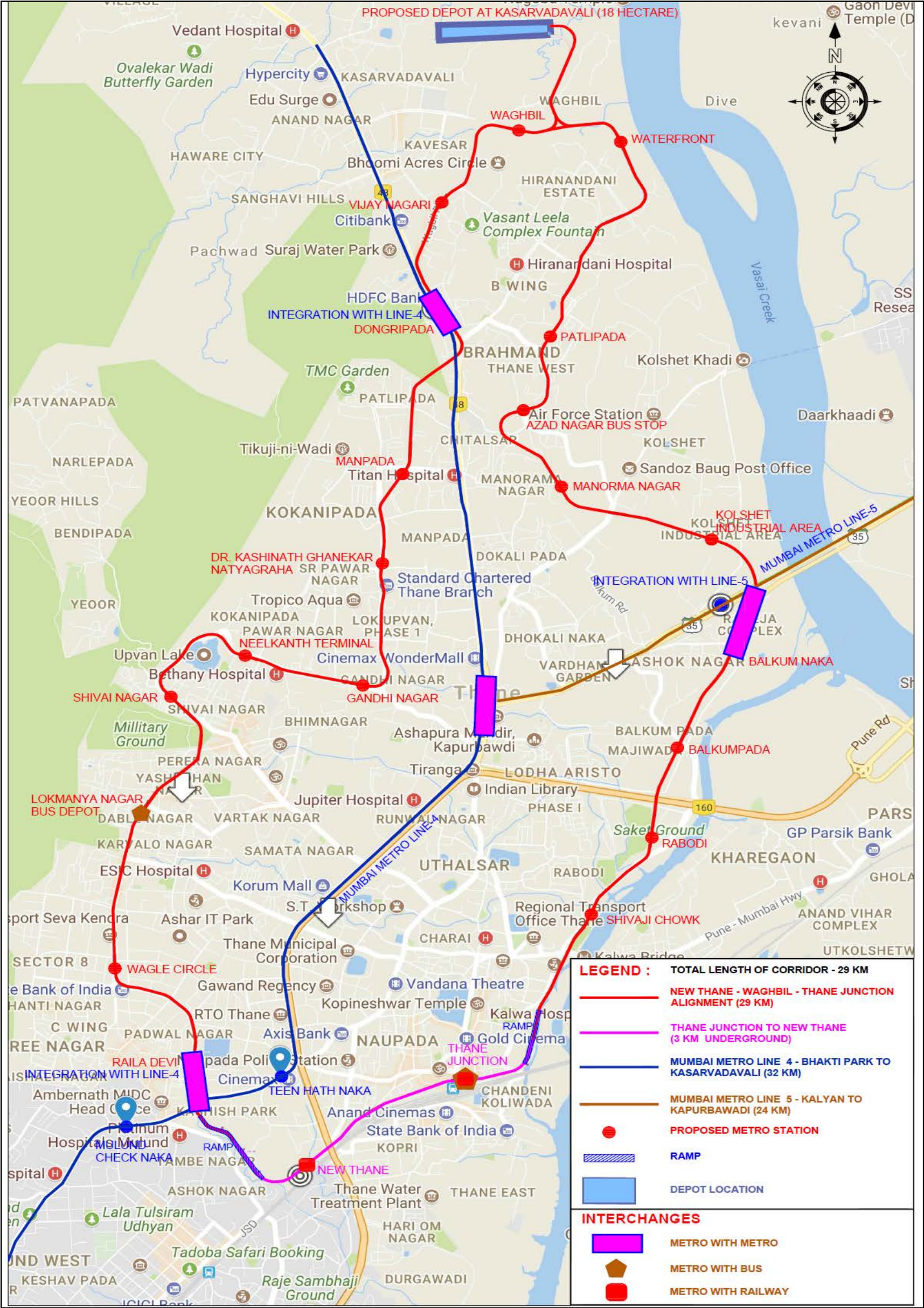
- Thane Junction Railway Station to Kopri

- ii. Switch Over Ramp from Underground to Elevated
- iii. Railadevi-Waghbil- Shivaji ChowkSection
- iv. Switch Over Ramp from Elevated to Underground
- v. Kasarvadavali Depot Entry

i. Thane Junction Railway Station to Kopri

- This section is completely underground from Ch: 0m to Ch: 317m and from Ch: 25342m to Ch: 27400.2m(total 2375.2m) and consisting of total 2 nos. underground stations namely Thane Junction and New Thane Station. All the stations have been proposed by Cut & Cover method.
- Entire stretch in this section is densely populated with very narrow lanes leading to no path for movement of construction equipments and machinery, hence planned for construction by TBM or NATM, to keep in mind this underground section is designed 15m below the ground level.
- All the underground stations are off the road and are proposed in open land leading to ease in construction and avoidance to disruption in road traffic.
- Thane Junction station has been proposed inside open land of Thane Bus depot and Private land near Thane Junction for better integration with existing Railway station and Bus system. Master plan/Modifications Plan of Thane Junction railway Station has been considered for planning of station. An area of about 4940 sqm will be required on temporary basis for about 4 years period for construction of underground stations by Cut & Cover method.
- There exists a 4-storied Hotel Mourya within proposed Thane station boundary, which needs to be demolished during construction of underground stations by Cut & Cover method.
- New Thane Station, the second underground station, has been proposed inside open land of State government for better integration with proposed sub-urban Kopri Railway station. Around 4940 sqm of land will be required on temporary basis for about 4 years period for construction of station by Cut & Cover method.

FIGURE 5.1: PROPOSED THANE METRO RING CORRIDOR – NEW THANE TO NEW THANE VIA DONGRIPADA & THANE JUNCTION



- Both Stations, in this underground stretch have been proposed with 1- Island platform.
- After Ch: 317m, alignment is planned on rising gradient to come out from underground to At-grade.

ii. Switchover Ramp From Underground to Elevated

- Further, the alignment after New Thane station heads in North-West direction along Nallahnear mental Hospital.
- To become elevated from underground (from -8.0m to +7.5m), ramp has been provided along Nallah. The switch over ramp has been proposed from Ch: 317m to Ch: 1181m. About 11628sqm land will be required permanently for locating the ramp.

iii. Railadevi - Waghbil - Shivaji Chowk Section

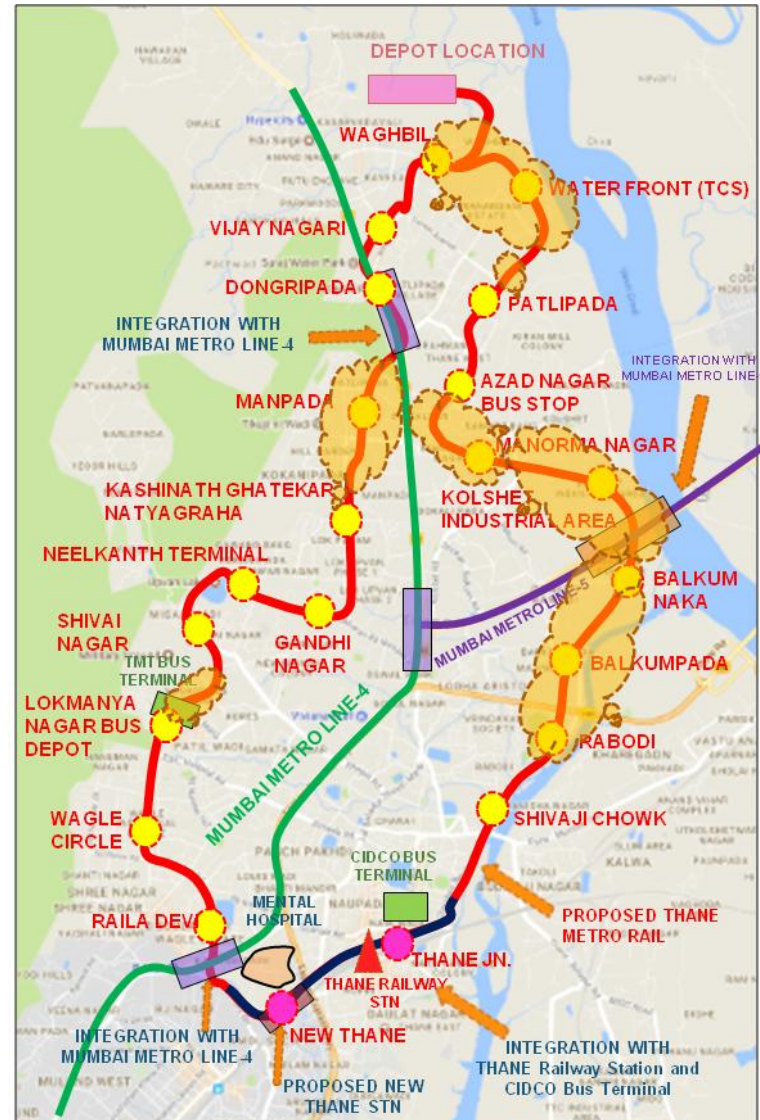
- The proposed section is completely elevated from Ch: 737m to Ch: 25127m with total length of 24.390 Km and consists of total 20 elevated stations with 2- sided platform namely Raila Devi, Wagle Circle, Lokmanya Nagar Bus Depot, Shivai Nagar, Nilkanth Terminal, Gandhi Nagar, Dr. Kashinath Ghatekar Natyagraha, Manpada, Dongripada, Vijay Nagari, Waghbil, Water Front, Patlipada, Azad Nagar Bus Stop, Manorma Nagar, Kolshet Industrial Area, Balkum Naka, Balkumpada, Rabodi and Shivaji Chowk
- The alignment mostly follows the High Capacity Mass Transit Route (HCMTR) and Future Development Plan Roads (DP Roads) in this section. As shown in **Figure 5.2**.
- The alignment runs from Ch: 1300m to Ch: 4400m (Raila Devi to N.G. Vihar), Ch: 9500m to Ch: 11100m (Bhavani Nagar to Patlipada), Ch: 18900m to Ch: 22600m (Manorma Nagar to Balkumpada) and Ch: 24000m to Ch: 26000m (Shivaji Chowk to Thane Junction Railway Station) on proposed HCMTR.
- In terms of Future Development Plan Roads (DP Roads) in this section, Thane Ring Metro Alignment has been planned from Ch: 4400 to Ch: 5350, Ch: 9500 to Ch: 11100, Ch: 13450 to Ch: 15200, Ch: 16000 to Ch: 16400, Ch: 17650 to Ch: 18800, Ch: 18800 to Ch: 20900 and Ch: 20900 to Ch: 23250 aligns along 40m, 30m, 40m, 20m, 40m, 30m and 40m DP Roads respectively.

FIGURE 5.2: LOCATION OF HCMTR AND DP ROADS

LOCATIONS OF HCMTR AND DP ROADS ALONG ALIGNMENT

LEGEND

- METRO CORRIDOR (ELEVATED)
- THANE METRO CORRIDOR (UNDERGROUND)
- MUMBAI METRO LINE – 4 (WADALA – GHATKOPAR-MULUND-TEEN HATH NAKA- KASARVADEVALI)
- MUMBAI METRO LINE – 5 (THANE- BHIWANDI-KALYAN)
- HIGH CAPACITY MASS TRANSIT ROUTE (HCMTR)
- PROPOSED DEPOT LOCATION (about 20 Ha)
- BUS TERMINAL
- ▲ THANE RAILWAY STATION
- ELEVATED STATION
- UNDERGROUND STATION
- BUFFER ZONE ALONG DP ROADS/ALIGNMENT



- Passenger Integration of Thane Ring Metro with Mumbai Metro line- 4&5 has been planned at three locations namely Modella Chowk, Dongripada and Balkum Naka. For this arrangement suitable vertical clearance has been maintained.
- At Ch: 1255m (Raila Devi), proposed alignment encounters with Mumbai Metro line- 4 and Lal Bahadur Shastri Marg, where Rail level of Mumbai Metro line-4 is 35.2m with 19.5m as vertical clearance from ground. Due to availability of sufficient vertical clearance, proposed Thane Ring Metro has been planned below the Mumbai Metro line-4 with Rail level 24.8m. A special span bridge has been proposed from Ch: 1200m to Ch: 1308m.
- The alignment passes through a cluster of buildings between Ch: 4400m to Ch: 5000m (from Lokmanya Nagar Bus Depot to Pokharan Road No.1). The section is part of HCMTR and shall be developed before take up of the metro project work. The section is shown in **Figure 5.3**.

FIGURE 5.3: CONDITION AT LOKMANYA NAGAR BUS DEPOT AREA



- The proposed alignment crosses Mumbai Metro line-4 and Ghodbunder- Patlipada flyover at Ch: 11020m (Dongripada), where Rail level of Mumbai Metro line-4 is 35.7m and vertical clearance from ground is 18.4m. Due to availability of sufficient

vertical clearance, proposed Thane Ring Metro has been planned below the Mumbai Metro line-4 with Rail level 27.2m. A special span bridge has been proposed in this section.

- From Ch: 11050m to Ch: 11450m and Ch: 11920m to Ch: 12050m, two flyovers exist on Ghodbunder Road, to keep in view metro alignment has been kept to off road from median in this stretch.
- The alignment crosses proposed line-5 of Mumbai Metro and SH-35: Old Mumbai-Agra Road at Balkum Naka (Ch: 20620m), where Rail level of Mumbai Metro line-5 is 19.0m and vertical clearance from ground is 10.3m. Thane Ring Metro fly the Mumbai Metro line-5 at this location. A special span bridge has been proposed from Ch: 20555m to Ch: 20721m to accommodate both structures.
- At Kalwa Bridge crossing near Shivaji Chowk, a new clover leaf bridge is proposed in future development plan and NH-4: Mumbai- Pune Highway crossing exists, to keep in view sufficient lateral clearance has been kept from the proposed bridge. At this location, a special span bridge has been proposed from Ch: 24232m to Ch: 24340m.

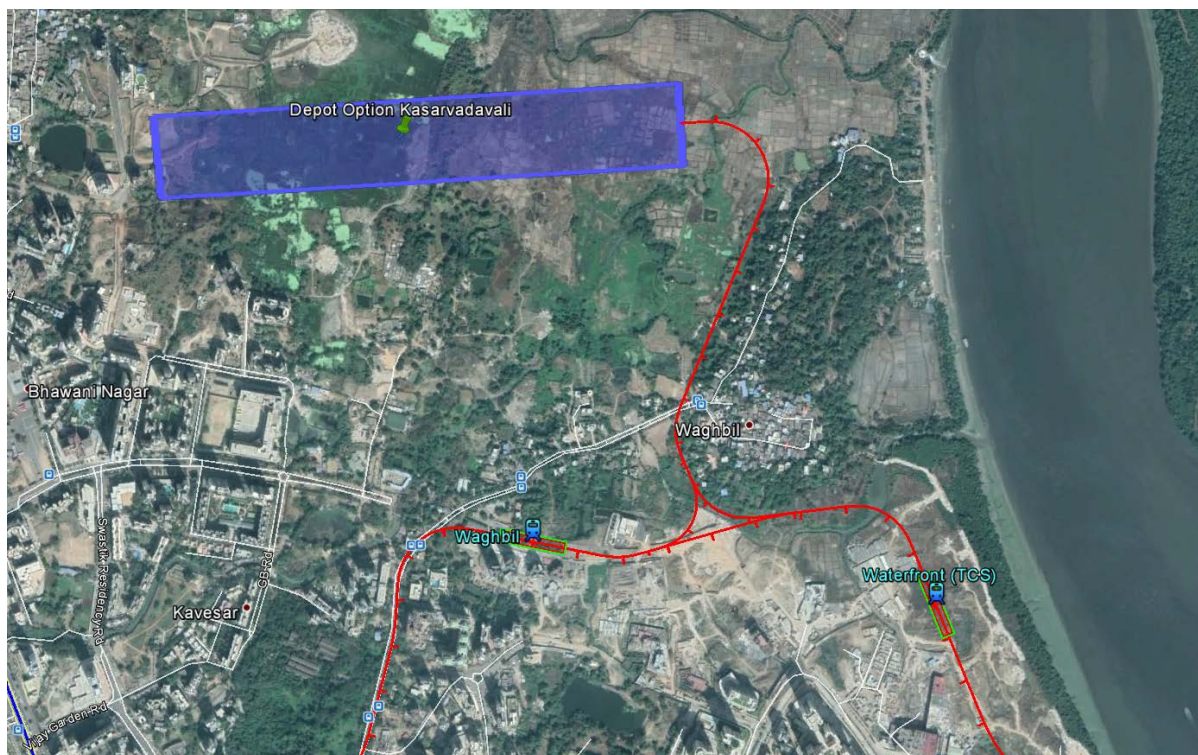
iv. **Switch Over Ramp from Elevated to Underground**

- In this stretch, ramp is required to provide transition from elevated to underground alignment after Shivaji Chowk station. Horizontal and vertical alignment in this stretch has been designed in such fashion so that minimum land is required.
- The alignment runs elevated till Ch: 24917m, thereafter, from Ch: 24917m to Ch: 25342m ramp has been proposed to become underground (from +7.5m to -8.0m) with a gradient of 3.7% (Compensated) along the creek in open land of State Government. About 4900 Sqm of Govt. land has been proposed for locating ramp.

v. **Kasarvadavali Depot Entry**

- Two separate connections for Up and Down connectivity as third line have been proposed at Waghbil station and Waterfront (TCS) station. The alignment length for Up and Down connectivity is 1177m each up to start point of depot. This connectivity is proposed along the 40m development planned Road. In the planning of connectivity provision of sufficient vertical clearance has been kept. A Ramp at limiting gradient of 4% is proposed to meet the ground and enters in Kasarvadavali depot of length 1140m. Depot location is shown in **Figure 5.4**.

FIGURE 5.4: KASARVADAVALI DEPOT LOCATION



- **Major Depot at Kasarvadavali**

Separate depot of size 1140mx180m with an area of 18 Ha is proposed at at Kasarvadavali and was found suitable in the Thane Municipal Corporation (State Govt.) land identified by District Administration. The said land piece is identified by avoiding the adjoining creek area land. As shown in **Figure 5.5**.

A. Reference Point

For the planning convenience, the zero point of the Corridor is considered at the centre line of the proposed New Thane station near proposed Kopri sub-urban Railway station. The chainage along the Ring Metro Alignment increases in clockwise direction and the last point of alignment meets with the first point of alignment. All elevations are from Mean Sea Level (MSL).

B. Interchange Stations

Efforts have been made to select station locations in such a fashion so as to provide convenient and efficient passenger interchange with other modes of transport such as other Railway system, Metro system and Bus system. Interchange stations provided along the Corridor are shown in **Table 5.5**.

FIGURE 5.5: DEPOT CONNECTIVITY NEAR KASARVADAVALI

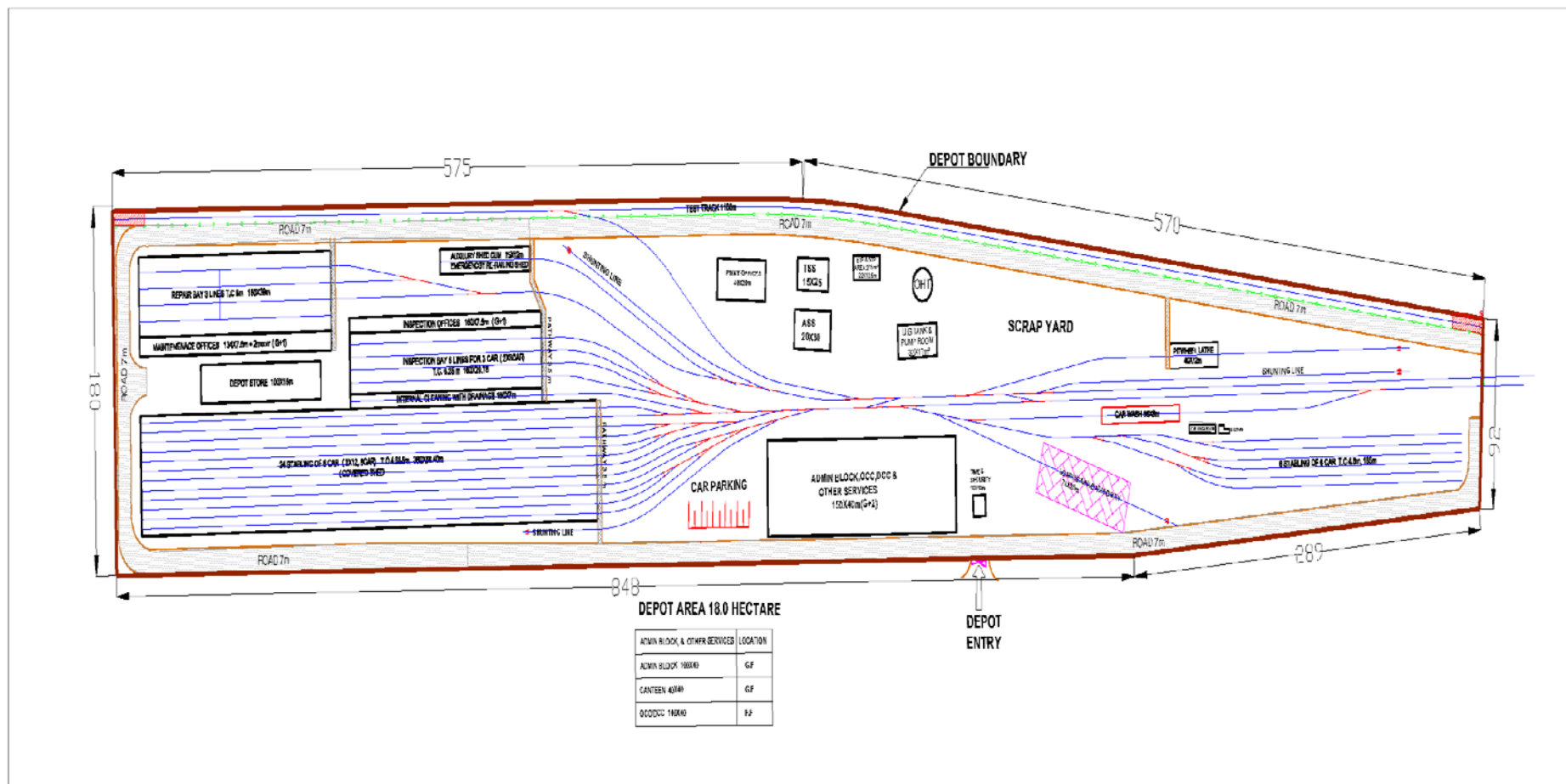


TABLE 5.5: INTERCHANGE STATIONS OF CORRIDOR

S. No.	Name of Metro station	Mode	Interchange with
1	New Thane	IR Broad Gauge	Proposed Suburban Kopri Railway Station
2	Raila Devi	Metro	Mumbai Metro Line-4
3	Wagle Circle	Bus System	TMT Bus Stand Near Wagle Industrial Estate
4	Lokmanya Nagar Bus Depot	Bus System	Lokmanya Nagar Bus Depot
5	Dongripada	Metro	Mumbai Metro Line-4
6	Balkum Naka	Metro	Mumbai Metro Line-5
7	Thane Junction	IR Broad Gauge & Bus System	Thane Railway Station and CIDCO Bus Stand at Thane Railway Station

C. Major Roads along/ across the Corridor

The major roads along and across the alignment are given in **Table 5.6** and **5.7** respectively.

TABLE 5.6: MAJOR ROADS ALONG CORRIDOR

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
1	SG Barve Road	1400	2650
2	Road Number 22	2850	4400
3	Development planned Road- 40m	4400	5300
4	Pokharan Road No. 1/ Upvan Road	5300	6500
5	Pokharan Road No. 2	6500	7800
6	Smt Gladys Alvares Road	7950	9500
7	Development planned Road- 30m	9500	11100
8	Ghodbunder Road	11100	12050
9	Wagbil Road	12150	13450
10	Development planned Road- 40m	13450	15200
11	Park Lane	15400	16000
12	Development planned Road- 20m	16000	16400
13	Brahmand Patlipada Link Road	16950	17650
14	Development planned Road- 40m	17650	18800
15	Development planned Road- 30m	18800	20900
16	Development planned Road- 40m	20900	23250
17	Rabodi- Kalwa Road	23250	24800

TABLE 5.7: MAJOR ROADS ACROSS CORRIDOR

S. No.	Description	Chainage
1	Lal Bahadur Shastri Marg at Modella Chowk	1290
2	Nirmaladevi Dighe Marg- Towards Mahanagar Palika	3878
3	Ahinsa Marg at Lokmanya Tilak Chowk	4400
4	Smelting Koros Road- Towards Laxmi Park	4882
5	Smelting Koros Road	5047
6	Road Towards Kashinath Ghatekar Natyagraha	6875
7	Pokharan Road No.-2	7900
8	Vasant Vihar Junction	8345
9	Milog Circle	8975
10	Garden Street Road- Khewra Circle Road at Khewara Circle	9425
11	Tikuji Ni Wadi Road	9950
12	Ghodbunder Road- Patlipada Flyover Crossing	11070
13	Hiranandani Estate Road	11310
14	Hiranandani Estate Road- Towards Vijay Garden	12100
15	Towards Swastik Residency Road	12600
16	Wagbil Road- Towards Wagbil Gaon	13450
17	Road Near Eva Building Rodas Enclave	15450
18	Park Lane- Towards Hiranandani Circle	16120
19	Brahmand-Patlipada Link Road- Towards RUTU Towers	16950
20	Akbar Camp Road	17620
21	Mahatma Phule Marg	17940
22	Kolshet Road- Towards Kapurbawadi	19160
23	Old Agra Road- (SH-35)	20618
24	Balkum Road	21155
25	Rabodi - Kalwa Road	22150
26	Pipe Line Road	22645
27	Mumbai- Nashik Eastern Express Highway- (NH-3)	22700
28	Rabodi - Kalwa Road	23237
29	Akaskganga Road- Towards Panchganga	24000
30	Mumbai-Pune Highway- (NH-4)	24315
31	Chendani Bunder Road	25480
32	TMT Flyover at Thane Junction	26000
33	Eastern Express Highway Near Thane Junction	27180

D. HT Power Lines across the Corridor

The HT Power Lines across the alignment are given in **Table 5.8**.

TABLE 5.8: HT POWER LINES ACROSS CORRIDOR

S. No.	Location	Type of Line	Vertical Clearance (m)	Ownership
1	Near Eastern Express Highway (Saket Ground)	HT Power Line	9.75	MAHADISCOM
2	Near Balkum Road	HT Power Line	12.05	MAHADISCOM
3	Between Balkum Road & Old Agra Road	HT Power Line	6.00	MAHADISCOM
4	Near Sub-Station Wall Corner	HT Power Line	9.05	MAHADISCOM
5	Near Koshet Sub-Station Wall Corner	HT Power Line	12.38	MAHADISCOM
6	Near Shiv Temple & Smt. Gladys Amares Road	HT Power Line	12.60	MAHADISCOM
7	Khewara Circle	HT Power Line	12.60	MAHADISCOM
8	on S G Barve Road Near HDFC Bank	HT Power Line	9.31	MAHADISCOM
9	Near Hutment & Vijay Laxmi Society	HT Power Line	12.00	MAHADISCOM
10	Open Land Near Loc Everest Housing Society & Railway Line	HT Power Line	12.25	MAHADISCOM

5.1.4. Stations

- Stations have been located so as to serve major passenger catchment areas and to enable convenient integration with other modes of transport.
- Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, availability of open land, interchange requirements with other modes of transport, construction feasibility, inter station distance, alignment geometry, utilities, road and pedestrian requirements, future infrastructural developments and joint site visits & consultations with MMRCL and TMC.
- Possibility of Parking space at all the stations has also been explored.

- List of stations along with their chainage and interstation distances (ISD) for Corridor is given in **Table 5.9**. Wherever space and site condition permits, portal type arrangement is proposed for elevated stations. However, due to limited ROW and narrow roads, most of the elevated stations are proposed with Cantilever type arrangement, which is also used extensively in Maha Metro.
- Schematic diagram for Thane Metro Corridor is shown in **Figure 5.6**.

5.2 ANALYSIS OF CORRIDOR OPTIONS TO BE ELEVATED, UNDERGROUND OR AT GRADE

5.2.1. Corridor Selection

i. Comprehensive Mobility Plan (CMP)& Alternative Analysis Report (AAR)

Comprehensive Mobility Plan prepared in 2018 has been taken as basis of ridership and proposed corridor for mass rapid transit systems.

Comprehensive Mobility Plan has been prepared for a planning period up to 2045 with a vision for best performing transport systems to address the needs and concerns of the city. The CMP had proposed with mass rapid transit corridor with a total length of about 61 km to be developed by 2045.

Alternative Analysis Report for MRTS system selection has been taken as the basis for selection of metro system for the study area.

ii. Site Reconnaissance

A site reconnaissance survey was carried out by RITES along with TMC & MMRCCL officials to finalise the alignment of Thane Metro corridor. The details of catchment areas as well as the abutting land use along the corridor and Development Plan Thane were also collected during the site visit. Photo graphs were also taken during site reconnaissance to identify the alignment options of Metro Corridor, Depot and Station locations.

TABLE 5.9: LIST OF STATIONS

S. No.	Station Name	Chainage (Km)	Inter Station Distance (m)	Ground level (m)	Proposed Rail Level (m)	Station Height/ Depth (m)	Underground/ Elevated	Proposed Length (m)	Proposed Width (m)
1	New Thane	0	-	7.307	-7.200	-14.507	Underground	190	26
2	Raila Devi	1664	1664	18.251	33.600	15.349	Elevated	140	22
3	Wagle Circle	2903	1239	38.622	52.900	14.278	Elevated	140	22
4	Lokmanya Nagar Bus Depot	4291	1388	44.436	59.000	14.564	Elevated	140	22
5	Shivai Nagar	5520	1229	46.959	67.300	20.341	Elevated	140	22
6	Neelkanth Terminal	6774	1254	47.708	59.500	11.792	Elevated	140	22
7	Gandhi Nagar	7634	860	28.642	43.700	15.058	Elevated	140	22
8	Dr. Kashinath Ghanekar Natyagraha	9032	1398	34.783	49.000	14.217	Elevated	140	22
9	Manpada	9792	760	32.639	47.700	15.061	Elevated	140	22
10	Dongripada	11622	1830	22.018	38.500	16.482	Elevated	140	22
11	Vijay Nagari	12372	750	13.900	28.700	14.800	Elevated	140	22
12	Waghbil	13611	1239	4.973	19.700	14.727	Elevated	140	22
13	Waterfront	14685	1074	1.465	16.000	14.535	Elevated	140	22
14	Patlipada	16734	2049	13.475	29.000	15.525	Elevated	140	22
15	Azad Nagar Bus Stop	17581	847	34.313	46.000	11.687	Elevated	140	22
16	Manorma Nagar	18616	1035	11.389	26.500	15.111	Elevated	140	22
17	Kolshet Industrial Area	19954	1338	2.782	17.600	14.818	Elevated	140	22
18	Balkum Naka	21118	1164	3.373	20.500	17.127	Elevated	140	22
19	Balkumpada	22098	980	4.441	19.000	14.559	Elevated	140	22
20	Rabodi	22986	888	3.777	17.800	14.023	Elevated	140	22
21	Shivaji Chowk	23873	887	4.515	19.100	14.585	Elevated	140	22
22	Thane Junction	25841	1968	8.795	-6.400	-15.195	Underground	190	26

FIGURE 5.6: SCHEMATIC DIAGRAM OF THANE METRO

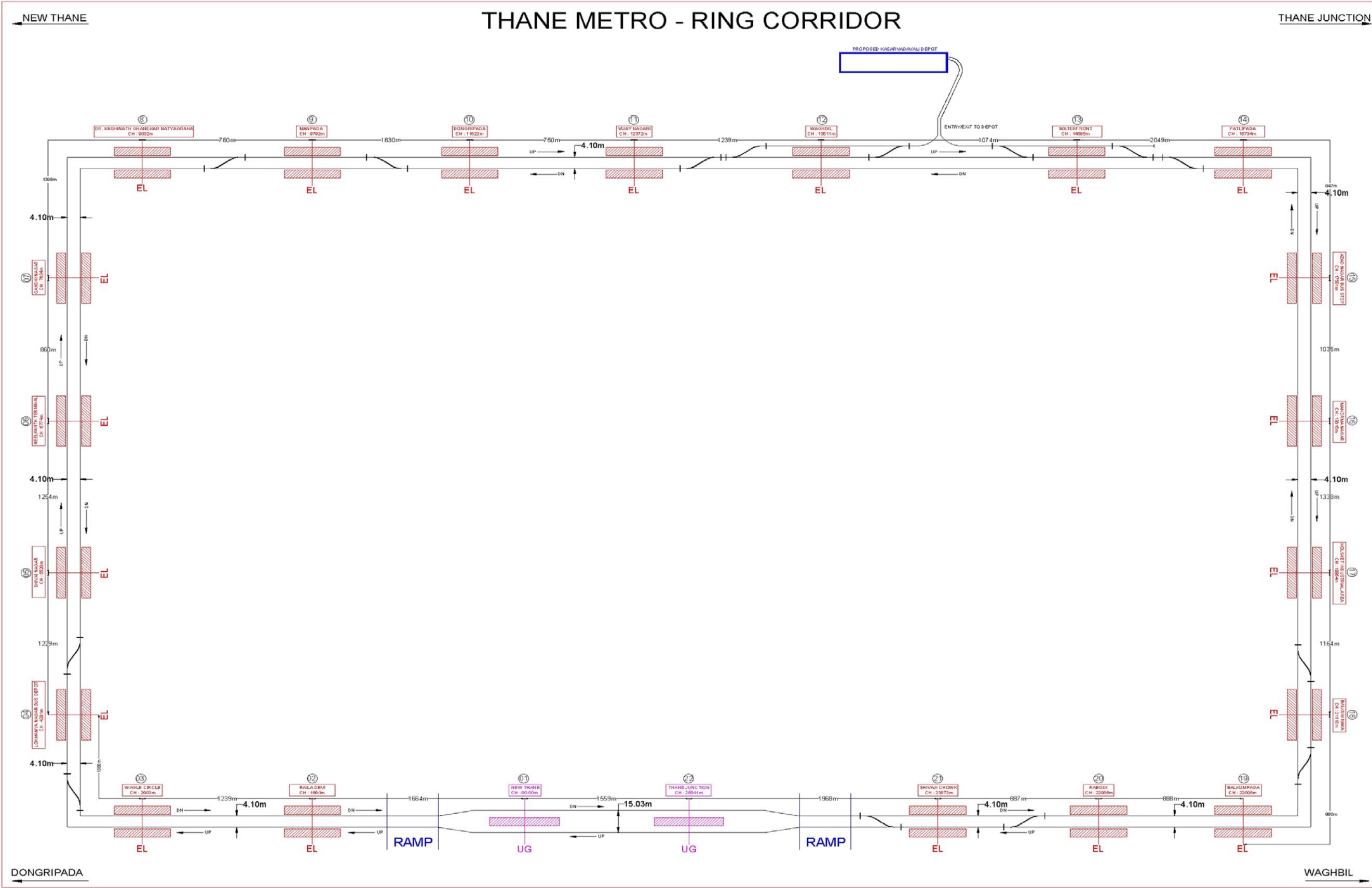
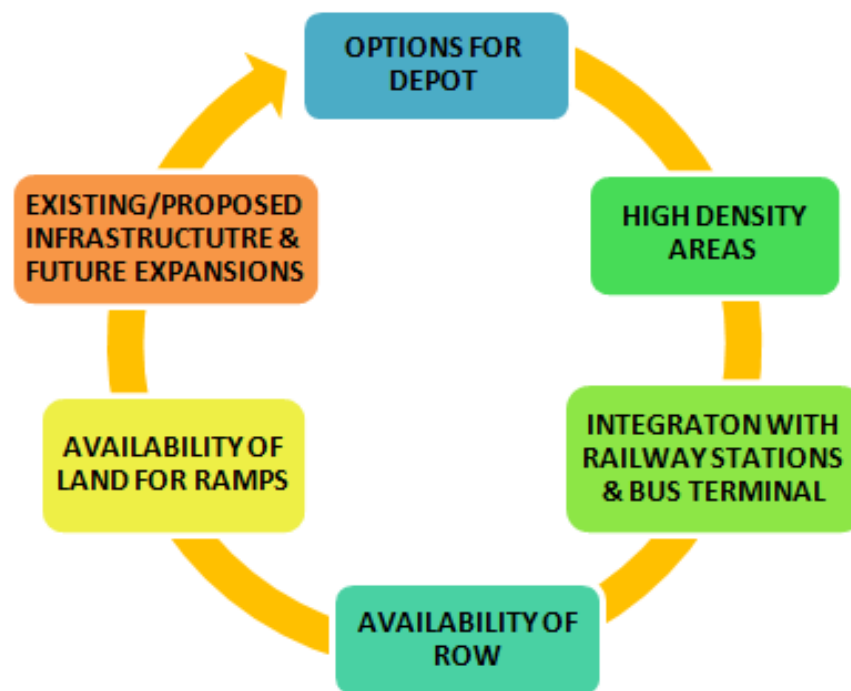


FIGURE 5.7: ALIGNMENT OPTIONS PARAMETERS



5.3 DESIGN NORMS

5.3.1 Track Geometry

The geometric design norms presented in subsequent paragraphs have been worked out based on detailed evaluation of passenger comfort, safety, experience and internationally accepted practices being followed in currently operating rapid transit and rail systems.

i. Principles for Metro Corridor

While fixing the alternatives on proposed corridor, following requirements/constraints have been kept in view:

- i. To remain on the CL of the existing road or Government premises/land to the extent feasible.
- ii. To utilize the existing road Right of Way (ROW) to the maximum extent in order to minimise the land acquisition and also length of diversions.
- iii. To avoid dismantling of existing structures/Buildings etc. to the extent feasible.

- iv. To avoid private built up areas, villages, habitation and religious structures etc. to the extent feasible.
- v. To provide adequate clearance from existing Railway/ Highway structures.
- vi. To satisfy the requirements of sound economic engineering practices
- vii. To rationalise the location of proposed stations and underground ramps

ii. Geometric Design Parameters

A. Alignment Considerations: As far as possible-

- Tangent alignment has been maximized.
- Flattest possible curves have been proposed.
- Number of curves has been minimized.
- Maximum possible transition lengths, commensurate to operating speed have been proposed.
- Elevated alignment has been maximized.
- Number of gradients has been minimized.
- Flattest possible vertical curves have been proposed.
- Cants of appropriate values, commensurate to operating speed at specific locations have been proposed to counter the effect of centrifugal force.
- Vertical curves & transition curves of horizontal alignment do not overlap.

B. General Criteria

General Criteria used for the design purpose are given in **Table 5.10**.

TABLE 5.10: DESIGN CRITERIA

S. NO.	CRITERIA	DIMENSION
1	Gauge	1435 mm
2	Design Speed	80 Kmph
3	Maximum Axle Load	16T
4	Electric Power Collection	25KV AC, OHE

C. Horizontal Alignment

Horizontal alignment gives the details of curves in horizontal plane as the entire alignment can-not be on straight. The alignment on mainline track shall consist of tangent sections connected to circular curves by spiral transitions.

i. Circular Curves

Circular curves shall be defined by their radii in meters. Larger radii shall be used whenever possible to improve the riding quality. The minimum radius of curvature for mainline track shall be governed by the design speeds and by the limits for cant but shall not be less than 120m. The horizontal curve parameters are tabulated below in **Table 5.11**.

TABLE 5.11: HORIZONTAL CURVE PARAMETERS

Description	U/G Section	Elevated Section
Desirable Minimum Radius	300 m	200 m
Absolute minimum Radius	200 m	120 m
Minimum curve radius at stations	1000 m	
Maximum permissible cant (Ca)	110 mm*	
Maximum cant deficiency (Cd)	85 mm	
* The applied cant will be decided in relation to normal operating speeds at specific locations like stations/vicinity to stations.		

ii. Reverse Curves

The use of reverse curves is discouraged but where necessary, the two curves have been separated by minimum 25 m. If provision of 25 m straight length is restricted by physical constraints, the two curves have provided without any straight in between.

iii. Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth transition from straight section to curved section and vice-versa. **Table 5.12** shows required Length of transitions for Horizontal curves.

TABLE 5.12: LENGTH OF TRANSITIONS OF HORIZONTAL CURVES

Minimum Length	0.44 * actual cant (in mm) 0.44 * cant deficiency (in mm) whichever is higher
Desirable Length	0.72 * actual cant (in mm) 0.72 * cant deficiency (in mm) whichever is higher
Minimum Straight between two transition curves	25 m or NIL
Minimum horizontal curve length between two transition curves	25 m
No Overlap is allowed between transition curves and vertical curves	

D. Vertical Alignment

The purpose of this section is to establish criteria for use in all design stages of the vertical alignment and track centre of the viaduct, tunnel, station and depot area.

i. Elevated Section

As per para 2.12.2 of IRC: SP-73, "*Minimum 5.50 m vertical clearance shall be provided from all points of the carriageway of project Highways to the nearest surface of the overpass structure*". However, it is recommended to keep suitable margin for future raising of road by resurfacing etc. Rail level will also depend upon the type and detailed design of pier cap and super-structure elements.

Rail levels at elevated station locations have been proposed by providing minimum vertical clearance and con-course of 3.50 m. Structural design of con-course floor slabs and viaduct will also govern the final rail level. **Table 5.13** shows required Track centres and height for elevated station.

TABLE 5.13: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.10 m	9.50 m
Station w/o Scissor Cross-over	4.10 m	9.50 m
Station with Scissor Cross-over	4.95 m	9.50 m

ii. Underground Section

Rail level at mid-section tunnels has been proposed with a view to provide minimum cover of tunnel diameter 'D' to the foundation of structures located

above. At stations, depth of rail below the ground level shall accommodate station concourse also. **Table 5.14** shows required Track centres and depth for underground station.

TABLE 5.14: TRACK CENTRE AND DEPTH IN UNDERGROUND SECTION

Description	Minimum Track Centre	General Depth below Ground Level
Running section by TBM	15.00 m	15.0 m
Running section by cut & cover except ramp	4.60 m	12.60 m
Stations by cut & cover and island platform of 12 m	15.03 m	15.0 m
Stations by cut & cover and side platform	4.60 m	15.0 m
Stations by NATM	22.00 m	18.0 m

E. Gradients

i. Mid-Section

The grade on the mid-sections shall not be generally steeper than 3.0%. However, there are a few situations, where steeper gradients are unavoidable, such as:

- Switch over ramp between underground and elevated sections where a grade of up to 4% (compensated) may be adopted to minimise the length of ramp.
- Where the existing road gradient is more than 2.5% as the elevated section is kept parallel to the road surface to minimise the rail level (to reduce the pier height).

Suitable longitudinal grades with drains at the low point are proposed for assuring proper drainage.

ii. Stations

Preferably, the stations shall be on level stretch with suitable provision for drainage by way of cross slope and slope of longitudinal drains. However, maximum grade shall not exceed 1 in 400. There shall be no change of grade on turnouts on ballastless track.

iii. Depot

For connectivity to track depot, maximum 4% (compensated) gradient is proposed. For other portions of depot, gradient as flat as possible with adequate track drainage shall be designed to suit the actual ground slope. All shop tracks shall be at level. Sidings shall be level or shall fall away from the main line connection at a gradient not exceeding 0.25%. There shall be no change of grade within 30 m of any points and crossing on ballasted track. **Table 5.15** shows gradient parameters.

TABLE 5.15: GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 3%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

F. Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%. However, it is recommended that all changes in grade shall be connected by a circular curve or by a parabolic curve.

It is proposed that vertical curves and transition curves of horizontal alignment do not overlap. Minimum radius and length of vertical curves are shown in **Table 5.16**.

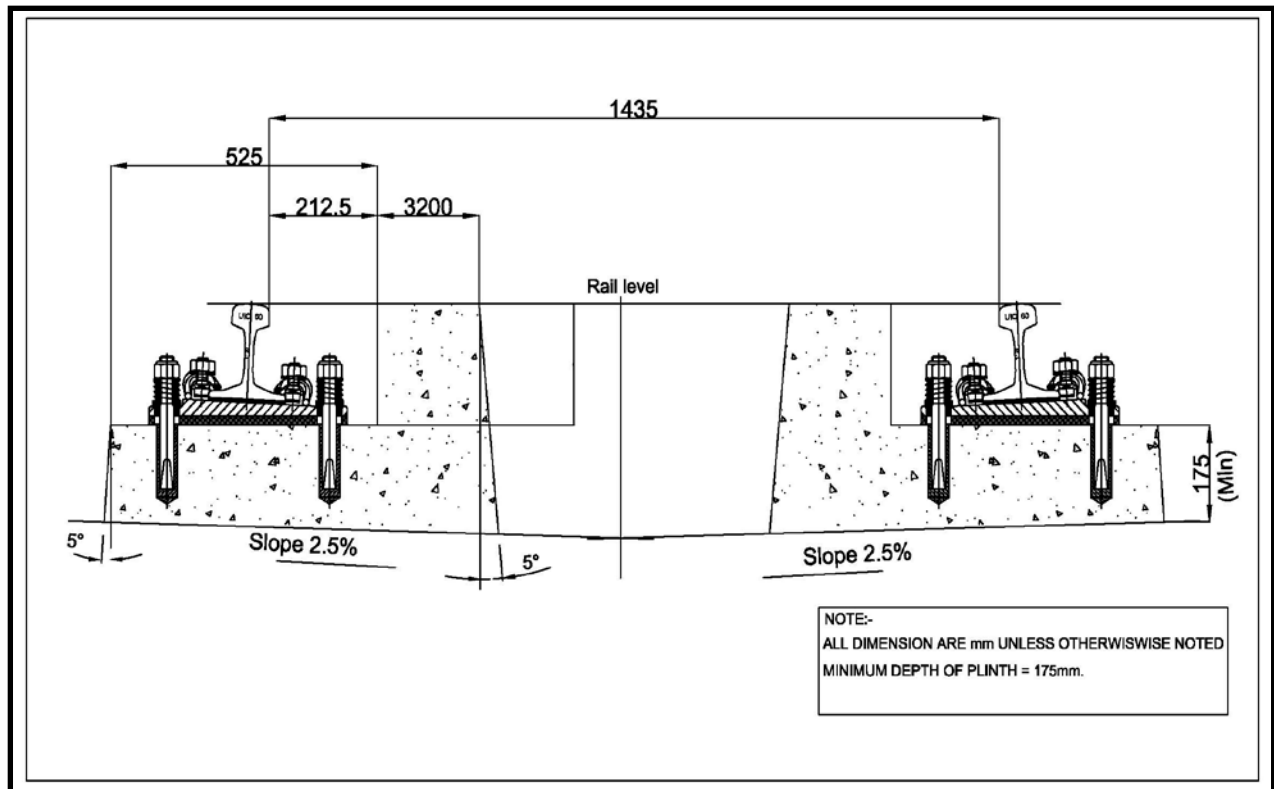
TABLE 5.16: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

G. Welding

To minimize noise and vibrations, track joints should be welded by Flash Butt Welding Technique and Alumino-Thermit Welding may be done only for those joints which cannot be welded by Flash Butt Welding Technique

FIGURE 5.8: TYPICAL CROSS SECTION OF BALLASTLESS TRACK ON VIADUCT



URE 5.9: 1 IN 9 TYPE TURN-OUT

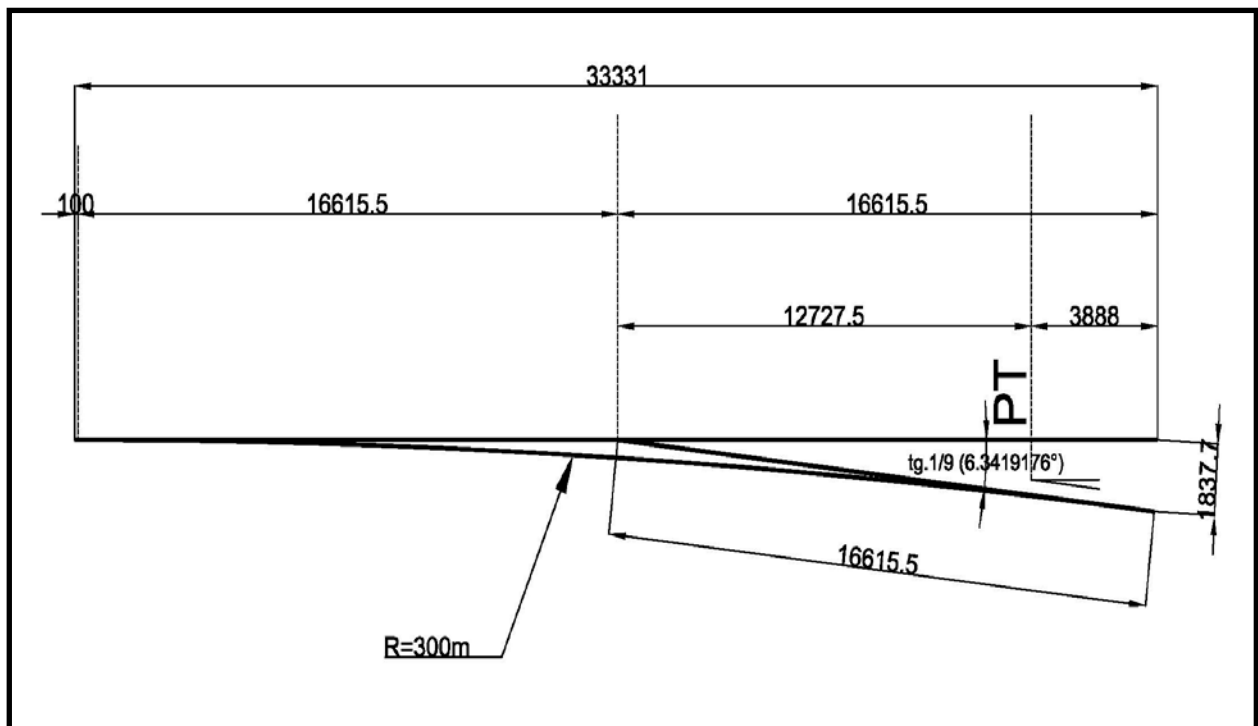
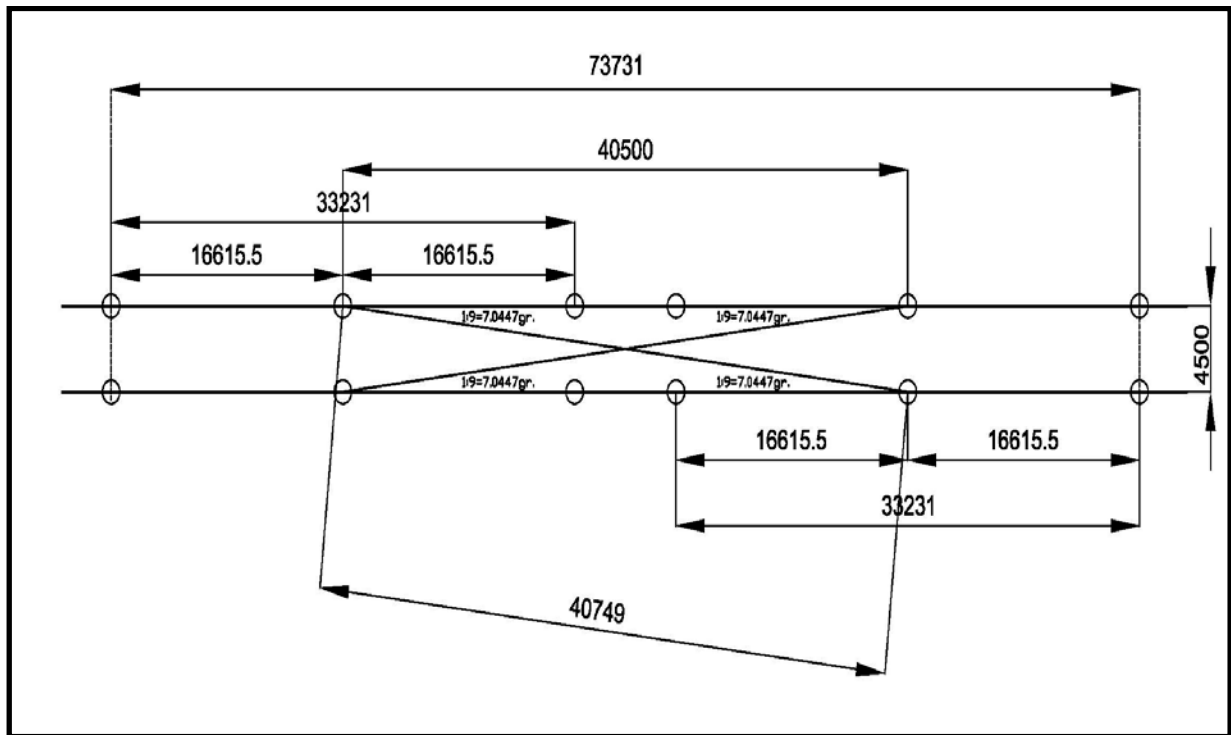


FIGURE 5.10: SCISSOR CROSS-OVER (1 IN 9 TYPE)



iii. Design Speed

The maximum sectional speed will be 80 km/h, subject to further restriction by radius of horizontal curves, cant and cant deficiency. The parameters of radius of horizontal curve, cant and permitted speed are summarized below. **Table 5.17** shows Radius, Cant and Permitted Speed as per SOD of the Maha Metro.

TABLE 5.17: RADIUS, CANT AND PERMITTED SPEED

Radius (m)	Actual Cant (Ca) (mm)	Permitted Speed (km/h)
3000 or more	15	80
2800	15	80
2400	20	80
2000	20	80
1600	25	80
1500	30	80
1200	35	80
1000	40	80
800	55	80
600	70	80
500	90	80

Radius (m)	Actual Cant (Ca) (mm)	Permitted Speed (km/h)
450	95	75
400	105	75
350	110	70
300	110	65
200	110	50
190	110	50
175	110	50
150	110	45
120	110	40

5.3.2 Fixed Structure Clearance & Construction Methodology

Construction of elevated, underground alignment involves following type of constructions:-

- Sub-structure - Columns on Open/Pile foundations with pier cap at top of columns. Alternatively, Portal arrangement is provided at certain locations.
- Superstructure by segmental construction of whole unit construction. Box segments are most common type of segmental construction. I-Girder and U-girder are most common type of non-segmental construction methods where the structural element for whole span length is pre-casted and launched in position.
- Underground alignment by means of tunnels made through Tunnel Boring Machine / open cut and cover method/ NATM method.
- Underground stations by means of cut and cover method or NATM method.
- Earth retaining structures like diaphragm walls, sheet piles, secant piles etc.

i. Cast in-situ and Pre-Cast Construction

A. Cast in-situ construction

In cast in-situ construction method, structure is cast at its final location of use. This involves erection of temporary shuttering, scaffolding and support system for casting the structure. The temporary supports and shuttering is removed when the

concrete is set and structure attains the strength to bear its dead weight and other loads. This method involves longer construction time and interference to road users for longer period. This method is restricted to casting of substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures.

B. Pre - cast construction

In this method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are casted by pre-cast technique. Pre cast construction may be segmental or non-segmental type.

Casting yard is required for casting of precast structural segments and other precast units like U-girder, I-Girder etc. The construction depot has arrangement 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 2.5 Ha to 3 Ha is required for each construction depot.

Pre-cast construction has following advantages:-

- Reduction in construction period due to concurrent working for substructure and superstructure.
- For segmental, pre-cast element (of generally 3.0m length), transportation from construction depot to site is easy and economical. For other type of construction i.e. I-Girder, U Girder etc. longer trailer and straighter roads are required but erection can be done by using road cranes in comparatively less time.
- As the pre-cast elements are cast on production line in a construction depot, better and uniform quality control can be exercised.
- This method reduces the interference to road users to minimum.

For casting of segments, both long line and short line method can be adopted. However, the long line method is more suitable for spans curved in plan while short line method is good for straight spans. A high degree of accuracy is required for setting out the curves on long line method for which pre-calculation of offsets is necessary. Match casting of segments is required in either method. The cast

segments are cured on the bed as well as in stacking yard. Ends of the segments are to be made rough through sand blasting so that gluing of segments can be effective.

The segmental construction has following advantages.

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Segmental construction permits a reduction of construction time as segments are manufactured in a casting yard while substructure work is in progress, and erected rapidly thereafter.
- Better quality control is possible in the casting yard.
- It is easier to transport smaller segments by road trailers on city roads.
- Interference to the traffic during construction is significantly reduced.

ii. Structural System of Viaduct

A. Sub-structure

Two broad categories of sub-structure i.e. Pile Foundation and Open foundation are considered for Metro Systems. For heavy/medium loads and loose/soft/filled up upper strata, Pile foundation systems are proposed. This requires lesser space and time for excavation. Pile load bearing capacity is calculated as per IS 2911 Part 2 & IRC- 78. At locations where hard strata/rock is available close to ground level, open foundations may be adopted.

The viaduct superstructure will be supported on single cast-in-place RC pier. The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs. Rectangular piers (with size 1.5 m to 2m - longitudinal as well as transverse) are generally used.

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0m height above existing road level has been proposed all around the pier. A gap of 25mm has been also provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that the required minimum clearance of 5.5m 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 8.5m. The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8m.

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 3.0m. The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be selected to ensure minimum footprint at ground/road level traffic. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

Pier caps are casted over the columns to support the superstructure. Soffit width of superstructure governs the width of Pier cap. While box girder requires less width of pier, I-girder and U-girders require larger width of Pier caps to support the full width of soffit of such superstructures. At locations where elevated alignment moves from central verge of the road to side of the road and vice versa, Portal arrangement is made instead of column and Pier cap. Also at locations where elevated alignment takes a perpendicular left or right turn, portal type arrangement is provided to provide support to superstructure.

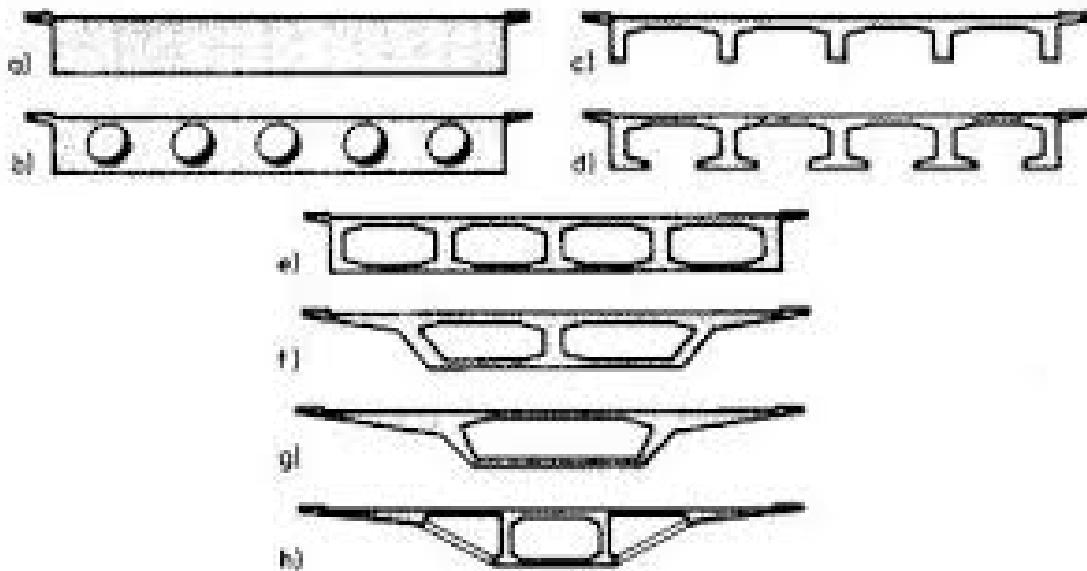
B. Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability, maximum safety, least disturbance and inconvenience to road users and maximum standardization of the form-work for wide span ranges. Following types of superstructure may be considered.

- i) Precast segmental box girder using external unbonded tendon.
- ii) Precast U-Channel superstructure with internal pre-stressing.
- iii) Precast U-Channel segmental superstructure using external unbonded tendon.

- iv) I-Girder with internal pre-stressing.
- V) Special spans

FIGURE 5.11: TYPES OF SUPERSTRUCTURE



Three types of superstructures are further deliberated as under:-

C. Precast Segmental Box Girder using External Unbonded Tendon

The superstructure shall be constructed “span by span” sequentially, starting at one end of a continuous stretch and finishing at the other end. A number of launching girders will be required so as to work on different stretches simultaneously to enable completion of the project in time.



For Box girder segmental construction, normally span of 31m is kept by providing 9 segments of 3m length and two end segments of 2m length each. The other standard spans (c/c of pier) comprises of 28m, 25 m, 22m, 19m & 16m, which shall be made by removing/adding standard segments of 3.0m each from the center of the span.

The number of “breaks” in the stretch can be identified by number of continuous units. The suggested method of erection will be detailed in the construction drawings. The launching girder (or, more accurately, the “assembly truss”) is capable of supporting the entire dead load of one span and transferring it to the temporary brackets attached to the pier. The governing weight of the segments will be of the order of 55 M.T. The launching girder is slightly greater than two span lengths. It must be able to negotiate sharp curves in conjunction with temporary brackets.

Transportation of segments from casting yard to the sites of erection will be effected by appropriately designed low-bedded trailers (tyre-mounted). The segments can be lifted and erected using erection portal gantry moving on launching girder.

In such construction, the pre-stressing is placed outside the structural concrete (inside the box section) and protected with high density polyethylene tubes which are grouted with special wax or cement. The match cast joints at the interface of two segments are provided with shear keys as in traditional segmental construction.

The main advantages of externally pre-stressed pre-cast segmental construction can be summarized as follows:-

FIGURE 5.12: LAUNCHING OF BOX GIRDER SEGMENTS



- Simplification of all post-tensioning operations, especially installation of tendons.
- Reduction in structural concrete thickness as no space is occupied by the tendons inside the concrete.
- Good corrosion protection due to tendons in polyethylene ducts; the grout inspection is easier and leaks, if any, can be identified during the grouting process.

- Simplified segment casting. There is no concern about alignment of tendons. Increased speed of construction.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facilitates inspection and monitoring of tendons during the entire service life of the structure.

However, higher depth and higher construction-transportation- erection cycle time are disadvantages of Box Girder.

D. Precast U-Channel Superstructure with Internal Pre-stressing

The single/Double U type of viaduct structure is also a pre-cast construction with internal pre-stressing. Double U-Girders are provided for 25-28m span. For shorter spans, Single U girders may be provided.

FIGURE 5.13: PRECAST U-CHANNEL SUPERSTRUCTURE



The main advantages for this type of structural configuration of superstructure are:-

- Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
- Saving in construction and erection cycle time.
- Built in structural elements capable to maintain the coaches on the bridge in case of derailment (a standard barrier design allows this).
- Built in cable support and system function.

- Built in maintenance and evacuation path on either side of the track.
- Built in sound barrier.

However, Single U- girder has weight in the range of 300 MT per unit and it is difficult to transport girder of such length and weight. To reduce the weight per girder, double U- girder may be used, but it results into wider track center of 4.6m to accommodate the two inside walls of the two girders.

E. Precast U-Channel segmental Superstructure with Internal Pre-stressing

In this arrangement, superstructure consists of U-shape segments. These are to be launched in a similar way as box segments. This type of superstructure results in shallow depth of superstructure in comparison to box type segments.

FIGURE 5.14: LAUNCHING OF U-CHANNEL GIRDER



F. Precast I-Girder Superstructure with Internal Pre-stressing

Pre-cast I-Girders for various span ranges 20-34 m can be designed. At locations with restricted head room, I-Girder with span range of 20m may be used. Precast, pre-stressed I-Girders are casted in casting yard, transported to site and erected as 3/4 I-girders per span (depending upon Detailed design) by using road cranes, connected together at site by casting diaphragm wall and thereafter top slab is casted at site.



The depth of I-girder is comparable to Box girder. Since unit length of I-Girder is for full span, their transportation is not possible for all locations. However, the unit

weight of I-Girder is approximately in the range of 70 MT, which is almost half when compared to Double U-girder and hence can be launched with lower capacity road cranes. Deck Slab of I-Girder can easily be planned to accommodate curved alignment. I-Girders are most suitable for station locations, where Box and 'U' Girders are not continued.

FIGURE 5.15: LAUNCHING OF I-GIRDER



G. Special span configuration

Regular spans upto 31m span are not suitable for crossing large openings like road over bridges, wide surface road crossings, railway tracks, wide canals, Rivers etc. Cantilever construction Method using PSC spans are used in such situation. Some of common span arrangements are suggested as under:-

- 34m + 45m + 34m
- 34m + 60m + 34m
- 75m + 105m + 75m

Other span configurations may also be designed as per specific site requirement.

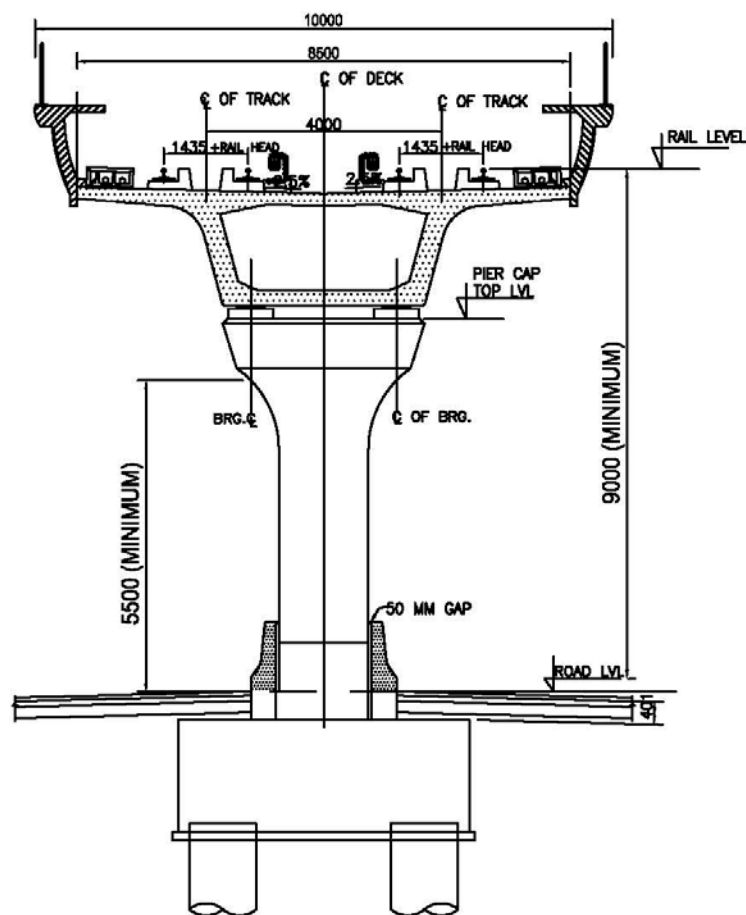
Other alternative is to use steel span. Steel span of upto 60m have been used in Metro systems in India.

FIGURE 5.16: CLC SPAN 75M + 105M + 75M AND STEEL SPAN 60M

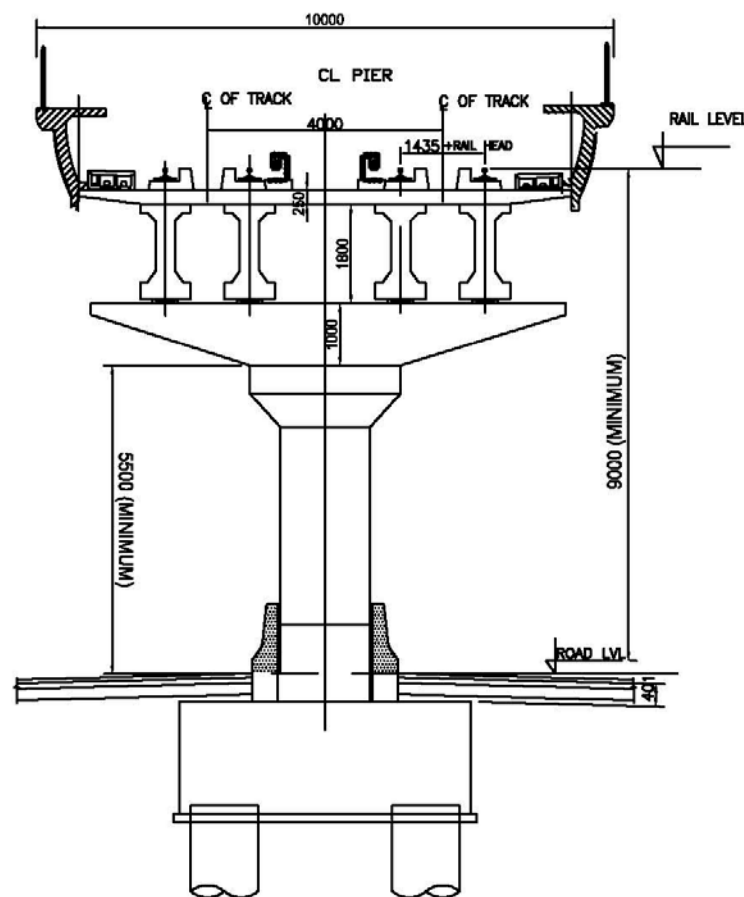


FIGURE 5.17: TYPICAL BOX GIRDER VIADUCT SECTION

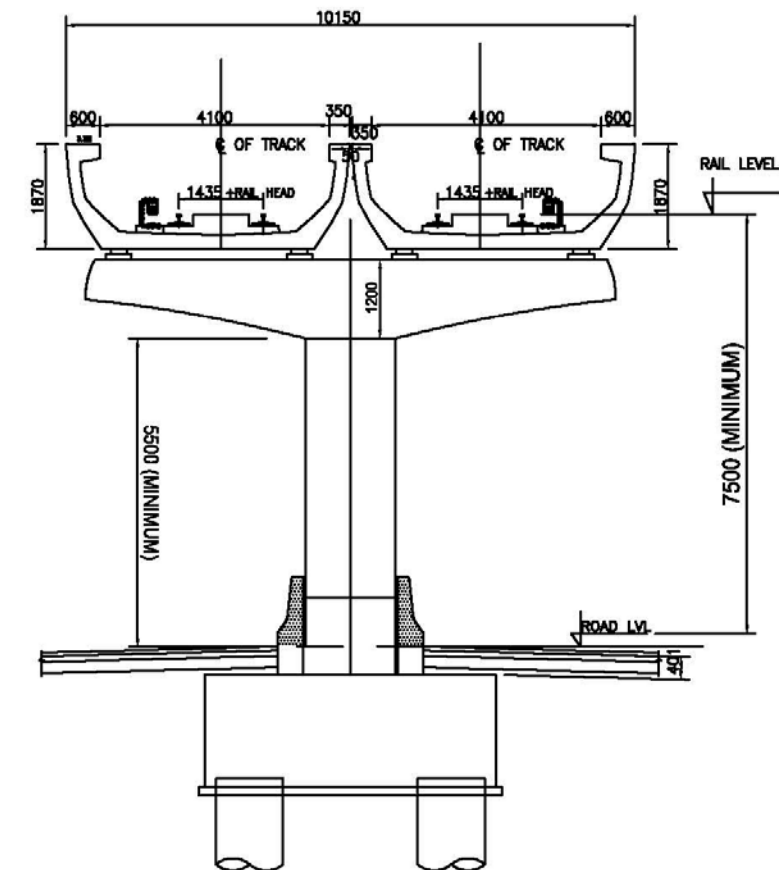
CROSS SECTION OF BOX-GIRDER VIADUCT



CROSS SECTION OF I-GIRDER VIADUCT



CROSS SECTION OF DOUBLE U-GIRDER VIADUCT



Recommendation

The Design and Build Contractor may choose any type of super structure keeping in view site conditions, availability of construction time and other resources i.e. road cranes/launching girders/shuttering etc. Combination of above type of superstructure may also be chosen. Appropriate special spans may be provided for specific locations.

iii. Construction of Elevated Stations

Elevated stations with elevated concourse over the road are proposed for elevated stretch of alignment. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus a separate structural configuration is required, with shorter spans and lower depth of superstructure, although this may necessitate the 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 same manner. Two configurations as under are available for elevated station super-structure:-

- a. Three-legged portal structure supporting concourse and platform level decks through series of Precast I girders resting on the Portal beam ledge.
- b. Cantilever structure with single centre pier with the arms extending in transverse direction at concourse level and platform level.- Concourse and Platform decks are supported by I girders resting on extended pier arms.

Comparative analysis of above two types of structural arrangements is shown in **Table 5.18**.

Typical Elevated Station

The elevated station is generally located on the road median 81 m long and 23 m wide and is a three level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities 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. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid

zone, after accommodating the passenger movement and other station facilities is earmarked for commercial utilization.

TABLE 5.18: COMPARATIVE ANALYSIS OF TYPES OF STRUCTURAL ARRANGEMENTS

Item	Three-legged portal structure	Cantilever Structure
General	Three-legged portal structure is best suited for stations having high traffic load requiring more width. Central median of 3.0 m can be created to position the Central leg of the portal. This median can also divide the road traffic into two carriageways on either side of the median. Entry structures can be built beyond the carriageway on either side.	Cantilever station is more suitable for densely populated downtown areas having narrow ROW. The main elevated superstructure is already supported on cantilever pier caps and to accommodate the platform width (approx. 4m each), total 8m additional width of cantilever is required to support the comparatively lighter load of platform and passengers. The station rooms, entry/exit staircases etc. may be planned by providing more width at these locations only and such wider width can be supported on portal.
Merit	- Three-legged portal is a better structural arrangement with respect to vibration induced by the train loads, long term deflections of the concrete members etc., - The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are effectively transferred to the ground through portal legs in the shortest path. - Need for Bus bays, drop/pick up points is avoided as the outmost lane can be used for this purpose.	- Station structure will be compact and economical. Cantilever arrangement may be properly designed to withstand all dead loads, live loads, seismic and wind loads as well as train induced vibrations. - No need to provide Service road to access adjoining properties. - The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are to be transferred to the ground through portal arrangement.
Demerit	- Cost of the station structure will be more due to large built up area. Wherever there is scope of property development, same may be planned at Concourse level to use the available space. - Service lane need to be provided to ensure access to adjoining properties.	There is need for Bus bays, drop/pick up points.

Since the stations are planned generally in the middle of the road, minimum vertical clearance of 5.50 m has been provided under the concourse. Concourse floor level is about 7.0 m above the road. Consequently, platforms are at a level of about 13.0 m from the road. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. **Figure 5.20** shows a typical cross section of elevated station.

iv. Construction of Tunnels for Underground Alignment

For underground alignment, tunneling arrangements are decided based upon following objectives:-

- Minimization of the surface settlement to maintain all metropolitan activities without adverse effect.
- Expeditious tunnel execution to minimize duration and space of the surface effects due to tunnelling.
- Economy in tunnelling costs.

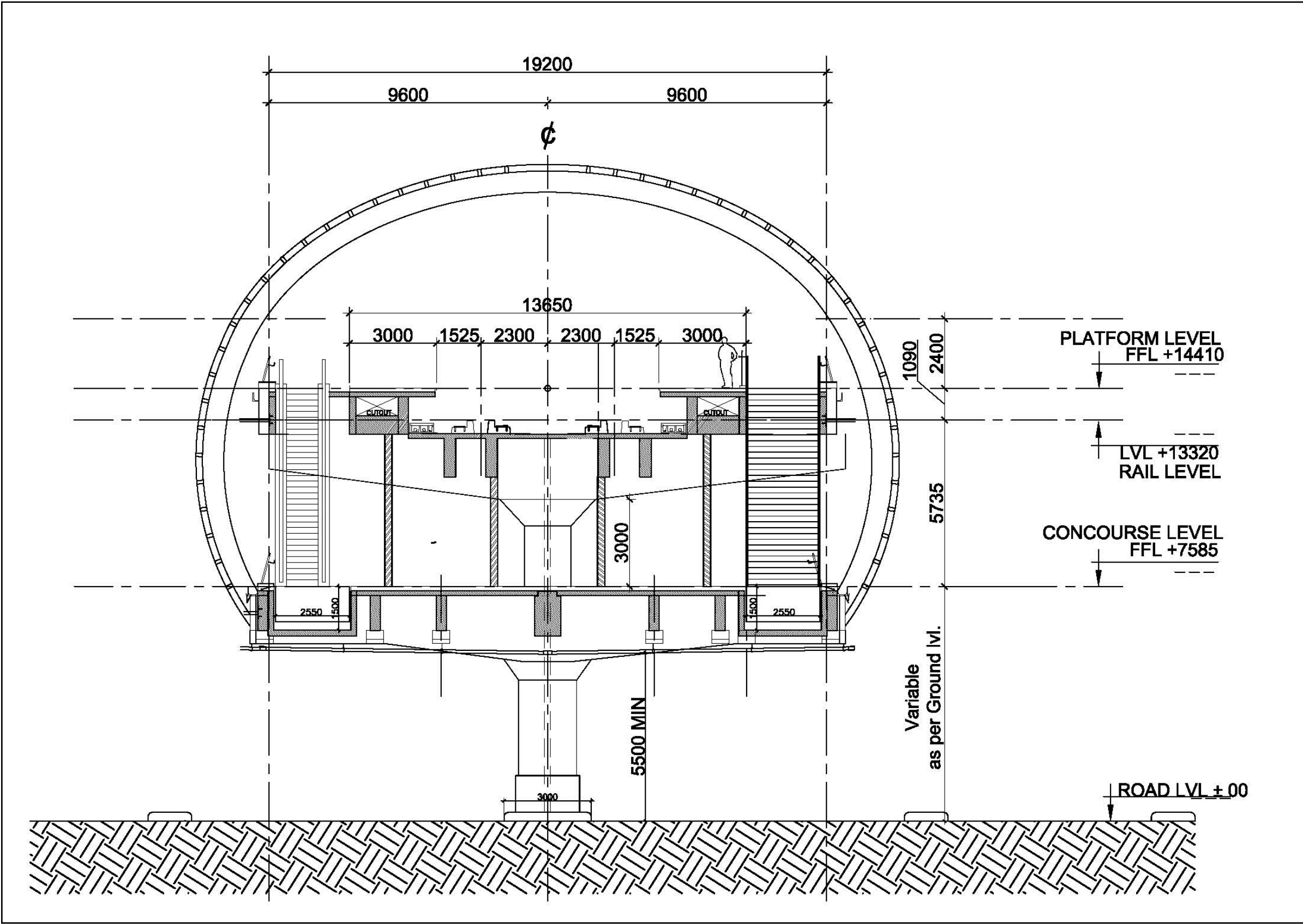
To achieve above objectives, use of Tunnel Boring Machine (TBM) is the prime method of tunneling. Locations where deployment of TBM is not possible (tunneling of short length, cross passages, underground stations which are not possible by cut and cover method etc.) are tackled by NATM method.

A. Selection of TBM

Choice of appropriate TMB depends upon the detailed geological studies and soil conditions. In the rocky strata, heavy disc cutters are required in the cutter head, whereas for excavating soft soils, scrappers are provided in the cutter head. In mixed soil conditions, the TBM should be capable of excavating soils and rocks both, hence combination of scrappers and disc cutters is used under such situations.

The most important issues to be addressed in selecting a Shield tunnelling method is face stability and minimum displacement/settlement of ground and structures confronting suitable TBM in this project will be the closed type. The Closed type TBM is further categorized as Earth- Pressure Balanced (EPB) TBM and Slurry type TBM. EPB is further categorized into Earth-pressure type TBM and Mud-pressure type TBM.

FIGURE 5.18: TYPICAL ELEVATED STATION



- **Earth-pressure type TBM**

The Earth-pressure type TBM is suitable for certain types of soil that can be directly fluidized. Fluidized soil fills the cutter chamber and the screw conveyor is used for discharge of muck, thereby keeping the cut face stable. The shield machine is able to simultaneously excavate soil during shield advance, so not only is the face well stabilized, but also the effects on the surrounding ground are minimized.

FIGURE 5.19: EARTH PRESSURE BALANCE TBM



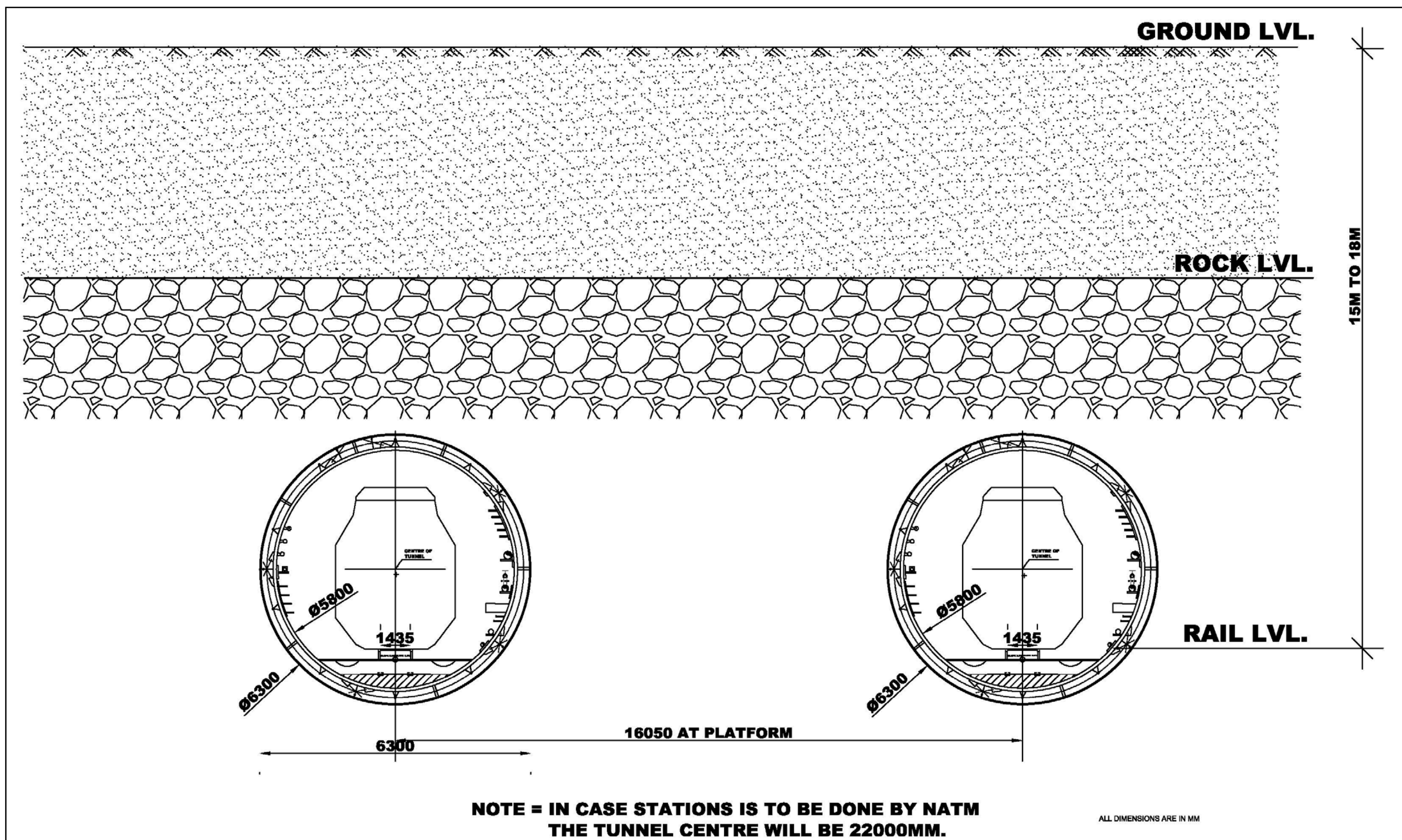
- **Mud-pressure type TBM**

The Mud-pressure type TBM is that soil pressure at the face is transferred efficiently to ground that is high in sand content and low in fluidity through the addition of water, mud, and additives. It is applicable to a large range of soils, including soft ground with low solidity such as alluvial sand/gravel, sand, silt and clay, alluvial deposits, and alternating hard and soft soil layers. The only limitation is that the soil discharge screw conveyor is unable to operate when the ground has high hydrostatic pressure. For this reason, it is necessary to closely study the soil properties before implementation.

- **Slurry type TBM**

Slurry type TBM (Air tunnel-boring machine) is used for tunnel-boring in highly permeable unstable terrain, or under civilian structures sensitive to ground disturbances.

FIGURE 5.20: TYPICAL TWIN TUNNEL ARRANGEMENT



When digging in highly unstable or liquid terrain, the pressure exerted by the terrain is directly governed by the depth at which digging is performed. It is therefore necessary to balance the pressure exerted by the terrain: the front shield of the Slurry TBM is filled with excavated material, with the exception of one air-filled part. The pressure within this air bubble is subject to fine control. Bentonite injection waterproofs the working face and improves its resistance.

B. Proposed Dimensions

TABLE 5.19: DIMENSIONS OF TBM

Parameter	Proposed dimension
Tunnel internal diameter	5200 mm (minimum)*
Tunnel external diameter	5800 mm
Tunnel excavation diameter	6200 mm
TBM cutter head diameter	6270
Number of segments/rings	5 + 1 Key
Width of segments	1.2m/1.4m/1.5m
Thickness of segments	300 mm
Weight to segments	Normal segments Approx 3.0 T each Key segment 1 T
Weight of complete ring	16 T
Grade of concrete	M - 45

*Wider Tunnel diameter may be adopted based upon detailed Geotech investigation at Detailed Design Stage.

C. Sequence of Tunnelling by TBM

Between two stations tunnel is constructed by TBM. It will be launched from launching shaft. It is dragged in station area and continues from other side of station. Ground settlement analysis and monitoring is required during tunneling by TBM. Two separate tunnels are constructed by two different TBM. Depending upon the soil/rock strata, suitable type of TBM shall be used for tunneling.

a. Pre-Assembly Activities

The following construction sequence is necessary before Assembly of TBM can be taken up:

i. Construction of Head Wall & Installation of rubber seal ring

This is a concrete structure designed to hold the main frame of the Entrance ring of TBM and prevent water and slurry flowing into the shaft during the assembly and operation of the TBM. Rubber Seal (25 mm thick) and seal retainers keep full contact with the shield TBM. Three air ventilation tubes are installed near the tunnel crown and one at the invert, to release the air, when the void is being filled with grout while launching the TBM. These can also be used for grouting.

ii. Construction of Cradle

This is a Pre-fabricated steel structure over which the TBM is assembled in-situ. This also acts as guide to help TBM oriented in the required direction, while in operation. After the TBM becomes operational, the cradle will be carefully dismantled so that the same material can be used at different shaft.

iii. Construction of Reaction Frame

This is a steel Structure consisting of the Frame and supports which is fixed to the shaft floor and is designed to safely bear the thrust [a force of App. 1200 ton (30% of total thrust)] applied by the TBM during its working (force required by the cutting edge to cut the rock). The machine is to be assembled in- situ on a platform called Cradle and a Reaction frame is to be constructed in advance to bear the reaction of the force exerted by the main drive of the TBM for cutting the rock. Once the TBM becomes operational, the steel work in the Reaction Frame will be carefully dismantled as the same material is to be used repeatedly at subsequent assemblies at different sites.

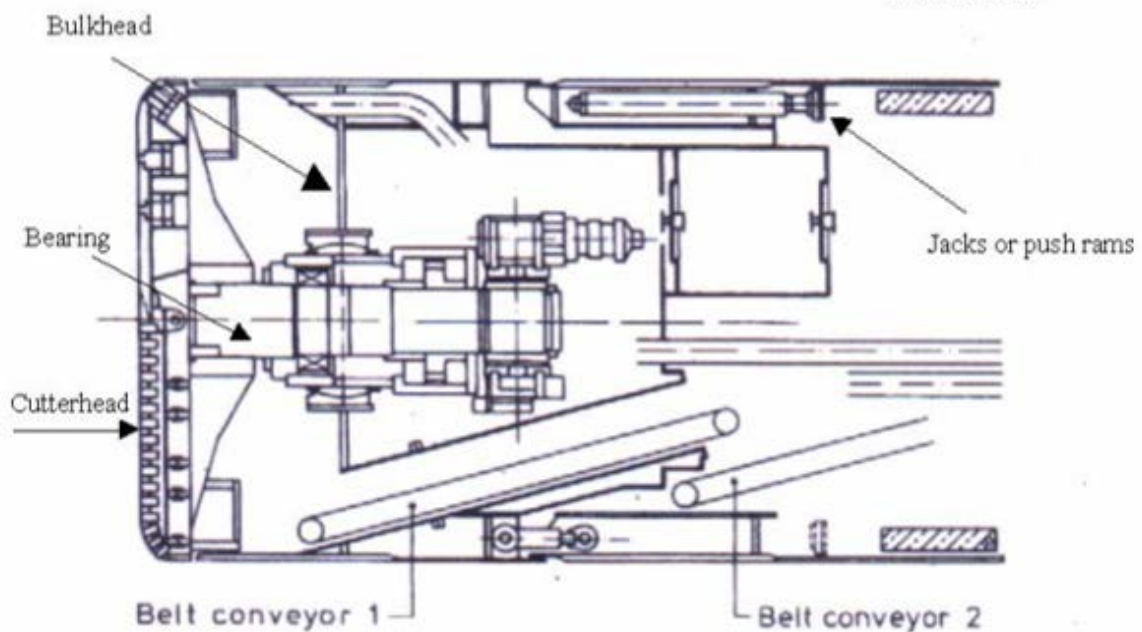
b. Assembly of TBM

After the Head Wall, Entrance ring, Cradle, Reaction Frames are constructed and other preparatory works are completed, the TBM can be assembled in- situ in a launching chamber on the cradle and launched for tunneling. Metro underground station being constructed by cut and cover method can be used as launching shaft for TBM.

FIGURE 5.21: LAUNCHING CHAMBER



FIGURE 5.22: TYPICAL ASSEMBLY OF TUNNEL BORING MACHINE



Following steps are involved in the assembly of TBM:

- 1) Lowering of the shield,
- 2) Lowering of Cutter Head and fixing the same to the shield,
- 3) Fixing Segment erector and screw conveyor erection,
- 4) Lowering and Assembly of back up gantries.

FIGURE 5.23: MAIN SHIELD ERECTION



FIGURE 5.24: ERECTOR, SCREW CONVEYOR & BACKUP SYSTEM



It takes about three-four weeks each for completing the preparatory work and actual assembly of TBM in position, before it could be launched. The cradle and the Reaction Frames are specially designed for every situation depending upon the machine characteristics and the rock characteristics. A 35 ton crane with a traveling gantry (or a suitable road mobile crane) is required for assembling the TBM. A 50 ton mobile crane will be required at the receiving end for dismantling TBM before shifting the same to another location.

c. Excavation

The TBM will operate at all times in enclosed mode. The pressure being maintained by balancing excavated material and foam introduced against material removed via the screw. A belt weighing device will be included on conveyor belt. This will measure the weight of the excavated material as it is transported on the conveyor belt.

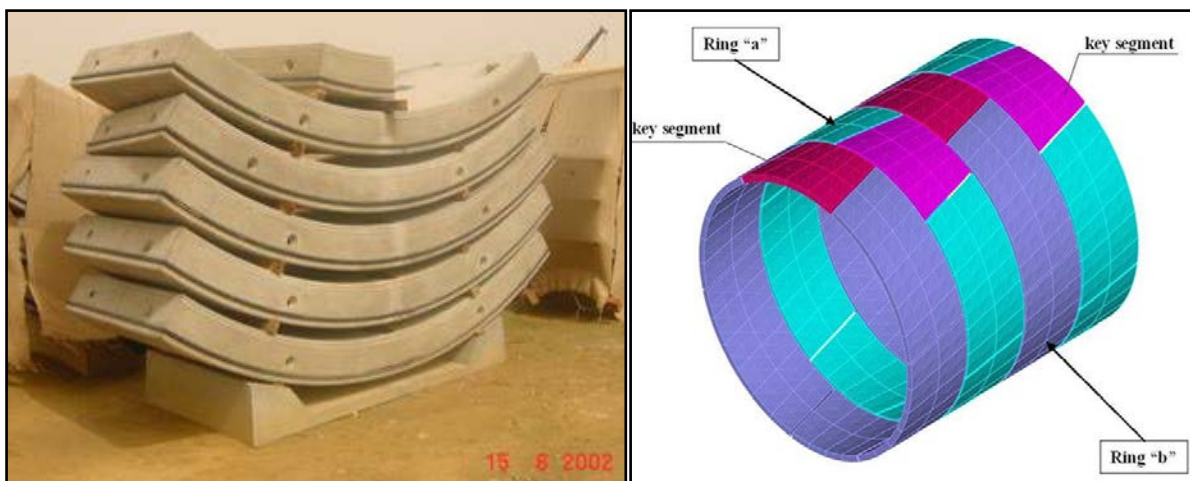
FIGURE 5.25: EXCAVATION



d. Ring Erection

As the machine advances, the construction of the permanent lining takes place behind the excavation face of the machine and typically consists of 6 segments which make one ring.

FIGURE 5.26: RING SEGMENT



e. Settlement Control

Settlement is primary caused by over excavation by TBM and the failure to fill annular voids behind the segments. To prevent over excavation during the TBM drives the following actions will be carried out:-

- Surface monitoring scheme to be agreed and installed prior to TBM launch.
- Provision of belt weighing device to measure excavated material weight.
- Ground treatment of launch area & receiving area (if required)
- Display in TBM drivers cabin to show actual excavated volume vs. theoretical excavated volume in real time. Data to be recorded by TBM data logger.

To ensure settlement do not occur due to the annulus ring not being filled by grout the following actions will be carried out.

- Grouting system based on pressure control.
- Recording of grout volumes & pressure by TBM data logger.
- Tabulation of grout volumes to be done weekly showing running 10 ring averages. Grout pressure will be adjusted as necessary.

The above actions should ensure all annular voids are filled during the initial drive thereby controlling settlement caused by poor grouting practices.

f. Grouting and Waterproofing

After ring installation, theoretical void distance between the excavated radius and the external radius of the precast ring need to be filled up. Grouting fill the voids and it also controls the ground settlement. Grouting pressure is calculated on the basis of overburden pressure. Structures shall be watertight if the leakage does not exceed 5 ml/m²/hour. Inside surface above spring line of the tunnel shall be always kept dry condition.

Cavity grouting of segmental lining

Cavity grout shall be executed during the tunnelling in order to:

- Secure the waterproofing of the tunnel

- Maintain the tunnel ring shape
- Limit the surface settlement
- Distribute ground pressures evenly onto the lining

The grouting can be distinguished into two types. These are single compound type and the other is the two compounds type. The hardening time of the one compound type is relatively slow and its strength is also low. On the other hand it is relatively easy for the two compounds type to adjust the hardening time and strength. Hence it is recommended to use the two compounds type for the cavity grout.

The two compounds type is also distinguished into two types - liquid type and plastic type. The liquid type can be sometime diluted by the underground water and segregated. However, the plastic type is changed instantly into gel and kept very stable until it gets its own strength. Thus plastic type grout is recommended. The major materials of the liquid-A for the plastic type are mainly cement, fly-ash and bentonite. And the major material of the liquid-B for the plastic type is sodium silicate.

Primary grouting is the initial cavity grouting which is applied simultaneously or immediately after a unit of lining has been built. Where primary grouting does not completely fill all cavities, secondary grouting shall be carried out. Primary grouting shall be undertaken at a pressure sufficient to place the grout properly but not greater than 1 bar above the prevailing hydrostatic pressure at the location of grouting. Primary grouting shall be timed so as to minimize ground movement and be injected through grout holes provided in the linings or via shield tail skin injection pipes.

Secondary grouting shall be undertaken in selected rings by means of removing grout plugs from the tunnel lining and drilling a hole to the back of the existing grout. Secondary grouting is the re-grouting of lining and shall be completed as soon as practicable but within 14 days of the primary grouting or when the face has advanced 50 m from the location of primary grouting whichever first occurs. Secondary grouting shall be at a pressure consistent with filling all voids. Automatic grouting system as TBM advances shall be equipped.

Segment Gasket

It is recommended to apply the three layers of gasket to the perimeter of the segment. The materials for the gasket are mainly distinguished into chloroprene rubber type and natural rubber type. It should be tested for durability and water swelling ratio before using. The natural rubber type is suitable for the tunnel under high water pressure and the chloroprene rubber type is suitable for the tunnel under low water pressure.

- Gaskets shall be fitted into the grooves provided in the edges of the segment to be sealed in the manner recommended by the gasket manufacturer. The gasket dimensions shall match the groove width, subject to the specified tolerance.
- Sealing strips of the hydrophilic or gasket type, or a combination of the two, shall be provided at all faces between segments to provide a seal against ingress of ground water. Gaskets must be capable of withstanding the anticipated water pressure when in use in the tunnel. Test certificates or other information shall be provided to demonstrate this capability.
- Elastomeric gasket materials shall comply with the requirements of BS 2494, including resistance to chemical attack and microbiological degradation.
- Immediately prior to the erection of a gasketed segment, the gasket shall be checked for cleanliness and position. The gasket shall be lubricated as recommended by the gasket manufacturer.

g. TBM in Station Area

Cradle will be installed to drag the TBM in station area and again drive to other end of station by cutting D-wall. One end of station is receiving chamber and other end is launching chamber.

v. New Austrian Tunnelling Method (NATM)

The term New Austrian Tunnelling Method Popularly Known as NATM, was first used by Mr. Rabcewicz in 1962. This method has been evolved as a result of experience gained in Austrian Alpine tunnelling condition. The first use of NATM in soft ground tunnelling is done in Frankfurt metro in 1969. The basic aim of NATM is for getting stable and economic tunnel support systems. Providing flexible primary lining

in shape of shotcrete, wire mesh, rock bolts, lattice girder. In case of weaker rock mass

FIGURE 5.27: TBM THROUGH THE DIAPHRAGM WALL



FIGURE 5.28: TBM PUSHED TO THE OTHER END OF THE STATION



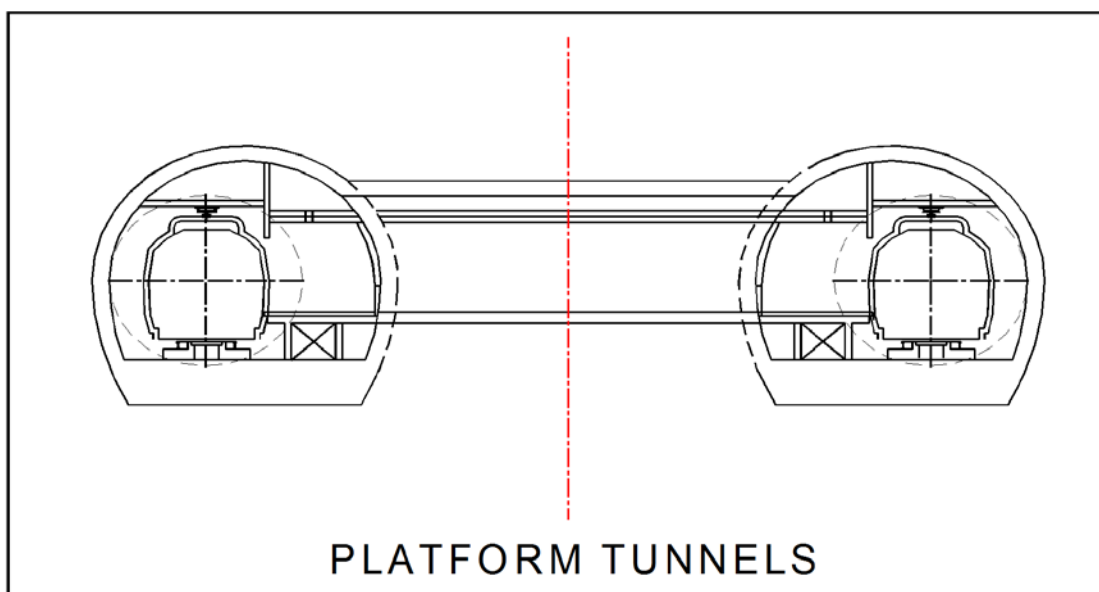
the use of pipe forepole/pipe roofing is also resorted for crown support which in turn leads to less over-break as well as ensure safety during the execution. The main aspect of the approach is dynamic design based on rock mass classification as well as the in situ deformation observed. This method has been very useful in complex diversified geological condition where forecasting of the rock mass is difficult due to rapidly changing geology.

Generally, two separate tunnels each accommodating a track and platform are constructed for two tracks and these two platform tunnels are interconnected by cross passages at regular interval so that both the platforms are accessed through a common set of stair cases and escalators provided at two shafts. In fact, these two platforms interconnected with number of cross passages act as an island platform.

FIGURE 5.29: CONSTRUCTION OF TUNNEL BY NATM



FIGURE 5.30: TYPICAL CROSS SECTION OF TWIN TUNNELS OF U/G STATION BY NATM



A. Broad Principles of NATM

NATM broadly based on the following principles:

- i. **Dynamic Design** – The design is dynamic during the tunnel construction. Every face opening classification of rock is done and the supports are selected accordingly. Also the design is further reinforced based on the deformation as noticed during the monitoring.
- ii. **Mobilization of the strength of rock mass:** The method relies on the inherent strength of the rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.
- iii. **Shotcrete Protection:** Loosening and excessive rock mass deformation should be minimised by applying a layer 25-50mm of sealing shotcrete immediately after opening of the face.
- iv. **Measurements:** Every deformation of the excavation must be measured. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground such as load cells, extensometers and reflectors.
- v. **Primary Lining:** The primary lining is thin. It is active support and the tunnel is strengthened not by a thicker concrete lining but by a flexible combination of rock bolts, wire mesh and Lattice girders.
- vi. **Closing of invert:** Early as far as possible closing the invert so as to complete the arch action and creating a load-bearing ring is important. It is crucial in soft ground tunnels.
- vii. **Rock mass classification:** The participation of expert geologist is very important as the primary support as well as the further designing of supports etc. during the excavation of rock requires the classification of the rock mass.

B. Construction of Shafts

Generally the shafts meant for entry / exits are constructed by Cut and Cover method. Due to presence of buildings very close to excavation area rigid support system in the form of Diaphragm Walls and Secant Pile Walls is proposed to be adopted for the braced excavation in the soil. However, the excavation in rock is usually done by stabilizing the rock face by means of shotcrete and rock dowels. A

combination of two may be necessary where diaphragm wall / secant pile is provided in the over burden soil and rock excavation is done below.

It is proposed to construct permanent diaphragm wall duly socketed into the rock and excavation below the diaphragm wall level be done by supporting rock face by shotcrete / rock bolting depending on the rock conditions. Once the excavation proceeds in rock diaphragm wall can be extended below by jacketing. For this it is proposed to use couplers in the diaphragm wall reinforcement. In some cases, however, where it is considered risky to do trenching for diaphragm wall panel on account of poor soil conditions and proximity to the building temporary secant pile or diaphragm wall with shorter panels may be adopted.

C. Cross Passage

It is recommended to follow NFPA 130 which is an international standard for the underground structures. Cross passageways shall not be further than 244m (800ft) apart according to the NFPA 130. At least one cross passage is required in each underground section between the stations. Construction method of cross passage is briefly explained below:

- The SGI segment is sometimes used at the location of the cross passage in order to strengthen the segment lining because some parts of the segment lining must be dismantled during the construction of the cross passage.
- Ground treatment is carried out from the ground surface. Usually the jet grout is applied. The jet grout is much more effective than other methods for the ground treatment because the original soil is totally replaced by the improved soil.
- Ground treatment is also carried out from the tunnel after the jet grouting above ground. The purpose of the grouting from the tunnel is supplementary grouting for the jet grouting above ground.
- Dismantling of the piece of the segments is commenced one piece by one piece together with carefully confirming of the soil condition. Additional grouting should be done if necessary.
- Excavation to the other tunnel with lagging or shotcreting.
- Structural work

D. Support Measures

Support measures prescribed for these NATM tunnels generally included shotcrete, wire mesh, lattice girders, forepiling etc. M25 grade of shotcrete is generally adopted for these tunnels. Standard shotcrete thickness is 25-30 cm for such sizes of platform tunnels, cross adits and service tunnels. However, in special areas such as intersections and transitions and areas of weak ground a higher shotcrete thickness of approximately 30-40 cm is applied. To avoid the buildup of water pressure on the shotcrete lining weep holes are drilled through the shotcrete lining. These weep holes are equipped with slotted PVC pipes wrapped in geo-textile.

Lattice girders are installed to provide immediate support for the exposed rock mass during excavation and to serve as template for the excavation geometry. They also serve as guidance and support for forepiling and are considered as reinforcement of the shotcrete lining. Different types of lattice girders are installed depending on the applied shotcrete thickness.

FIGURE 5.31: LATTICE GIRDER



For the tunnels wire mesh 150/150/6 mm are applied as standard. Wire mesh is applied after application of a shotcrete sealing layer. Proper overlap of 300 mm (2 mesh Openings) is provided in both directions i.e. circumferential and in longitudinal direction.

In some cases, forepiling is installed in the crown area of the top heading to avoid development of loosening rock zones. Forepiling is installed after each round from the current top heading face to provide safety for the following top heading excavation round. It is installed from the top of the last lattice girder installed.

vi. Construction of Underground Stations

Construction of underground station is mostly done by **Cut and Cover Method** where adequate ROW is available to support the excavation width to cover the width of station including protection work. Margin for road traffic also need to be available beyond the excavation line. Where ROW is restricted, only half width of station will be tackled at a time. In cases where ROW is extremely restricted and cut & Cover method is not possible, excavation will be done by **New Austrian Tunneling Method (NATM)**.

A. Cut and Cover Method

In this method, entire volume required to accommodate structure is first excavated, structures are casted followed by backfilling. The open cut excavation with slope but without support is not suited due to large depths of excavation involved. Hence support of excavated sides by way of diaphragm wall/sheet pile/soldier piles/secant piles is essentially done in cut and cover method. The support walls are often braced to effectively resist the huge earth pressure. The braced cut and cover method involves following steps:-

- Identification and diversion of utilities
- Construction of support walls
- Excavation between support walls along with bracing, ties or anchors
- Concrete construction
- Removal of temporary supports
- Backfilling and restoration of surface/utilities

There are two methods for cut and cover construction:-

- Bottom Up Construction:** This is the conventional construction method in which excavation is carried out through to the design depth and then construction starts from bottom most floor slab and proceeds upwards. In this method the restoration of top surface is possible only after all the structures are constructed upto top level and hence it involves longer restoration time.

ii. **Top Down Construction:** In this method, after excavation of first stage, floor slabs are constructed. These floor slabs are permanent structures which replace temporary steel struts in the braced excavation method to counteract the earth pressure from back of retaining wall. In this way, the underground structure construction is finished with the completion of excavation process. The floor slabs used in this method are heavier than steel struts used in conventional excavation method. In addition, superstructure being constructed simultaneously during excavation puts more weight on the column. Hence, bearing capacity of column is to be considered. Typical construction procedure of top down construction method is as under:-

- a. Construct the retaining wall.
- b. Construct piles. Place the steel columns where piles are constructed.
- c. Proceed to the first stage excavation.
- d. Cast the floor slab.
- e. Begin to construct superstructure.
- f. Proceed deeper to second stage of excavation. Cast the floor slab.
- g. Repeat the same procedure till designed depth is achieved.
- h. Cast bottom most slab.

The merits and de-merits of this method are shown in **Table 5.20**.

TABLE 5.20: MERITS AND DEMERITS OF TOP-DOWN METHOD

Merit	De-merit
- Shortened construction period due to simultaneous construction of underground structure and superstructure. - Faster restoration of ground surface and utilities as topmost slab of underground construction is casted first. - Higher stiffness of floor slabs compared to steel struts improves the safety of excavation.	- Higher cost. - Possibility of lateral displacement of retaining wall or ground settlement is more due to longer construction period of bottommost slab. - Natural ventilation and illumination is affected due to construction of first slab.

B. New Austrian Tunneling Method (NATM)

Where ROW is extremely restricted and it is not possible to adopt cut and cover method, stations are constructed by NATM. In this method, two separate tunnels consisting of one track and one platform are constructed by NATM method and are connected by means of cross passages. This method requires overburden of about 2-2.5 times dia of tunnel. In this method, progress is slow. This method is described in detail in tunnelling sub-section.

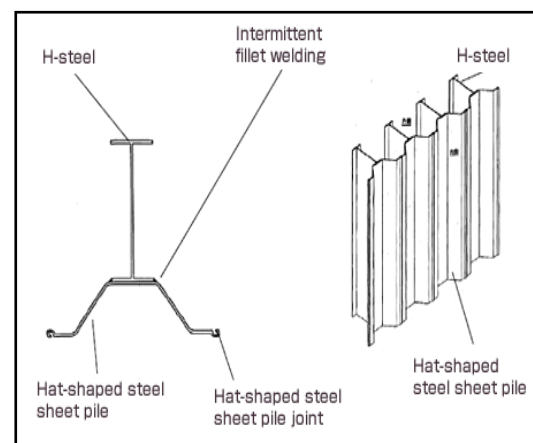
C. Earth retaining structures for underground stations

Following earth-retaining structures are used to support excavation for construction of underground stations:-

- a. **Soldier Piles:** H/I section steel piles are driven in the ground at an interval of 1-1.5 m and the gap between the two piles is filled by using laggings of timber planks/steel sheets/GI sheets. These piles are reusable, can be easily pulled out and results into less ground disturbance while driving and pulling out. However, these piles are not watertight and dewatering measures are required. Void between soldier piles and surrounding soil need filling.



- b. **Sheet Piles:** Sheet piles of 'Z' or 'U' shape are driven into soil by striking or static vibrating. The sheet pile is interconnected with adjoining piles to achieve interlocking and water sealing. Sheet piles can be used again and again and hence becomes economical. Driving of sheet piles require considerable efforts and cause vibrations to ground and adjoining structures. Sheet piles have higher stiffness than soldier piles.

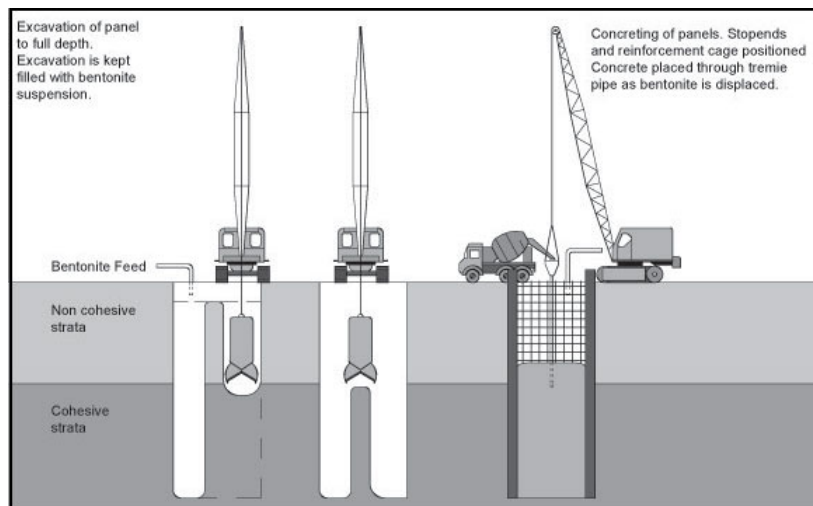


- c. **Secant Piles:** It is series of piles cutting into adjoining piles to achieve water tight retaining structure. In this method, alternate soft piles, called female piles, of dia

(D) 800 to 1000 mm (without reinforcement) are cast at an inter-distance of less than D and when these piles are still green, hard piles (containing reinforcement) are bored by cutting female piles. Thus, a series of alternate and interconnected hard and soft pile is achieved which acts as rigid earth retaining structure. It has all the advantages of diaphragm wall, except that it cannot be used as part of permanent structure.

- d. **Diaphragm Wall:** It is a rigid support system ensuring maximum safety against settlement/lateral displacement. Typically diaphragm wall of 1 m thickness is sufficient to retain the earth pressure in a cut cover construction. The diaphragm wall can be used as part of permanent structure. With diaphragm wall, it is possible to adopt top down construction method.

FIGURE 5.32: DIAPHRAGM WALL



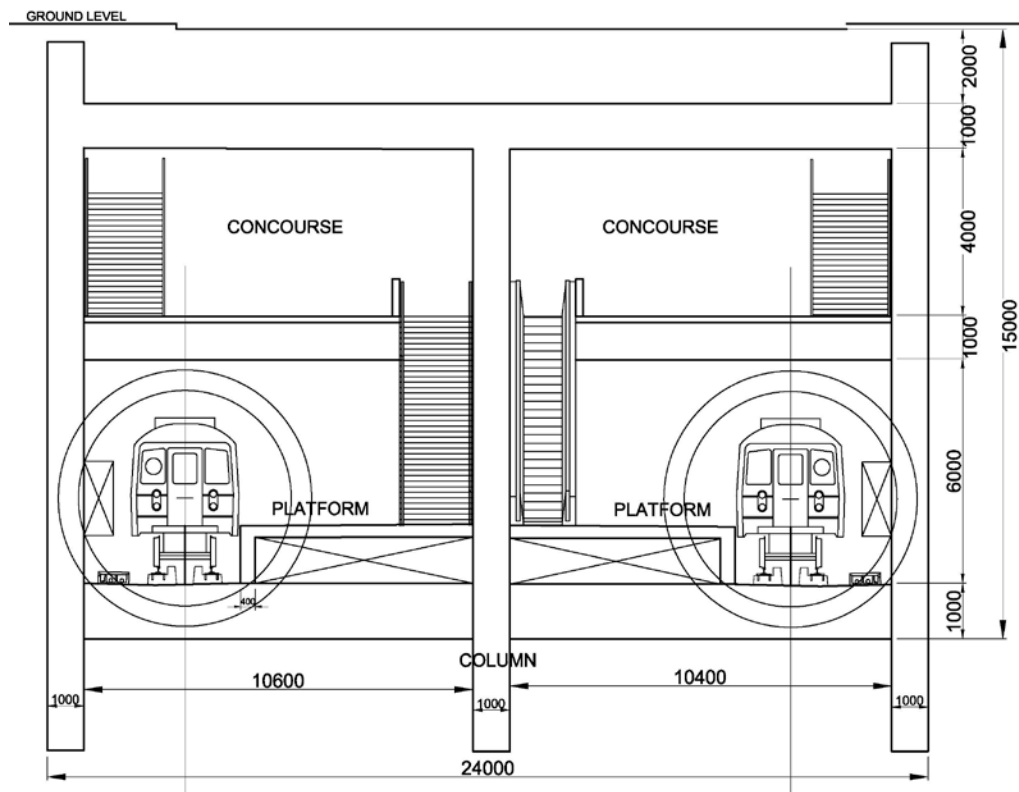
D. Typical Underground Station

A typical underground station is three level station with entrances and ventilation shafts at the ground level, a concourse with ticketing and AFCs at the mezzanine level and finally platforms at the lowest level. 140 m long island platform is proposed on the stations. Platform is 12 m wide with 2 sets of staircase/ Escalator planned leading to either end of the station. A lift is planned in the centre. **Figure 5.35** shows a typical cross section of underground station.

Two end concourses have been proposed, one at each end. The concourse is divided into paid and unpaid area by the AFC gates. Paid area is limited to access to the stair / escalator and corridor connecting the two concourses, also lead to the lift which is centrally provided.

Since, very limited space is available on the ground at stations, all the over-ground structures are therefore, planned as and where space is available and are therefore, not necessarily grouped at ground level.

FIGURE 5.33: TYPICAL UNDERGROUND STATION



vii. Flexible Joint at the Junction of the Tunnel and Station/Shaft

Following three models are considered for the connection.

- Rigid connection
- Pin connection
- Free connection

The Rigid connection is recommended. There are some measures for such joint between the tunnel and station which are as follows.

- RC segment only
- RC segment with elastic washers for 7 meters (1D long)

- SGI segment for 7 meters (1D long)
- SGI segment with elastic washers for 7 meters (1D long)
- Flexible joint

Considering safety and cost for the construction it is recommended to apply the rigid joint at the connection between tunnel and station. Detailed analysis such as FEM analysis should be done for the earthquake to estimate the displacement of the joint.

viii. Protection of Stray Current

The corrosion control system shall be designed to mitigate the potential effects of stray currents. The consultant team recommends the following measures.

- Connections shall be provided to enable electrical bonding of the inner reinforcement across isolation joints.
- Facilities for jointing any or all of the connections shall be provided.
- Reinforcement for segmental concrete lining shall be designed such that no electrical continuity will exist across the circle joint.
- SGI segments shall be bonded to mitigate potential stray current effects.
- Cathodic protection should be applied to all the pipes inside the tunnel.
- Bracket for the pipes or cable should be taken care of its insulation.

ix. Ventilation

A mechanical emergency ventilation system is required in a fixed guide way transit underground or enclosed train way that is longer than 304.8 m (1000 ft) according to the NFPA 130, 2003 edition. RITES recommends for adopting the Saccardo ventilation system in the project. This system is widely used in Japan, USA and Singapore.

Saccardo ventilation system is such a longitudinal ventilation operational system as high velocity air jet produces high volume airflow into the tunnel. This system is especially effective to the twin tunnels with a single track because the section area

of the tunnel is relatively small and the direction of the traffic is always same. Moreover, the innovation of the ventilation fan is so fast that this system is getting more effective to the ventilation of the even longer tunnels in these days.

The analysis of the ventilation for the normal and emergency condition can be made by the Subway Environment Simulation (SES) computer program, which was developed by the Department of Transportation of USA. However, the air velocity of 2 m/s is applied for designing the capacity of the ventilation fan in the Japanese latest metro system. This figure complies with the NFPA 130 and a reference for the system in the project.

x. Grade of Concrete

It is proposed to carry out construction work with design mix concrete. Computerized Automatic Batching Plants will be installed. Following grades of concrete are proposed for various members as per design requirement/durability considerations.

- i. Piles : M-35
- ii. Pile cap and open foundation : M-35
- iii. Piers : M-40/M-50
- iv. All pre-cast elements for viaduct and stations: M-45
- v. Tunnel segments : M-45
- vi. Cantilever piers and portals: M-45 /M-50/M-60
- vii. Other miscellaneous structures: M-30

For all main structures, permeability test of concrete is recommended to ensure impermeable concrete.

xi. 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 T 13 and or 19 K 15 is recommended (confirming to IS:14268).

5.3.3 Geo-Technical Details with New Innovative Techniques to be used for Implementation in Civil Works, Track System

i. Coverage

Geotechnical investigation was carried out by RITES for Thirty (30) boreholes drilled throughout the Corridor with the objective of determining subsurface profile of the underlying strata and required strength characteristics of the underlying soil / rock strata in order to propose the suitable substructure for elevated section, stations buildings, other buildings and underground alignment.

Geotechnical report includes field investigation, laboratory test results of the soil samples to evaluate the soil parameters and recommendations with regard to suitable sub-structure which may be adopted for various elevated and underground structures.

ii. Physiography

The headquarters of the district is the city of Thane. Other major cities in the district are Navi Mumbai, Kalyan-Dombivli, Mira-Bhayander, Bhiwandi, Ulhasnagar, Ambarnath, Badlapur, Murbad and Shahapur.

The district is situated between 18°42' and 20°20' north latitudes and 72°45' and 73°48' east longitudes. The revised area of the district is 4,214 km². The district is bounded by Nashik district to the north east, Pune and Ahmadnagar districts to the east, and by Palghar district to the north. The Arabian Sea forms the western boundary, while it is bounded by Mumbai City District and Mumbai Suburban District to the southwest and Raigad District to the south.

The district is the northernmost part of the Konkan lowlands of Maharashtra. It comprises the wide amphitheatre like Ulhas basin on the south and hilly Vaitama valley on the north together with plateaus and the slopes of Sahyadri. From the steep slopes of the Sahyadri in the east, the land falls through a succession of plateaus in the north and centre of the district to the Ulhas valley in the south. These lowlands are separated from the coast by a fairly well-defined narrow ridge of hills that runs north-south to the east of the Thane creek, parallel to the sea, keeping a distance of about 6 to 10 km from the shores. Isolated hills and spurs dot the district area.

iii. Rainfall and Climate

There are two distinct climates in the district, one on the western coastal plains and the other on the eastern slopes of Sahyadri. The climate on the western coastal plains of Thane, Vasai, Palghar and Dahanu talukas is tropical, very humid and warm. The climate on the plains at the foot of the slopes (Kalyan, Bhiwandi, Vada, Ulhasnagar, Ambarnath and Talasari talukas) and on the eastern slopes of Sahyadri (Murbad, Shahapur, Jawhar, Vikramgad and Mokhadatalukas) is comparatively less humid. The temperature variation is more in the eastern part of the district comparing to the western coastal areas.

The district has four seasons. Winter is from December to February, followed by summer from March to June. The southwest monsoon season is from June to September. October and November months constitute the post-monsoon season, which is hot and humid in the coastal areas.

In the coastal area, the average daily maximum temperature in summer is 32.9 °C (maximum recorded at Dahanu is 40.6 °C on 19 April 1955) and in winter average mean daily minimum temperature is 16.8 °C (minimum recorded at Dahanu is 8.3 °C on 8 January 1945). But in the interior parts of the district, the average daily minimum temperature is slightly lower in the winter season and the average daily maximum temperature is higher in the summer.

The average annual rainfall in the district is 2293.4 mm. The rainfall in the district increases from the coastal areas to the interior. The rainfall varies from 1730.5 mm at Mahim on the coast to 2588.7 mm at Shahapur in the interior. The rainfall during the southwest monsoon season, June to September, constitutes about 94% of the annual rainfall. July is the wettest month with a rainfall of about 40% of the annual total. The variation in the annual rainfall from year to year in the district is not large. The highest rainfall recorded in 24 hours at any station in the district was 481.1 mm at Dahanu on 1 September 1958 CE.

iv. General Geology & Related Characteristics

The Thane district forms part of western slope of Sahayadri hill range. This hill range passes through the eastern part of the district. Major part of the district constitutes rugged and uneven topography, characterized by high hills and steep valleys. Physiographically, district can be divided into two broad divisions-Undulating Hilly Tract and Coastal Plain in western part. The area is drained by innumerable streams

and tributaries of Vaitarna and Ulhas River. The four main tributaries of river Vaitarna are Surya, Tansa, Deharaja and Pinjal Rivers. Ulhas River is the other important river in the district. Most of the soils in the district can be considered as being derived from trap (Basaltic) rocks. The soil has been classified into three broad categories based on the characteristics and relationship with topographic set up.

- 1) Soil of Coastal Lands with Residual Hills** - These soils are slightly deep, poorly drained, fine soils on gentle sloping land and very fine soil on sloping land. These soils are calcareous and occur along the coast of Vasai, Palgarh and Dahanu.
- 2) Lighter Colored soils** - These soils are occurring on the undulating, elongated hills and 5 intervening valleys. These are medium to deep grayish in color, poor in fertility, clayey to loamy in nature, shallow in depth and coarse in texture. These soils are known as Varkas and are suitable for rice. These soils occur on the eastern part of the district.
- 3) Black Colored Soil**- These soils occur on plains in the middle and eastern part of the district along the valleys.

The soils of thane district can be conveniently divides into three categories

- a. Block Soil containing sand.**
- b. Red soil in the eastern region mostly on the slopes**
- c. Brownish-black soil in the patches of the valleys mostly lying between the coastal plains and the hilly slopes of Sahayadri.**

The first type of soil, which is found in Dahanu, Palghar, Vasai and Thane tahsil, is fertile and useful for horticulture, Paddy cultivation and vegetables. Whereas, the second type which is found in Mokhada, Talasari and some parts of other tahsils on the Eastern slopes is useful for growing coares millets like Nagli and Varai. The third type of soil found in Bhiwandi, Kalyan and Shahapur tahsils is useful, particularly for Paddy cultivation.

v. Seismicity

In peninsula India the state of Maharashtra, along with Gujarat and Madhya Pradesh, has suffered from frequent earthquakes, both deadly and damaging, although not located on or near any plate boundaries. All the earthquakes here, as in all of peninsula India, are interpolating events. In the 20th century alone, three earthquakes with magnitudes greater than 6.0 were recorded here. According to

GSHAP data, the state of Maharashtra falls in a region of moderate to high seismic hazard. As per the 2002 Bureau of Indian Standards (BIS) map, Maharashtra also falls in Zones II, III & IV. Historically, parts of this state have experienced seismic activity in the M6.0-6.5 range. Approximate locations of selected towns and basic political state boundaries are displayed in **Figure 5.36**.

Seismic Zones in India and Earthquake Hazard map are shown in **Figure 5.37** and **Figure 5.38**.

vi. Scope of Investigations

Field Investigation at the site were planned to determine the required strength characteristics of the underlying soil/rock to design the foundations of the proposed structure to be constructed. The geotechnical investigation work includes:

- a. Drilling of 150mm diameter boreholes in all kind of soil including gravels and cobbles, & 76 mm dia. drilling in Weathered Rock, Soft Rock & Hard Rock up to depth ranging from 15m to 21m. Boreholes have been terminated after completing at least 3 m drilling in fresh and hard Rock. These bore holes have been drilled at an interval of about 1000m c/c distance along the alignment or at change of strata.

FIGURE 5.34: SEISMIC ACTIVITY

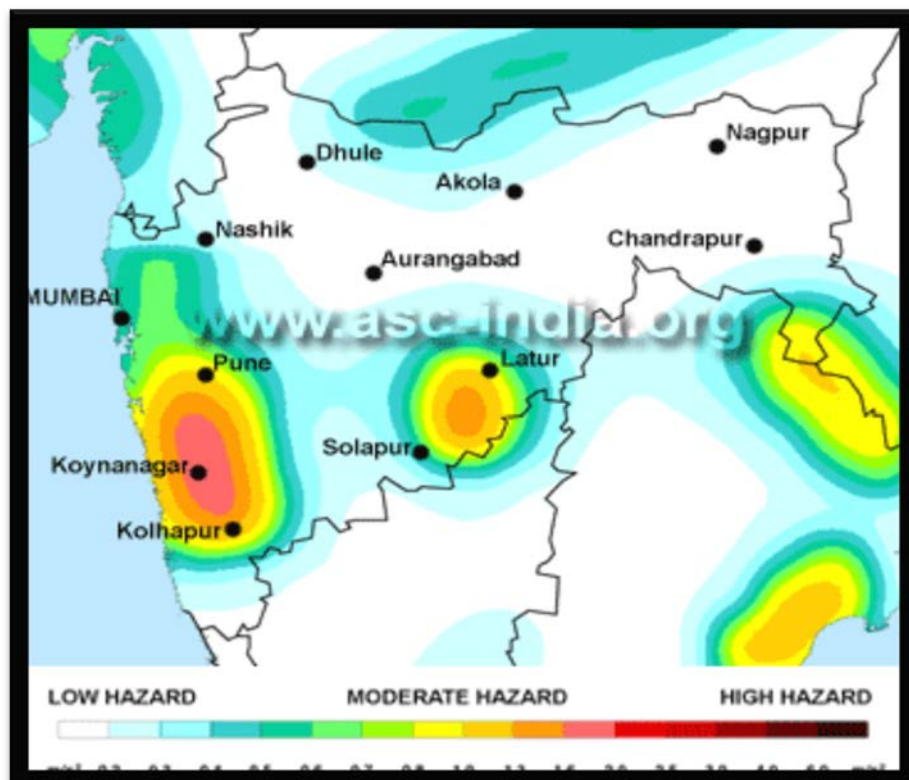
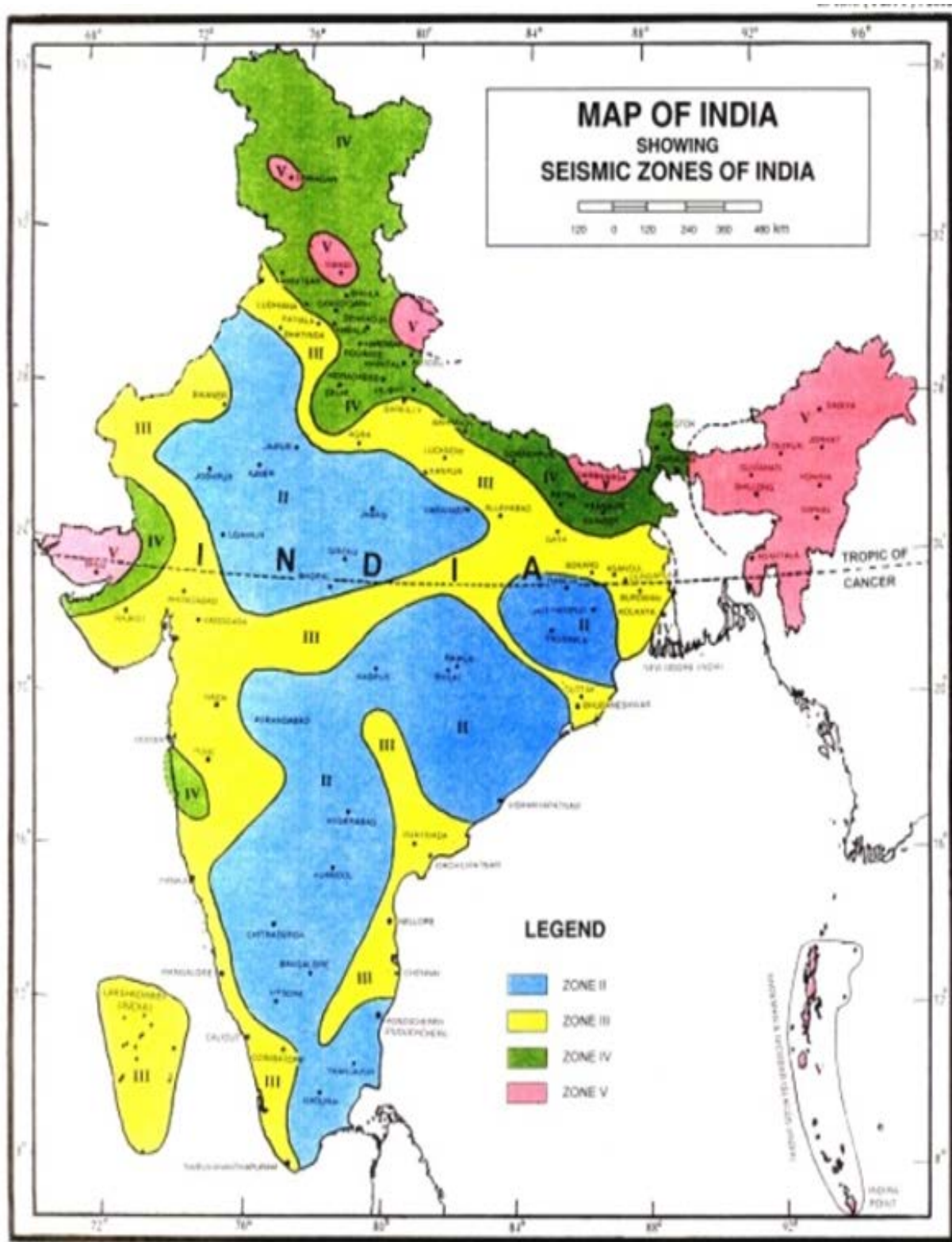
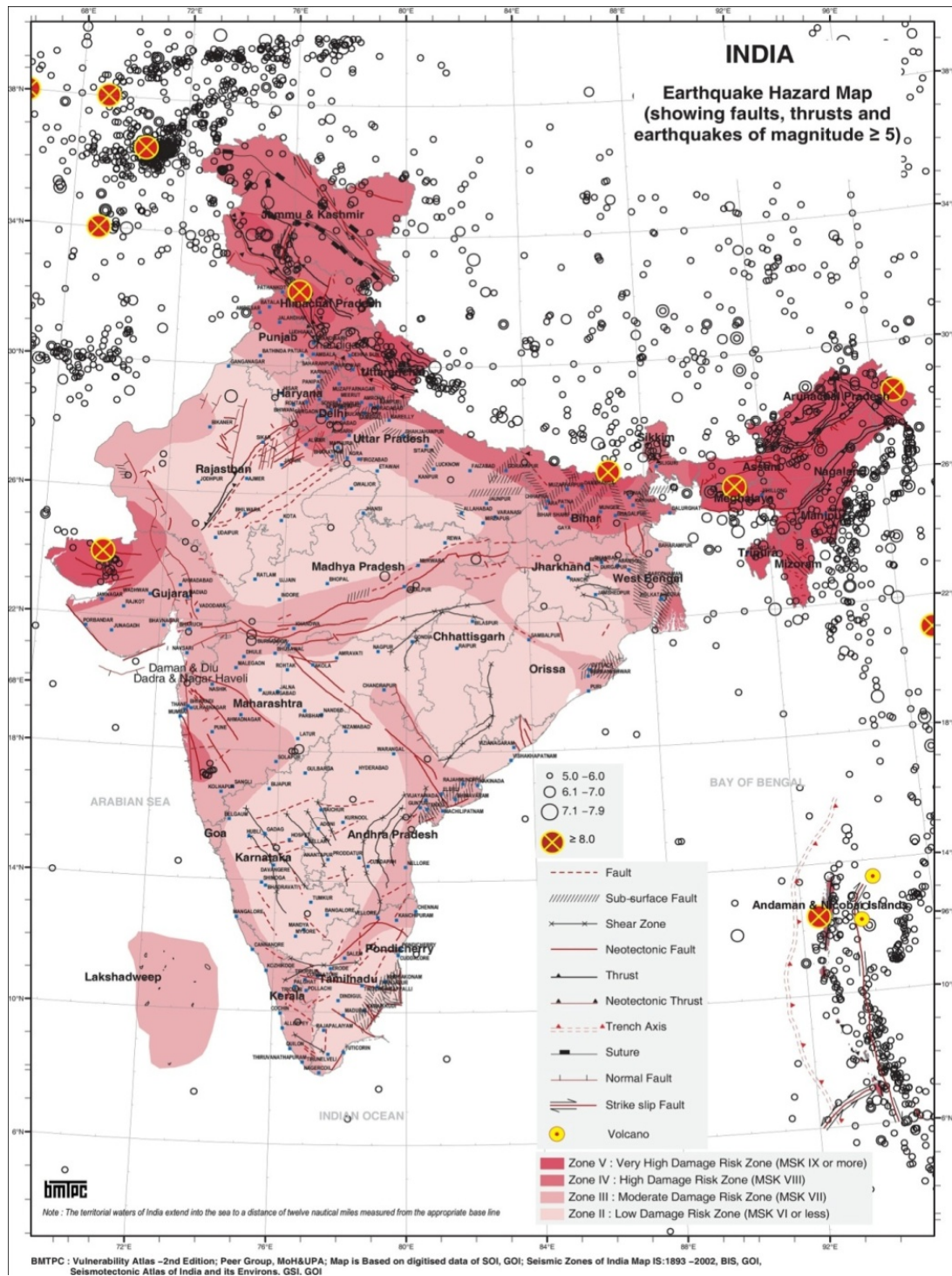


FIGURE 5.35: SEISMIC ZONES OF INDIA



NOTE : Towns falling at the boundary of zones demarcation line between two zones shall be considered in High Zone.

FIGURE 5.36: EARTHQUAKE HAZARD MAP



- Conducting Standard Penetration test (SPT) at every 3.0 m interval upto BH termination depth.
- Collection of disturbed & undisturbed soil samples as per IS:2132.

Following laboratory tests were conducted on collected soil samples:

TABLE 5.21: GEOLOGICAL SUCCESSION FOR SOIL

S. NO.	PARTICULARS OF PROPERTIES	RELEVANT IS CODE	DISTURBED SAMPLES	UNDISTURBED SAMPLES
1.	Sieve Analysis	IS 2720 (part IV)	✓	✓
2.	Atterberg's Limit	IS 2720 (part V)	✓	✓

Following laboratory tests were conducted on selected Rock core samples:

TABLE 5.22: GEOLOGICAL SUCCESSION FOR ROCK

S. NO.	PARTICULARS OF PROPERTIES	RELEVANT IS CODE	ROCK CORE SAMPLES
1.	Water Absorption	IS 1330	✓
2.	Porosity	IS 1330	✓
3.	Specific Gravity	IS 1330	✓
4.	Uniaxial Compressive Strength	IS 8764	✓
5.	Point load Index	IS 8764	✓

vii. Details of Geotechnical Investigation

A. General

In total, 30 bore holes have been drilled up to maximum 21.00 m depth along the proposed Corridor for investigation. In which one Bore Hole has been drilled in Kasarvadavali Depot area.

Standard Penetration Test (SPT) was conducted in the boreholes at every 3.0 m interval and change of strata as per specifications. Standard split spoon sampler attached to lower end of drill rods was driven in the boreholes by means of standard hammer of 63.50 kg falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications and number of blows required for each 15 cm penetration was recorded. The number of blows for the first 15 cm penetration was not taken into account as it is considered seating drive. The number of blows for next 30 cm penetration was designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed Soil samples obtained from standard split spoon sampler were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to laboratory for testing.

Undisturbed Soil Samples (UDS)UDS wherever could not recover due to presence of hard strata or slipped during lifting, were duly marked in the respective bore logs.

The depth of **Ground Water Table** was checked/ measured in all bore holes. The ground water table was encountered in all bore holes during the boring activity.

B. Details for Corridor

A total of 29 BHs have been drilled in the soil for corridor. Summary of the boreholes drilled in the corridor is given in **Table 5.23**.

TABLE 5.23: SUMMARY OF BORE HOLES

S. No.	BH Nos.	BH Location	Chainage (m)	Depth of Borehole (m)	Ground Water Table (m B.G. L)
1	BH-1	Near New Thane	430	18.00	5.40
2	BH-2	Near Kashish Park	1155	15.00	5.50
3	BH-3	Near Modella chowk	1580	15.00	6.50
4	BH-4	Near Neheru Nagar	2665	21.00	7.50
5	BH-5	Near Wagle Industrial Estate	3485	17.00	6.50
6	BH-6	Near Lokmanya Nagar Bus Depot	4395	19.50	5.50
7	BH-7	Near Shastri Nagar	5300	16.00	9.70
8	BH-8	Near Upvan Lake	6600	16.00	5.50
9	BH-9	Near Gandhi Nagar	7740	16.00	7.50
10	BH-10	Near Vasant Vihar	8850	15.00	7.50
11	BH-11	Near Khewra Circle	9620	15.00	7.00
12	BH-12	Near Patlipada	10195	19.50	6.70
13	BH-13	Near Hiranandini Estate Road	11180	15.00	4.60
14	BH-13 A	Near Vijay Nagri	12800	15.00	6.70
15	BH-13 B	Near Waghbil	14065	18.00	7.50
16	BH-13 C	Near Hiranandini Road Enclave	15615	15.00	5.80
17	BH-13 D	Near New Brahmand	16750	15.00	7.80
18	BH-14	Near Azad Nagar Bus Stop	17800	18.00	7.50
19	BH-15	Near Manorma Nagar	19235	15.00	7.50
20	BH-16	Near Kolshet Industrial Area	20000	18.00	6.00
21	BH-17	Near Old Agra Road	20790	15.00	7.50
22	BH-18	Near Balkum Naka	21500	16.00	5.50

S. No.	BH Nos.	BH Location	Chainage (m)	Depth of Borehole (m)	Ground Water Table (m B.G. L)
23	BH-19	Near Balkumpada	22300	16.50	6.80
24	BH-20	Near Saket	22850	18.00	8.30
25	BH-21	Near Rabodi	23660	16.50	5.30
26	BH-22	Near Shivaji Chowk	24485	15.00	6.50
27	BH-23	Near Thane Junction	25460	16.00	6.50
28	BH-24	Near Brahman Society Thane Junction	26585	21.00	4.50
29	BH-25	Near New Thane	27355	16.50	4.50
30	BH-D-1	Depot Area		15.00	5.80

C. Details for Depots

A total of 1 BH having 15.0 m depth has been drilled in soil for the proposed depot. Summary of the borehole drilled is given below in **Table 5.24**.

TABLE 5.24: SUMMARY OF BORE HOLES FOR DEPOTS

S. No.	BH Nos.	BH Location	Chainage (m)	Depth of Borehole (m)	Ground Water Table (m B.G. L)
1	BH-D-1	Kasarvadavali Depot Area		15.00	5.80

viii. Engineering Parameters of Each Layer

Sub Soil Profile

The sub-soil strata at proposed alignment are generally homogeneous and comprises of mainly three types of layers (based on field tests & laboratory test result data). Description of engineering parameters of each layer met along the corridor and Depot areas are tabulated below in **Table 5.25**;

LAYER TYPE – I: Overburden comprising of silty sandy soil with gravels and pebbles yellowish brown in colour

LAYER TYPE– II: Moderately to highly weathered amygdaloidal basalt

LAYER TYPE –III: BedrockRock comprising fresh & hard Basalt with zeolite Type of Foundation

TABLE 5.25: DETAILS OF LAYER MET ALONG THE CORRIDOR

BH Nos.	BH Location	LAYER TYPE –I		LAYER TYPE –II		LAYER TYPE –III	
		Depth (m)		Depth (m)		Depth (m)	
		From	To	From	To	From	To
BH-1	Near New Thane	0.00	4.50	4.50	15.00	15.00	18.00
BH-2	Near Kashish Park	0.00	6.00	6.00	12.00	12.00	15.00
BH-3	Near Modella chowk	0.00	3.50	3.50	12.00	12.00	15.00
BH-4	Near Neheru Nagar	0.00	6.00	6.00	18.00	18.00	21.00
BH-5	Near Wagle Industrial Estate	0.00	6.50	6.50	14.00	14.00	17.00
BH-6	Near Lokmanya Nagar Bus Depot	0.00	6.00	6.00	16.50	16.50	19.50
BH-7	Near Shastri Nagar	0.00	4.50	4.50	13.00	13.00	16.00
BH-8	Near Upvan Lake	0.00	6.00	6.00	13.00	13.00	16.00
BH-9	Near Gandhi Nagar	0.00	4.50	4.50	13.00	13.00	16.00
BH-10	Near Vasant Vihar	0.00	4.50	4.50	12.00	12.00	15.00
BH-11	Near Khewra Circle	0.00	4.50	4.50	12.00	12.00	15.00
BH-12	Near Patlipada	0.00	7.50	7.50	16.50	16.50	19.50
BH-13	Near Hiranandini Estate Road	0.00	3.00	3.00	12.00	12.00	15.00
BH-13 A	Near Vijay Nagri	0.00	4.00	4.00	12.00	12.00	15.00
BH-13 B	Near Waghbil	0.00	9.00	9.00	15.00	15.00	18.00
BH-13 C	Near Hiranandini Road Enclave	0.00	7.50	7.50	12.00	12.00	15.00
BH-13D	Near New Brahmand	0.00	4.50	4.50	12.00	12.00	15.00
BH-14	Near Azad Nagar Bus Stop	0.00	7.50	7.50	15.00	15.00	18.00
BH-15	Near Manorma Nagar	0.00	6.00	6.00	12.00	12.00	15.00
BH-16	Near Kolshet Industrial Area	0.00	4.50	4.50	15.00	15.00	18.00
BH-17	Near Old Agra Road	0.00	9.00	9.00	12.00	12.00	15.00
BH-18	Near Balkum Naka	0.00	10.50	10.50	13.00	13.00	16.00
BH-19	Near Balkumpada	0.00	10.50	10.50	13.50	13.50	16.50
BH-20	Near Saket	0.00	9.00	9.00	15.00	15.00	18.00
BH-21	Near Rabodi	0.00	10.50	10.50	13.50	13.50	16.50
BH-22	Near Shivaji Chowk	0.00	9.00	9.00	12.00	12.00	15.00
BH-23	Near Thane Junction	0.00	10.50	10.50	13.00	13.00	16.00
BH-24	Near Brahman Society Thane Jn.	0.00	4.50	4.50	18.00	18.00	21.00
BH-25	Near New Thane	0.00	4.50	4.50	13.50	13.50	16.50
BH D-1	Depot Area	0.00	4.50	4.50	12.00	12.00	15.00

A. Introduction

The proposed alignment has been explored by drilling of 30 boreholes down to depth of 21.0m below ground level. As the strata met mostly rocky at most of the sites and heavy loads are expected.

B. Safe Load Carrying Capacity and Safe Uplift Capacity for Pile

Depth of foundations in soil shall be decided as per clause 7 of IS: 1904 for special cases like; where volume change is expected / scour is expected / foundations on sloping ground / foundation on made up or filled up ground / frost action is expected etc. The Depth of foundation also depend upon the Rock Strata encountered down the ground level at adequate depths and hence, calculated as per IRC-78 2014. The safe pile load carrying capacity and safe uplift capacity for various lengths and diameters of piles has been worked out as per IS 2911 (Part 1/Sec 2): 2010- Design and Construction of Pile Foundations equation and tabulated below in **Table 5.26** and **Table 5.27**.

TABLE 5.26: SAFE LOAD CARRYING & UPLIFT CAPACITY OF CORRIDOR

BH Nos.	BH Location	Pile Stem Dia.D (m)	Length of pile below cut-off (m)	Vertical Safe Load Capacity of Pile, (KN)	Vertical Safe Load Capacity of Pile, (T)
BH-1	Near New Thane	1.0	15.00	2320	232
		1.2	15.00	3180	318
BH-2	Near Kashish Park	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-3	Near Modella chowk	1.0	12.00	2214	221
		1.2	12.00	3053	305
BH-4	Near Neheru Nagar	1.0	18.00	3307	330
		1.2	18.00	2214	221
BH-5	Near Wagle Industrial Estate	1.0	14.00	2267	226
		1.2	14.00	3117	311
BH-6	Near Lokmanya Nagar Bus Depot	1.0	16.50	2532	253
		1.2	16.50	3435	343
BH-7	Near Shastri Nagar	1.0	13.00	2267	226
		1.2	13.00	3117	311

BH Nos.	BH Location	Pile Stem Dia.D (m)	Length of pile below cut-off (m)	Vertical Safe Load Capacity of Pile, (KN)	Vertical Safe Load Capacity of Pile, (T)
BH-8	Near Upvan Lake	1.0	13.00	2267	226
		1.2	13.00	3117	311
BH -9	Near Gandhi Nagar	1.0	13.00	2267	226
		1.2	13.00	3117	311
BH-10	Near Vasant Vihar	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH- 11	Near Khewra Circle	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-12	Near Patlipada	1.0	16.50	2532	253
		1.2	16.50	3435	343
BH -13	Near Hiranandini Estate Road	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-13 A	Near Vijay Nagri	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-13 B	Near Waghbil	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-13 C	Near Hiranandini Road Enclave	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-13 D	Near New Brahmand	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-14	Near Azad Nagar Bus Stop	1.0	15.00	2320	232
		1.2	15.00	3180	318
BH-15	Near Manorma Nagar	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-16	Near Kolshet Industrial Area	1.0	15.00	2320	232
		1.2	15.00	3180	318
BH-17	Near Old Agra Road	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-18	Near Balkum Naka	1.0	13.00	2267	226
		1.2	13.00	3117	311
BH-19	Near Balkumpada	1.0	13.50	2267	226

BH Nos.	BH Location	Pile Stem Dia.D (m)	Length of pile below cut-off (m)	Vertical Safe Load Capacity of Pile, (KN)	Vertical Safe Load Capacity of Pile, (T)
		1.2	13.50	3117	311
BH-20	Near Saket	1.0	15.00	2320	232
		1.2	15.00	3180	318
BH-21	Near Rabodi	1.0	13.50	2267	226
		1.2	13.50	3117	311
BH-22	Near Shivaji Chowk	1.0	12.00	2267	226
		1.2	12.00	3117	311
BH-23	Near Thane Junction	1.0	13.00	2267	226
		1.2	13.00	3117	311
BH-24	Near Brahman Society Thane Junction	1.0	18.00	3307	330
		1.2	18.00	2214	221
BH-25	Near New Thane	1.0	13.50	2267	226
		1.2	13.50	3117	311

TABLE 5.27: SAFE LOAD CARRYING CAPACITY & SAFE UPLIFT CAPACITY OF DEPOT

BH Nos.	BH Location	Pile Stem Dia.D (m)	Length of pile below cut-off (m)	Vertical Safe Load Capacity of Pile, (KN)	Vertical Safe Load Capacity of Pile, (T)
BH D-1	Depot Area	1.0	12.00	2267	226
		1.2	12.00	3117	311

C. Safe Bearing Pressure for Shallow Foundation Resting on Rock

Net Safe bearing Capacity of shallow foundation at depot locations, where bed rock is met at shallow depth has been calculated and tabulated below in Table 5.28.

TABLE 5.28: SBC OF SHALLOW FOUNDATION (DEPOT LOCATION)

BH No.	Depth of foundation (m)	Qc (Average UCS of the rock cores in T/sqm)	Nj (Empirical coefficient depending upon the spacing of discontinuities)	Qs (Safe bearing pressure in T/sqm)
D-1	4.50	360	0.20	72

ix. Conclusions & Recommendations

Thirty boreholes have been drilled down to maximum depth of 21.00 m below ground level for sub soil/Rock exploration. Following is recommended for different type of foundations:

- Since heavy loads are to be transferred to sub soil strata at viaduct part of alignment therefore Pile Foundations have been recommended for the proposed viaduct
- The design safe load carrying capacity of Deep Foundation has been given in **Table 5.26** above.
- The load capacities of piles are based on empirical correlation's and should be confirmed by conducting **pile load test as per IS: 2911 (Part 4)** on test piles before execution of working piles.
- Since the proposed site is situated in seismic **Zone III** of the seismic zonation map of India, suitable seismic coefficient commensurate to seismic Zone III (IS: 1893) should be adopted in the design of the structures.

5.4 GEOMETRIC DESIGN OF CORRIDOR INCLUDING PLAN/PROFILE

5.4.1. Alignment Design Considerations

Following considerations have been kept in view, while designing the alignment.

- a. The alignment has been proposed to cover the high-density traffic corridor and origination/destination centers.
- b. The elevated alignment has been generally proposed along the median of the road.
- c. Track Centre of 4.1 m has been proposed for elevated section for superstructure.
- d. Underground alignment has been designed with a view to avoid high rise buildings having deep foundations.
- e. To minimize the construction cost, underground stations have been proposed to be constructed by Cut and Cover method.

- f. Traffic diversion will be required where elevated stations are proposed along the road.
- g. Effort has been made to minimize disruption to road traffic during construction phase.
- h. Effort has been made to position the ramps and depots on Government land.

5.4.2. Thane Ring Corridor: New Thane – Waghbil – Thane Junction

A. Horizontal Curvature

The proposed alignment negotiates frequent horizontal curves to follow the existing road median. At some places there are sharp turns and curves along the road and this necessitates provision of sharp curves on metro alignment also.

Total 82 nos. horizontal curves have been provided on the entire length of the alignment. The minimum radius of curves is 200 m in underground section and 120 m in elevated section. About 51.17% alignment is on straight & about 47.83% of alignment is on curves. The abstract and details of curves are indicated in **Table 5.29** and **5.30** respectively.

TABLE 5.29: ABSTRACT OF HORIZONTAL CURVES

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	31	5570.59	42.51
2	>150 <300	25	3699.48	28.23
3	≥300 ≤ 500	17	2815.94	21.49
4	>500 ≤ 800	6	629.70	4.80
5	>800 ≤ 1000	0	0.00	0.00
6	>1000	3	389.83	2.97
	Total	82	13105.544	100.00

B. Gradients

While designing vertical alignment, efforts have been made to avoid frequent gradients. The number of gradients has been kept to minimum, however, due to ground profile, difference in rail level of viaduct over mid section and station location, horizontal alignment and switch over ramps, gradients are inevitable. Efforts have been made to provide the gradients as flat as possible, subject to ground profile.

TABLE 5.30: DETAILS OF HORIZONTAL CURVES

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	95.00	516.02	Right	200	106	10	19.2	50	50	292.49	321.02	421.02	--
2	756.29	901.43	Left	-125	43	21	47.16	50	50	75.31	45.14	145.14	240.27
3	946.27	1087.54	Right	125	41	30	1.8	50	50	73.06	41.27	141.27	44.84
4	1122.63	1248.48	Right	130	33	15	19.8	50	50	64.25	25.86	125.86	35.09
5	1273.81	1399.06	Left	-310	13	32	34.08	50	50	62.85	25.25	125.25	25.33
6	1425.12	1550.86	Right	230	18	30	56.88	50	50	63.28	25.73	125.73	26.07
7	1762.87	1890.61	Left	-250	17	29	7.8	50	50	64.24	27.73	127.73	212.01
8	1998.98	2128.88	Left	-125	36	22	21.36	50	50	66.61	29.90	129.90	108.38
9	2227.82	2358.17	Left	-200	23	0	40.32	50	50	65.82	30.36	130.36	98.94
10	2452.55	2578.45	Left	-360	12	2	40.92	50	50	63.12	25.90	125.90	94.38
11	2603.60	2832.78	Right	125	82	4	30.36	50	50	134.61	129.18	229.18	25.14
12	3329.51	3462.81	Right	350	13	22	52.68	50	50	66.88	33.30	133.30	496.73
13	3753.68	3821.84	Right	1200	2	10	32.88	20	20	34.08	28.16	68.16	290.87
14	3957.27	4016.34	Left	-1500	1	21	45	17	17	29.54	25.07	59.07	135.43
15	4087.26	4220.76	Right	250	19	4	51.24	50	50	67.20	33.50	133.50	70.92
16	4492.95	4629.22	Right	250	19	27	41.04	50	50	68.63	36.27	136.27	272.20
17	4877.62	5025.61	Left	-125	44	33	0.36	50	50	76.98	47.99	147.99	248.40
18	5149.70	5312.25	Left	-125	51	21	8.64	50	50	85.78	62.55	162.55	124.09
19	5638.03	5894.65	Right	125	94	25	21.36	50	50	161.59	156.62	256.62	325.78
20	5955.46	6092.48	Left	-250	19	33	47.16	50	50	69.02	37.01	137.01	60.81
21	6150.30	6296.37	Right	125	44	1	14.88	50	50	75.85	46.07	146.07	57.82
22	6337.74	6559.99	Right	125	78	34	15.96	50	50	128.61	122.25	222.25	41.37
23	6560.03	6708.15	Left	-125	44	34	58.08	50	50	77.06	48.12	148.12	Nil
24	6889.63	6998.78	Right	600	6	21	39.24	40	40	54.62	29.14	109.14	181.49
25	7031.70	7159.18	Left	-350	12	24	36	50	50	63.93	27.48	127.48	32.93

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
26	7750.41	8087.33	Left	-135	121	27	44.64	50	50	268.77	236.92	336.92	591.23
27	8128.67	8255.02	Right	210	20	30	0.36	50	50	63.69	26.36	126.36	41.33
28	8339.59	8430.51	Left	-800	4	12	53.28	30	30	45.48	30.92	90.92	84.57
29	8456.84	8586.98	Right	350	13	4	15.24	50	50	65.28	30.14	130.14	26.32
30	8659.62	8809.00	Left	-230	24	27	7.92	50	50	75.57	49.38	149.38	72.64
31	8835.11	8961.79	Right	190	23	4	20.64	50	50	63.97	26.68	126.68	26.11
32	9103.36	9205.08	Left	-650	5	21	56.88	38	38	50.89	25.71	101.71	141.57
33	9237.74	9363.72	Left	-280	15	19	30.36	50	50	63.27	25.98	125.98	32.66
34	9429.58	9582.73	Right	125	47	9	52.2	50	50	80.05	53.15	153.15	65.86
35	9876.04	10006.30	Left	-150	30	23	36.24	50	50	66.29	30.27	130.27	293.31
36	10551.29	10741.13	Right	125	64	3	16.2	50	50	103.74	89.84	189.84	544.99
37	10938.99	11140.15	Left	-125	69	10	14.88	50	50	111.91	101.16	201.16	197.86
38	11216.02	11400.56	Left	-250	30	30	2.88	50	50	94.05	84.55	184.55	75.87
39	11694.24	11956.84	Right	1200	11	21	0.36	20	20	131.72	222.61	262.61	293.67
40	11985.76	12132.18	Right	125	44	6	50.4	50	50	76.06	46.42	146.42	28.92
41	12175.00	12292.80	Left	-500	8	12	11.16	45	45	58.97	27.80	117.80	42.82
42	12456.32	12588.93	Right	200	23	23	43.8	50	50	67.00	32.61	132.61	163.52
43	12679.43	12804.56	Right	240	17	33	39.6	50	50	62.93	25.13	125.13	90.50
44	12829.56	12970.62	Left	-125	41	26	33	50	50	72.94	41.06	141.06	25.00
45	13125.51	13251.27	Left	-400	11	15	10.8	46	46	63.03	33.76	125.76	154.89
46	13276.47	13540.59	Right	125	98	5	3.84	50	50	170.09	164.12	264.12	25.19
47	13793.02	13918.65	Left	-160	27	2	44.16	50	50	63.67	25.63	125.63	252.43
48	14152.98	14272.07	Right	480	8	25	57.36	46	46	59.63	27.09	119.09	234.34
49	14348.13	14560.95	Right	125	74	22	30.36	50	50	120.88	112.82	212.82	76.06
50	14924.19	15042.19	Left	-410	10	2	4.2	46	46	59.11	26.01	118.01	363.23
51	15092.57	15355.21	Right	125	97	16	51.6	50	50	168.38	162.65	262.65	50.38
52	15595.91	15747.76	Left	-125	46	24	37.08	50	50	79.27	51.85	151.85	240.70

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
53	15773.05	15898.25	Right	260	16	20	31.2	50	50	62.92	25.20	125.20	25.29
54	15934.58	16060.22	Left	-150	28	32	1.32	50	50	63.80	25.64	125.64	36.33
55	16085.28	16210.91	Right	160	27	2	43.44	50	50	63.67	25.63	125.63	25.06
56	16308.26	16434.22	Left	-125	34	29	25.44	50	50	64.42	25.96	125.96	97.35
57	16487.67	16616.50	Right	125	36	4	49.08	50	50	66.02	28.83	128.83	53.45
58	16805.57	16937.12	Left	-125	37	13	28.56	50	50	67.53	31.55	131.55	189.07
59	16970.15	17096.39	Left	-250	17	16	55.92	50	50	63.47	26.24	126.24	33.02
60	17121.53	17246.09	Right	175	24	14	37.32	50	50	62.96	24.56	124.56	25.14
61	17294.39	17510.64	Right	125	76	7	21	50	50	123.65	116.26	216.26	48.30
62	17651.32	18005.01	Left	-125	139	7	13.08	50	50	363.33	253.69	353.69	140.67
63	18247.90	18375.99	Right	150	29	29	42.36	50	50	65.12	28.10	128.10	242.89
64	18738.94	18902.36	Left	-125	51	35	28.32	50	50	86.32	63.42	163.42	362.94
65	19358.82	19475.94	Right	400	10	6	39.96	46	46	58.67	25.12	117.12	456.47
66	20029.08	20814.65	Right	450	94	5	43.08	46	46	507.17	693.57	785.57	553.14
67	21341.66	21471.30	Right	300	15	7	23.88	50	50	65.09	29.64	129.64	527.01
68	21583.43	21711.34	Left	-300	14	31	28.2	50	50	64.21	27.91	127.91	112.14
69	22547.83	22674.16	Left	-250	17	17	39.84	50	50	63.53	26.34	126.34	836.49
70	23097.96	23249.91	Right	125	46	26	6.36	50	50	79.33	51.95	151.95	423.80
71	23275.15	23382.64	Left	-600	6	15	50.76	40	40	53.79	27.49	107.49	25.24
72	23655.05	23783.27	Left	-180	24	32	9.24	50	50	64.85	28.23	128.23	272.41
73	23945.89	24074.87	Right	250	18	3	20.16	50	50	64.88	28.97	128.97	162.62
74	24161.17	24288.65	Left	-250	17	27	7.56	50	50	64.11	27.47	127.47	86.31
75	24633.31	24748.48	Right	550	7	11	1.32	45	45	57.64	25.17	115.17	344.66
76	24775.00	24901.13	Left	-210	20	27	42.12	50	50	63.57	26.13	126.13	26.52
77	24977.15	25082.41	Right	605	6	6	17.64	40	40	52.67	25.26	105.26	76.02
78	25240.08	25492.86	Right	200	58	3	14.04	50	50	136.35	152.79	252.79	157.67
79	25612.44	25744.68	Right	350	13	16	28.56	50	50	66.34	32.24	132.24	119.58

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
80	25936.72	26079.19	Left	-300	17	23	38.76	50	50	71.66	42.48	142.48	192.04
81	26510.68	26636.34	Left	-360	12	1	23.16	50	50	63.00	25.66	125.66	431.48
82	27139.05	27271.67	Left	-350	13	18	46.44	50	50	66.53	32.62	132.62	502.71

A total 86 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided for 29.44% of the alignment. Steepest gradient is 3.7% provided for ramp at Thane Junction Railway Station. The abstract and details of gradients are given in **Table 5.31 and 5.32** respectively.

TABLE 5.31: ABSTRACT OF GRADIENTS

S. No.	Description	No's of Occurrences	Length (m)	Percentage
1	Level (0%)	26	8056	29.40
2	>0% to 1%	15	5073	18.51
3	>1% to 2%	9	2255	8.23
4	>2% to 3%	23	7172	26.18
5	>3%	13	4844	17.68
	TOTAL	80	27400	100.00

TABLE 5.32: DETAILS OF GRADIENTS

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	0	156	156	-7.200	-7.200	0.00	Level
2	156	1602	1446	-7.200	33.600	2.82	Rise
3	1602	2000	398	33.600	33.600	0.00	Level
4	2000	2200	200	33.600	38.700	2.55	Rise
5	2200	2428	228	38.700	38.700	0.00	Level
6	2428	2900	472	38.700	52.900	3.01	Rise
7	2900	3087	187	52.900	52.900	0.00	Level
8	3087	3178	91	52.900	50.600	2.53	Fall
9	3178	3335	157	50.600	55.300	2.99	Rise
10	3335	3515	180	55.300	55.600	0.17	Rise
11	3515	3712	197	55.600	50.300	2.69	Fall
12	3712	4184	472	50.300	59.000	1.84	Rise
13	4184	4415	231	59.000	59.000	0.00	Level
14	4415	4798	383	59.000	47.500	3.00	Fall
15	4798	5457	659	47.500	67.300	3.00	Rise
16	5457	5644	187	67.300	67.300	0.00	Level
17	5644	5835	191	67.300	73.000	2.98	Rise
18	5835	6155	320	73.000	63.400	3.00	Fall
19	6155	6500	345	63.400	64.000	0.17	Rise
20	6500	6671	171	64.000	59.500	2.63	Fall
21	6671	6904	233	59.500	59.500	0.00	Level
22	6904	7494	590	59.500	41.800	3.00	Fall
23	7494	7581	87	41.800	43.700	2.18	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
24	7581	7765	184	43.700	43.700	0.00	Level
25	7765	8045	280	43.700	35.300	3.00	Fall
26	8045	8317	272	35.300	35.300	0.00	Level
27	8317	8773	456	35.300	49.000	3.00	Rise
28	8773	9192	419	49.000	49.000	0.00	Level
29	9192	9338	146	49.000	47.700	0.89	Fall
30	9338	10113	775	47.700	47.700	0.00	Level
31	10113	10274	161	47.700	44.200	2.17	Fall
32	10274	10497	223	44.200	43.700	0.22	Fall
33	10497	11077	580	43.700	26.300	3.00	Fall
34	11077	11571	494	26.300	38.500	2.47	Rise
35	11571	11776	205	38.500	38.500	0.00	Level
36	11776	12097	321	38.500	28.700	3.05	Fall
37	12097	12650	553	28.700	28.700	0.00	Level
38	12650	12938	288	28.700	20.000	3.02	Fall
39	12938	13485	547	20.000	16.100	0.71	Fall
40	13485	13605	120	16.100	19.700	3.00	Rise
41	13605	13805	200	19.700	19.700	0.00	Level
42	13805	13975	170	19.700	14.600	3.00	Fall
43	13975	14465	490	14.600	11.000	0.73	Fall
44	14465	14630	165	11.000	16.000	3.03	Rise
45	14630	14817	187	16.000	16.000	0.00	Level
46	14817	14930	113	16.000	12.600	3.01	Fall
47	14930	15510	580	12.600	15.600	0.52	Rise
48	15510	15953	443	15.600	13.100	0.56	Fall
49	15953	16267	314	13.100	16.700	1.15	Rise
50	16267	16677	410	16.700	29.000	3.00	Rise
51	16677	16909	232	29.000	29.000	0.00	Level
52	16909	17475	566	29.000	46.000	3.00	Rise
53	17475	17910	435	46.000	46.000	0.00	Level
54	17910	18560	650	46.000	26.500	3.00	Fall
55	18560	18750	190	26.500	26.500	0.00	Level
56	18750	19050	300	26.500	17.500	3.00	Fall
57	19050	19165	115	17.500	18.000	0.43	Rise
58	19165	19272	107	18.000	14.800	2.99	Fall
59	19272	19650	378	14.800	13.500	0.34	Fall
60	19650	19855	205	13.500	17.600	2.00	Rise
61	19855	20198	343	17.600	17.600	0.00	Level
62	20198	20571	373	17.600	28.800	3.00	Rise
63	20571	20778	207	28.800	28.800	0.00	Level
64	20778	21055	277	28.800	20.500	3.00	Fall

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
65	21055	21250	195	20.500	20.500	0.00	Level
66	21250	21540	290	20.500	11.800	3.00	Fall
67	21540	21845	305	11.800	13.100	0.43	Rise
68	21845	22042	197	13.100	19.000	2.99	Rise
69	22042	22220	178	19.000	19.000	0.00	Level
70	22220	22465	245	19.000	14.900	1.67	Fall
71	22465	22760	295	14.900	20.800	2.00	Rise
72	22760	22860	100	20.800	17.800	3.00	Fall
73	22860	23110	250	17.800	17.800	0.00	Level
74	23110	23220	110	17.800	15.700	1.91	Fall
75	23220	23450	230	15.700	13.700	0.87	Fall
76	23450	23672	222	13.700	19.100	2.43	Rise
77	23672	24126	454	19.100	19.100	0.00	Level
78	24126	24346	220	19.100	16.900	1.00	Fall
79	24346	24546	200	16.900	12.900	2.00	Fall
80	24546	24651	105	12.900	14.000	1.05	Rise
81	24651	24960	309	14.000	10.400	1.17	Fall
82	24960	25414	454	10.400	-6.400	3.70	Fall
83	25414	26140	726	-6.400	-6.400	0.00	Level
84	26140	26500	360	-6.400	-4.600	0.50	Rise
85	26500	27020	520	-4.600	-7.200	0.50	Fall
86	27020	27487.565	467.565	-7.200	-7.200	0.00	Level

* Note : All the change points are provided with Vertical curves

C. Special Span & Portals

The elevated corridor can be served through regular spans of 25 - 31m except diversion of the elevated alignment from centre of road to off the road and vice-versa, where portal arrangement will be required. Special span arrangement has also been suggested for Mumbai Metro Line-4/5 and NH/SH crossings. Details of locations having special spans and portal arrangement are given in **Table 5.33** and **Table 5.34** respectively.

TABLE 5.33: LOCATION OF SPECIAL SPANS

S. No	Location	Chainage		Configuration Special span
		From	To	
1	Modella Chowk, Mumbai Metro Line-4 Crossing	1200	1308	34m + 48m + 34m = 108m
2	Dongripada, Mumbai Metro Line-4 Crossing	10983	11091	34m + 48m + 34m = 108m

S. No	Location	Chainage		Configuration Special span
		From	To	
3	Balkum Naka, Mumbai Metro Line-5 Crossing	20555	20721	34m + 2x48m + 34m = 164m
4	Shivaji Chowk, New Kalwa Bridge Crossing	24232	24340	34m + 48m + 34m = 108m

TABLE 5.34: LOCATION OF PORTALS

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
1	Raila Devi	1320	1355	35	Before Raila Devi Station, the alignment is diverted from west side to east side of the road.
2	RailaDevi	1425	1475	50	Before Raila Devi Station, the alignment is diverted from off road to median.
3	Wagle Circle	2610	2670	60	Before Wagle Circle Station, the alignment is diverted off the road from median.
4	Wagle Circle	2770	2830	60	Before Wagle Circle Station, the alignment is diverted from off road to median.
5	Shivai Nagar	5310	5445	135	Before Shivai Nagar Station, the alignment is diverted from off road to median.
6	Shivai Nagar	5685	5715	30	After Shivai Nagar Station, the alignment is diverted off the road from median.
7	Shivai Nagar	5800	5845	45	After Shivai Nagar Station, the alignment is diverted from off road to median.
8	Neelkanth Terminal	6240	6320	80	Before Neelkanth Terminal Station, the alignment is diverted from off road to median.
9	Neelkanth Terminal	6580	6705	125	Before Neelkanth Terminal Station, the alignment is diverted from off road to median.
10	Gandhi Nagar	7760	7810	50	After Gandhi Nagar Station, the alignment is diverted off the road from median.
11	Gandhi Nagar	7900	8065	165	After Gandhi Nagar Station, the alignment is diverted from off road to median.
12	Manpada	9460	9540	80	Before Manpada Station, the alignment is diverted off the road from median.

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
13	Vijay Nagari	12260	12295	35	Before Vijay Nagari Station, the alignment is diverted off the road from median.
14	Vijay Nagari	12880	12960	80	After Vijay Nagari Station, the alignment is diverted from off road to median.
15	Waghbil	13360	13460	100	Before Waghbil Station, the alignment is diverted off the road from median.
16	Patlipada	15930	16010	80	Before New Patlipada Station, the alignment is diverted off the road from median.
17	Rabodi	23180	23240	60	After Rabodi Station, the alignment is diverted from off road to median.

D. Break-up of Alignment Length

Break-up of alignment length for Thane Ring Corridor is given in **Table 5.35**.

TABLE 5.35: BREAK-UP OF ALIGNMENT LENGTH

S. No.	Description	Chainage (m)		Length (m)	Method of Construction/ Structure Type
		From	To		
1	Underground	0.0	317.0	317.0	TBM/ Cut & cover/NATM
2	Switch over Ramp (-)8.0m to (+)7.5m	317.0	1181.0	864.0	Underground to Elevated Ramp
3	Elevated	1181.0	24917.0	23736.0	Box/I/U- Shape Girder
4	Switch over Ramp (+)7.5m to (-)8.0m	24917.0	25342.0	425.0	Elevated to Underground Ramp
5	Underground	25342.0	27400.2	2058.2	TBM/ Cut & cover/NATM
6	Depot Entry	0.0	1177.7	1177.7	Box/I/U- Shape Girder
			Total	28577.8	

5.5 IDENTIFICATION OF EXISTING SERVICES/ UTILITIES

5.5.1 Introduction

- Large number of sub-surface, surface and overhead utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, Overhead power transmission lines, power cables, traffic signals, etc. exists all along the proposed ring alignment.
- These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. Therefore, meticulous detailed survey and planning will be required to protect/divert the utility services.
- Accordingly, overhead utilities were identified during physical survey of corridor. Moreover, liaison with concerned utility owners was made for identification and mapping of various underground utilities. No trenching / GPR survey etc. was conducted for underground utilities.

5.5.2 Agencies for Utility Services

For identification of likely utilities in the proposed metro Corridor, liaison was made with following Organizations/Departments (**Table 5.36**):-

TABLE 5.36: UTILITY RESPONSIBILITY DEPARTMENTS

S. No.	Organization/ Department	Utility Services
1	Thane Municipal Corporation (TMC)	Sewer lines and Water lines
2	PWD/Bridges, Thane	City Road Bridges
3	Western Indian Railways	Telecommunication and signal cables
4	Mahanagar Gas Limited, Thane	Gas Pipelines
5	BPCL	Gas Pipelines
6	MSEDCL	HT cables, junction boxes etc.
7	BSNL	Optical Fibre Cable
8	MTNL	Optical Fibre and Copper Cables
9	RELIANCE Communication	Optical Fibre Cable
10	Vodafone	Optical Fibre Cable
11	Airtel	Optical Fibre Cable
12	Tata Telecommunication	Optical Fibre Cable

5.5.3 Guidelines for Diversion of Underground Utilities

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

- Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.
- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout of piles in the foundation may be suitably adjusted to ensure that no foundation needs be constructed at the location. The utility service can also be encased within the foundation piles.

5.5.4 Sewer Lines and Water Pipe Lines

The storm water drains and water pipe lines generally exists either side of under main carriageway or at some places on the central verge, as a result of subsequent road widening. However, majority of sewer lines are running in the centre of the road.

The major sewer, storm water drains and water pipe lines 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 the column supports of viaduct by change in span or by suitably adjusting the layout of pile foundations. Where, this is not feasible, lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility service lines. Details of sewer lines & storm water drains and water pipe lines affected are indicated in **Table 5.37 and 5.38**.

5.5.5 Gas Pipe Lines

Few gas pipe lines with varying diameters belonging to Mahanagar Gas Limited and BPCL, are running along and across the roads. Though, the alignment is planned almost along the road, en-route few pipelines running across and along the alignment likely to be affected by the alignment are detailed in **Table 5.39 and Table 5.40**.

5.5.6 Telecom Cables, OFC, Ducts, HT Lines and Trench

At several places, telecom cables and OFC of Vodafone, Reliance, Airtel, Tata, MTNL and BSNL, HT lines of MSEDCL and Telecommunication/signal cables of Indian Railways are also running along and across the proposed corridor and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are shown in **Table 5.41 to 5.49**.

TABLE 5.37: WATER PIPE LINES OF TMC

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1300	1500	200	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
2	I	1250	1300	50	LHS	100	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
3	I	1300	2150	850	LHS	400	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
4	I	1600	2000	400	RHS	500	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
5	I	2100	2180	80	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
6	I	3420	3420	100	ALIGNMENT CROSSING	400	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
7	I	3420	3600	180	LHS	500	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
8	I	3600	3850	250	LHS	600	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
9	I	3850	3850	30	ROAD CROSSING	600	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
10	I	3850	4150	300	RHS	500	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
11	I	4150	4150	30	ROAD CROSSING	500	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
12	I	3420	3850	430	LHS	400	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
13	I	3850	3850	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
14	I	3420	3850	430	RHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
15	I	3850	3850	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
16	I	4500	4500	100	ALIGNMENT CROSSING	200	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
17	I	4540	4540	100	ALIGNMENT CROSSING	350	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
18	I	4540	4540	100	ALIGNMENT CROSSING	200	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
19	I	4620	4620	100	ALIGNMENT CROSSING	350	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
20	I	4890	4890	100	ALIGNMENT	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
					CROSSING						
21	I	4880	4880	100	ALIGNMENT CROSSING	200	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
22	I	5050	5050	100	ALIGNMENT CROSSING	150, 3 NO,S	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
23	I	5250	5750	500	LHS	250	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
24	I	5750	5750	30	ROAD CROSSING LHS	300	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
25	I	5250	5680	430	RHS	200	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
26	I	5250	5680	430	RHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
27	I	5650	6650	1000	RHS	250	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
28	I	6300	6520	220	LHS	250	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
29	I	6520	6650	130	LHS	200	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
30	I	6650	6650	30	ROAD CROSSING	250	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
31	I	6650	6720	70	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
32	I	6650	6720	70	RHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
33	I	6650	6730	80	LHS	300	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
34	I	6720	6720	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
35	I	6730	7930	1200	LHS	300	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
36	I	6720	6890	170	RHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
37	I	6890	6890	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
38	I	6890	6930	40	LHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
39	I	6930	7550	620	LHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
40	I	7550	7550	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
41	I	7550	7930	380	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
42	I	6850	7930	1080	LHS	500	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
43	I	7930	8030	100	LHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
44	I	7930	8350	420	LHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
45	I	7930	8450	520	LHS	250	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
46	I	8450	8950	500	LHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
47	I	7930	8390	460	RHS	450	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
48	I	8390	8950	560	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
49	I	9000	9000	15	ROAD CROSSING(RHS)	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
50	I	9000	9100	100	RHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
51	I	9000	9420	420	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
52	I	9420	9420	30	ROAD CROSSING	500	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
53	I	9420	9420	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
54	I	8990	9400	410	LHS	400	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
55	I	9420	9700	280	RHS	200	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
56	I	9740	9740	100	DIAGONALLY ALIGNMENT CROSSING	100	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
57	I	9950	9950	100	ALIGNMENT CROSSING	150 & 200	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
58	I	9980	10250	270	RHS	100	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
59	I	10490	10490	100	ALIGNMENT CROSSING	350	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
60	I	11100	12100	1000	LHS	1016	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
61	I	11100	12100	1000	RHS	600	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
62	I	11100	11300	200	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
63	I	11300	11450	150	RHS	350	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
64	I	11640	11820	180	RHS	350	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
65	I	11820	13020	1200	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
66	I	13020	13550	530	RHS	200	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
67	I	12100	12830	730	RHS	400	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
68	I	12830	13550	720	RHS	300	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
69	I	12100	12250	150	LHS	400	BGL-1.0M	MILD STEEL	PARALLEL	ELEVATED	NO
70	I	12240	13020	780	LHS	200	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
71	I	12240	13020	780	LHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
72	I	16980	16980	30	ROAD CROSSING	100	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
73	I	17000	17300	300	RHS	100	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
74	I	17120	17120	30	ROAD CROSSING	100	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
75	I	17120	17500	380	LHS	600	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
76	I	17300	17300	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
77	I	17940	17940	100	ALIGNMENT CROSSING	500 & 1016	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
78	I	17950	17950	100	ALIGNMENT CROSSING	300	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
79	I	18120	18300	180	LHS	450	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
80	I	18640	18640	100	ALIGNMENT CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
81	I	19150	19150	100	ALIGNMENT CROSSING	200	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
82	I	19170	19170	100	ALIGNMENT CROSSING	1016	BGL-1.0M	MILD STEEL	PERPENDICULAR	ELEVATED	YES
83	I	19150	19150	50	ALIGNMENT CROSSING(RHS)	450	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
84	I	21150	21150	100	ALIGNMENT CROSSING	100 2 NO'S	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
85	I	23150	23380	230	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
86	I	23380	23380	30	ROAD CROSSING	300	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
87	I	23380	23580	200	LHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
88	I	23380	23690	310	RHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
89	I	23690	23690	30	ROAD CROSSING	300	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
90	I	23690	23850	160	LHS	300	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
91	I	24850	24850	30	ROAD CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	ELEVATED	YES
92	I	24280	24620	340	RHS	150	BGL-1.0M	DUCTILE IRON	PARALLEL	ELEVATED	NO
93	I	25480	25480	100	ALIGNMENT CROSSING	300	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
94	I	25550	25550	50	ALIGNMENT CROSSING(RHS)	300	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
95	I	25550	25830	280	LHS	100	BGL-1.0M	DUCTILE IRON	PARALLEL	U/G	YES
96	I	25830	25830	100	ALIGNMENT CROSSING	150 3 NO'S	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
97	I	25720	25720	100	ALIGNMENT CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
98	I	26000	26000	50	ALIGNMENT CROSSING(RHS)	100	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
99	I	26000	26200	200	RHS	100 2 NO'S	BGL-1.0M	DUCTILE IRON	PARALLEL	U/G	YES
100	I	26100	26100	100	ALIGNMENT CROSSING	100	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
101	I	26430	26430	100	ALIGNMENT CROSSING	100 2 NO'S	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
102	I	26530	26530	100	ALIGNMENT CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO
103	I	26700	27020	20	ON ALIGNMENT	100 & 150	BGL-1.0M	DUCTILE IRON	PARALLEL	U/G	YES
104	I	27190	27190	320	ALIGNMENT CROSSING	2000	BGL-1.0M	MILD STEEL	PERPENDICULAR	U/G	NO
105	I	27220	27220	100	ALIGNMENT CROSSING	150	BGL-1.0M	DUCTILE IRON	PERPENDICULAR	U/G	NO

TABLE 5.38: SEWER PIPE LINES OF TMC

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1300	2180	880	LHS	1200	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
2	I	2700	3420	660	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
3	I	3420	3420	30	ROAD CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
4	I	3420	4410	990	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
5	I	4410	4410	30	ROAD CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
6	I	4900	4900	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
7	I	5050	5050	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
8	I	5250	6100	850	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
9	I	6500	6910	410	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
10	I	6910	6910	30	ROAD CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
11	I	7900	8350	450	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
12	I	8350	8350	30	ROAD CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
13	I	8350	9700	1350	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
14	I	9950	9950	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	ELEVATED	YES
15	I	11100	12100	1000	LHS	600	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
16	I	16900	17600	650	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
17	I	23950	24050	150	RHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	YES
18	I	24050	24850	650	RHS	1200	BGL-3.50M	R.C.C. (NP3)	PARALLEL	ELEVATED	NO
19	I	25720	25720	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	U/G	NO
20	I	25720	25900	180	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	U/G	YES
21	I	25900	25900	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	U/G	NO
22	I	26000	26000	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	U/G	NO
23	I	26100	26100	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	U/G	NO
24	I	26000	26100	100	LHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	U/G	YES
25	I	26500	26660	160	ALIGNMENT RHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	U/G	YES
26	I	26660	26660	50	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	U/G	NO
27	I	26770	26770	100	ALIGNMENT CROSSING	450	BGL-3.50M	R.C.C. (NP3)	PERPENDICULAR	U/G	NO
28	I	26770	26950	180	ALIGNMENT RHS	450	BGL-3.50M	R.C.C. (NP3)	PARALLEL	U/G	YES

TABLE 5.39: GAS PIPE LINE OF MAHANAGAR GAS LIMITED (MGL)

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	1250	1250	30	ALIGNMENT CROSSING	300, 125	BGL-1.0M	SP,PP	PERPENDICULAR	ELEVATED	YES
2	I	1270	1970	740	LHS	200, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
3	I	1970	1970	30	ROAD CROSSING (RHS)	200, 125	BGL-1.50M	SP,PP	PERPENDICULAR	ELEVATED	YES
4	I	1970	2760	750	RHS	200, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
5	I	2760	2760	30	ROAD CROSSING (LHS)	200, 125	BGL-1.50M	SP,PP	PERPENDICULAR	ELEVATED	YES
6	I	2760	2975	220	LHS	200, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
7	I	4140	4140	30	ROAD CROSSING (LHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
8	I	4140	4410	270	LHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
9	I	4410	4410	30	ROAD CROSSING (RHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
10	I	5300	5300	30	ROAD CROSSING (LHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
11	I	5300	5360	60	LHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
12	I	5360	5950	590	LHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
13	I	6550	6720	190	LHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
14	I	6720	6720	30	ROAD CROSSING (RHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
15	I	6720	6840	120	LHS & RHS	90, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
16	I	6840	6840	30	ROAD CROSSING	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
17	I	6840	7100	270	LHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
18	I	6840	6930	90	RHS	125	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
19	I	7100	7100	30	ROAD CROSSING	90	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
20	I	7100	7240	110	LHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
21	I	7240	7850	310	LHS	125	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
22	I	8100	8190	90	RHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
23	I	8190	8190	30	ROAD CROSSING (LHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
24	I	8190	8340	150	LHS & RHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
25	I	8350	8380	30	RHS	125	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
26	I	8380	8380	30	ROAD CROSSING	125	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
27	I	8380	8640	240	RHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
28	I	8640	8970	260	RHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
29	I	8970	8970	30	ROAD CROSSING	125	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
30	I	8970	9030	60	RHS	125	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
31	I	9030	9430	450	ROAD CENTRE	63	BGL-1.0M	PP	PARALLEL	ELEVATED	YES
32	I	9430	9430	15	RAD CROSSING (LHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
33	I	9435	9435	15	ROAD CROSSING (RHS)	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
34	I	9430	9540	110	ROAD CENTRE	63	BGL-1.0M	PP	PARALLEL	ELEVATED	YES
35	I	9540	9620	80	ROAD CENTRE	125	BGL-1.0M	PP	PARALLEL	ELEVATED	YES
36	I	9950	9950	30	ALIGNMENT CROSSING	125	BGL-1.0M	PP	PERPENDICULAR	ELEVATED	YES
37	I	11050	11290	150	LHS	200, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
38	I	11290	11290	30	ROAD CROSSING (RHS)	125	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
39	I	11290	12080	830	LHS	200, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
40	I	12080	12080	30	ROAD CROSSING (RHS)	150, 125	BGL-1.50M	SP,PP	PERPENDICULAR	ELEVATED	YES
41	I	12080	12340	210	RHS	150, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
42	I	12080	12340	210	LHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
43	I	12340	12340	30	ROAD CROSSING	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
44	I	12340	12390	50	LHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
45	I	12340	12390	50	RHS	150, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
46	I	12390	12390	30	ROAD CROSSING	90	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
47	I	12390	12720	360	LHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
48	I	12720	12720	30	ROAD CROSSING	90	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
49	I	15470	15680	230	RHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
50	I	15680	15680	30	ROAD CROSSING	90	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES
51	I	15680	16100	420	RHS	90	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
52	I	16160	16160	50	ALIGNMENT CROSSING	63	BGL-1.0M	PP	PERPENDICULAR	ELEVATED	YES
53	I	16160	16200	60	RHS	63	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
54	I	16930	17600	650	LHS	125	BGL-1.0M	PP	PARALLEL	ELEVATED	NO
55	I	22670	22670	100	ALIGNMENT CROSSING	125	BGL-1.0M	PP	PERPENDICULAR	ELEVATED	YES
56	I	23200	24050	660	LHS	300, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO
57	I	24050	24050	30	ROAD CROSSING	63	BGL-1.50M	PP	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (MM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
58	I	24050	24330	280	LHS	300, 125	BGL-1.0M	SP,PP	PARALLEL	ELEVATED	NO

TABLE 5.40: GAS PIPE LINE OF BPCL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (INCH)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	22680	22680	50	ALIGNMENT CROSSING	18	BGL-2.0M	SP	PERPENDICULAR	ELEVATED	YES
2	I	27220	27220	50	ALIGNMENT CROSSING	18	BGL-2.8M	SP	PERPENDICULAR	U/G	YES

TABLE 5.41: RAILWAY SIGNAL CABLES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	0	200	200	ALIGNMENT LHS	12 CORE X 1.50 SQMM, 40 NO'S	BGL-1.2M	CORE	PARALLEL	U/G	YES
2	I	0	200	200	ALIGNMENT LHS	4 QUAD X 0.90 SQMM, 25 NO'S	BGL-1.2M	QUAD	PARALLEL	U/G	YES
3	I	25400	27230	1830	ALIGNMENT LHS	12 CORE X 1.50 SQMM, 40 NO'S	BGL-1.2M	CORE	PARALLEL	U/G	YES
4	I	25400	27230	1830	ALIGNMENT LHS	4 QUAD X 0.90 SQMM, 25 NO'S	BGL-1.2M	QUAD	PARALLEL	U/G	YES
5	I	27230	27270	40	ALIGNMENT LHS	12 CORE X 1.50 SQMM, 40 NO'S	BGL-1.2M	CORE	PARALLEL	U/G	YES
6	I	27230	27270	40	ALIGNMENT LHS	4 QUAD X 0.90 SQMM, 25 NO'S	BGL-1.2M	QUAD	PARALLEL	U/G	YES

TABLE 5.42: RAILWAY TELECOMCABLES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	0	200	200	ALIGNMENT LHS	20 & 50 PAIR CABLE, 2 NO'S	BGL-0.8M	JELLY FILLED	PARALLEL	U/G	YES
2	I	25400	27270	1830	ALIGNMENT LHS	20 PAIR CABLE, 2 NO'S	BGL-0.8M	JELLY FILLED	PARALLEL	U/G	YES

TABLE 5.43: OPTICAL FIBRE CABLE OF MSEDCL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (SQMM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1350	2800	1450	LHS	300	BGL-1.0M	1-22 KV	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (SQMM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
2	I	1350	2200	850	LHS	300	BGL-1.0M	4-11 KV, 5-22 KV	PARALLEL	ELEVATED	NO
3	I	2200	2600	400	LHS	300	BGL-1.0M	6-11 KV, 5-22 KV	PARALLEL	ELEVATED	NO
4	I	2600	2800	200	LHS	300	BGL-1.0M	6-11 KV, 7-22 KV	PARALLEL	ELEVATED	NO
5	I	1350	1950	600	RHS	300	BGL-1.0M	4-22 KV	PARALLEL	ELEVATED	NO
6	I	1990	2750	760	RHS	300	BGL-1.0M	2-11 KV, 3-22 KV	PARALLEL	ELEVATED	NO
7	I	1950	2750	800	RHS	300	BGL-1.0M	6-11 KV, 4-22 KV	PARALLEL	ELEVATED	NO
8	I	2750	2950	200	LHS	300	BGL-1.0M	6-11 KV, 4-22 KV	PARALLEL	ELEVATED	NO
9	I	2950	2950	30	ROAD CROSSING	300	BGL-1.0M	6-11 KV, 4-22 KV	PERPENDICULAR	ELEVATED	YES
10	I	3430	3870	440	LHS	300	BGL-1.0M	2-415 KV	PARALLEL	ELEVATED	NO
11	I	3870	3870	30	ROAD CROSSING	300	BGL-1.0M	2-415 KV	PERPENDICULAR	ELEVATED	YES
12	I	3870	4080	210	LHS	300	BGL-1.0M	2-415 KV	PARALLEL	ELEVATED	NO
13	I	3980	4080	100	RHS	300	BGL-1.0M	2-415 KV	PARALLEL	ELEVATED	NO
14	I	4080	4080	30	ROAD CROSSING	300	BGL-1.0M	2-415 KV	PERPENDICULAR	ELEVATED	YES
15	I	4080	4160	80	LHS	300	BGL-1.0M	2-415 KV	PARALLEL	ELEVATED	NO
16	I	4160	4160	30	ROAD CROSSING	300	BGL-1.0M	1-11 KV	PERPENDICULAR	ELEVATED	YES
17	I	4160	4410	250	RHS	300	BGL-1.0M	1-11 KV	PARALLEL	ELEVATED	NO
18	I	4410	4410	30	ROAD CROSSING	300	BGL-1.0M	1-11 KV	PERPENDICULAR	ELEVATED	YES
19	I	4500	4500	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-415 KV	PERPENDICULAR	ELEVATED	YES
20	I	4550	4550	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-415 KV	PERPENDICULAR	ELEVATED	YES
21	I	4870	4870	100	ALIGNMENT CROSSING BOTH SIDE	300	BGL-1.0M	2-22 KV	PERPENDICULAR	ELEVATED	YES
22	I	5050	5050	100	ALIGNMENT CROSSING BOTH SIDE	300	BGL-1.0M	2-415 KV	PERPENDICULAR	ELEVATED	YES
23	I	5200	5850	650	LHS	300	BGL-1.0M	3-22 KV	PARALLEL	ELEVATED	NO
24	I	6500	6860	360	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (SQMM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
25	I	6860	6860	30	ROAD CROSSING	300	BGL-1.0M	1-11 KV, 2-22 KV	PERPENDICULAR	ELEVATED	YES
26	I	6860	7930	1070	LHS	300	BGL-1.0M	1-11 KV, 4-22 KV	PARALLEL	ELEVATED	NO
27	I	6900	7930	1030	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
28	I	7930	8320	390	RHS	300	BGL-1.0M	1-11 KV, 8-22 KV	PARALLEL	ELEVATED	NO
29	I	7930	8320	390	LHS	300	BGL-1.0M	8-22 KV	PARALLEL	ELEVATED	NO
30	I	8320	8320	30	ROAD CROSSING	300	BGL-1.0M	8-22 KV	PERPENDICULAR	ELEVATED	YES
31	I	8320	9700	1380	RHS	300	BGL-1.0M	12-22 KV	PARALLEL	ELEVATED	NO
32	I	8320	9700	1380	RHS	300	BGL-1.0M	6-22 KV	PARALLEL	ELEVATED	NO
33	I	9950	9950	100	ALIGNMENT CROSSING	300	BGL-1.0M	12-22 KV	PERPENDICULAR	ELEVATED	YES
34	I	10490	10490	100	ALIGNMENT CROSSING	300	BGL-1.0M	12-22 KV	PARALLEL	ELEVATED	NO
35	I	11000	11500	500	LHS	300	BGL-1.0M	18-22 KV	PARALLEL	ELEVATED	NO
36	I	11100	11300	200	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
37	I	11320	12100	780	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
38	I	11490	11490	100	ALIGNMENT CROSSING	300	BGL-1.0M	16-22 KV	PERPENDICULAR	ELEVATED	YES
39	I	11500	12100	600	LHS	300	BGL-1.0M	20-22 KV	PARALLEL	ELEVATED	NO
40	I	12100	13500	1400	RHS	300	BGL-1.0M	1-22 KV LT LINE	PARALLEL	ELEVATED	NO
41	I	12900	12900	30	ROAD CROSSING	300	BGL-1.0M	1-22 KV LT LINE	PERPENDICULAR	ELEVATED	YES
42	I	12900	13500	600	LHS	300	BGL-1.0M	1-22 KV LT LINE	PARALLEL	ELEVATED	NO
43	I	15470	16100	630	RHS	300	BGL-1.0M	1-22 KV LT LINE	PARALLEL	ELEVATED	NO
44	I	16120	16400	280	LHS	300	BGL-1.0M	1-22 KV LT LINE	PARALLEL	ELEVATED	NO
45	I	16400	16400	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
46	I	16920	16920	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
47	I	16920	17600	680	LHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
48	I	16920	17650	730	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (SQMM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
49	I	17950	17950	100	ALIGNMENT CROSSING BOTH SIDE	300	BGL-1.0M	1-415 KV	PERPENDICULAR	ELEVATED	YES
50	I	18100	18280	180	LHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
51	I	18480	18480	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PERPENDICULAR	ELEVATED	YES
52	I	18700	18700	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PERPENDICULAR	ELEVATED	YES
53	I	19150	19150	100	ALIGNMENT CROSSING BOTH SIDE	300	BGL-1.0M	1-11 KV, 2-22 KV	PERPENDICULAR	ELEVATED	YES
54	I	21150	21150	100	ALIGNMENT CROSSING BOTH SIDE	300	BGL-1.0M	1-22 KV	PERPENDICULAR	ELEVATED	YES
55	I	22150	22150	100	ALIGNMENT CROSSING BOTH SIDE	300	BGL-1.0M	2-22 KV	PERPENDICULAR	ELEVATED	YES
56	I	22770	22770	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PERPENDICULAR	ELEVATED	YES
57	I	22900	23200	300	LHS	300	BGL-1.0M	4-22 KV	PARALLEL	ELEVATED	NO
58	I	23200	23550	350	RHS	300	BGL-1.0M	4-22 KV	PARALLEL	ELEVATED	NO
59	I	23200	23850	650	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
60	I	24000	24450	450	RHS	300	BGL-1.0M	2-22 KV	PARALLEL	ELEVATED	NO
61	I	25470	25470	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-11 KV	PERPENDICULAR	U/G	NO
62	I	25620	25620	100	ALIGNMENT CROSSING	300	BGL-1.0M	1-22 KV	PERPENDICULAR	U/G	NO
63	I	25720	25720	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PERPENDICULAR	U/G	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (SQMM)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
64	I	25840	25840	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PERPENDICULAR	U/G	NO
65	I	25900	25900	100	ALIGNMENT CROSSING	300	BGL-1.0M	2-22 KV	PERPENDICULAR	U/G	NO
66	I	25840	25900	60	LHS	300	BGL-1.0M	2-22 KV	PARALLEL	U/G	YES
67	I	26000	26000	100	ALIGNMENT CROSSING	300	BGL-1.0M	1-440 V	PERPENDICULAR	U/G	NO
68	I	26100	26100	100	ALIGNMENT CROSSING	300	BGL-1.0M	1-440 V	PERPENDICULAR	U/G	NO
69	I	26000	26100	100	LHS	300	BGL-1.0M	1-440 V	PARALLEL	U/G	YES
70	I	26550	26650	100	RHS	300	BGL-1.0M	1-440 V	PARALLEL	U/G	YES
71	I	26780	26780	100	ALIGNMENT CROSSING	300	BGL-1.0M	1-440 V	PERPENDICULAR	U/G	NO

TABLE 5.44: OPTICAL FIBRE CABLE OF BSNL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1270	1330	60	LHS	24 FIBER, DUCT-40MM, 2 CABLES	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO
2	I	1330	1450	120	LHS	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO
3	I	1450	1450	30	ROAD CROSSING (RHS)	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PERPENDICULAR	ELEVATED	YES
4	I	1450	4400	2960	RHS	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO
5	I	5350	5750	520	LHS	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO
6	I	5760	7140	1380	LHS	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
7	I	7140	7140	30	ROAD CROSSING (RHS)	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PERPENDICULAR	ELEVATED	YES
8	I	7140	7900	740	RHS	24 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO
9	I	11100	12200	1000	LHS	48 FIBER, DUCT-40MM, 1 CABLE	BGL-2.0M	OFC	PARALLEL	ELEVATED	NO

TABLE 5.45: OPTICAL FIBRE AND COPPER CABLE OF MTNL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1320	1320	50	ALIGNMENT CROSSING LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PERPENDICULAR	ELEVATED	YES
2	I	1320	2750	1430	LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
3	I	1320	4410	3090	RHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
4	I	2750	4410	1660	LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
5	I	4410	4410	30	ROAD CROSSING	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
6	I	5250	6900	1650	RHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
7	I	5250	9700	4450	LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
8	I	6920	7900	980	RHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
9	I	7920	9700	1780	RHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
10	I	9950	9950	100	ALIGNMENT CROSSING LHS ON BOTH SIDE	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PERPENDICULAR	ELEVATED	YES
11	I	11100	12100	1000	LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
12	I	11100	12100	2400	RHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
13	I	12100	13500	1400	LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600,	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
						400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM					
14	I	15450	16120	950	LHS	96F, 48F OFC CABLE & 2000, 1600, 1400, 1200, 800, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
15	I	15450	16580	2150	RHS	1200, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	COPPER	PARALLEL	ELEVATED	NO
16	I	16950	17600	650	LHS	96F, 48F OFC CABLE & 2000 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
17	I	16950	17600	650	RHS	96F, 48F OFC CABLE & 2000 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
18	I	17950	17950	100	ALIGNMENT CROSSING ON BOTH SIDE	96F, 48F OFC CABLE & 2000 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PERPENDICULAR	ELEVATED	YES
19	I	19180	19180	100	ALIGNMENT CROSSING ON BOTH SIDE	96F, 48F OFC 2 NO CABLES & 1200, 800, 400, 200 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
20	I	23150	24300	1120	LHS	96F, 48F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	ELEVATED	NO
21	I	24300	24300	50	ALIGNMENT CROSSING LHS	96F, 46F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PERPENDICULAR	ELEVATED	YES
22	I	24340	24340	100	ALIGNMENT	96F, 46F OFC CABLE & 2400,	BGL-	OFC AND	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
					CROSSING	2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	0.60M	COPPER			
23	I	24340	24850	420	LHS	96F, 46F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	U/G	YES
24	I	24340	24850	420	RHS	96F, 46F OFC CABLE & 2400, 2000, 1600, 1200, 800, 600, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	OFC AND COPPER	PARALLEL	U/G	YES
25	I	25480	25480	100	ALIGNMENT CROSSING	100, 50 COPPER CABLES, DUCT-40MM	BGL-0.60M	COPPER	PERPENDICULAR	U/G	NO
26	I	25850	25850	50	ALIGNMENT CROSSING RHS	200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	COPPER	PARALLEL	U/G	YES
27	I	25900	25900	50	ALIGNMENT CROSSING RHS	200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	COPPER	PARALLEL	U/G	YES
28	I	26000	26150	100	RHS	200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	COPPER	PARALLEL	U/G	YES
29	I	26150	26150	100	ALIGNMENT CROSSING	800, 400, 200, 100, 50, 20, 10 COPPER CABLES, DUCT-40MM	BGL-0.60M	COPPER	PERPENDICULAR	U/G	NO

TABLE 5.46: OPTICAL FIBRE CABLE OF RELIANCE

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1270	2310	1035	LHS	24 FIBER, DUCT-40MM, 2 CABLES	BGL-1.0M	OFC	PARALLEL	ELEVATED	NO
2	I	2310	2310	30	ROAD CROSSING	24 FIBER, DUCT-40MM,	BGL-1.0M	OFC	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
					(RHS)	2 CABLES					
3	I	6920	6920	30	ROAD CROSSING (LHS)	24 FIBER, DUCT-40MM, 2 CABLES	BGL-1.0M	OFC	PERPENDICULAR	ELEVATED	YES
4	I	6920	7530	610	LHS	24 FIBER, DUCT-40MM, 2 CABLES	BGL-1.0M	OFC	PARALLEL	ELEVATED	NO
5	I	11000	12100	1000	LHS	24 FIBER, DUCT-40MM, 2 CABLES	BGL-1.0M	OFC	PARALLEL	ELEVATED	NO
6	I	17950	17950	100	ALIGNMENT CROSSING	24 FIBER, DUCT-40MM, 2 CABLES	BGL-1.0M	OFC	PERPENDICULAR	ELEVATED	YES
7	I	19170	19170	100	ALIGNMENT CROSSING	24 FIBER, DUCT-40MM, 2 CABLES	BGL-1.0M	OFC	PERPENDICULAR	ELEVATED	YES
8	I	24320	24320	30	ROAD CROSSING	48 FIBER, DUCT-40MM, 3 CABLES	BGL-1.0M	OFC	PERPENDICULAR	ELEVATED	YES

TABLE 5.47: OPTICAL FIBRE CABLES OF VODAFONE

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1270	1360	90	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
2	I	1360	1360	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
3	I	1360	2090	730	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
4	I	2090	2090	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
5	I	2090	2180	90	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
6	I	2090	2310	220	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
7	I	2310	2310	30	ROAD CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
					LHS TO RHS	1 CABLE					
8	I	2310	2750	440	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
9	I	2750	3430	680	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
10	I	3430	3430	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
11	I	3430	3870	440	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
12	I	3870	3870	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
13	I	3870	4410	540	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
14	I	4410	4410	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
15	I	5230	5760	530	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
16	I	6870	6870	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
17	I	6870	7900	1090	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
18	I	7900	7900	30	ROAD CROSSING RHS TO LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
19	I	7900	8130	170	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
20	I	8130	8160	30	DIAGANALLY ROAD CROSSING RHS TO LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
21	I	8160	8320	160	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
22	I	8320	8370	50	DIAGANALLY ROAD CROSSING RHS TO LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
23	I	8370	8990	630	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
24	I	8990	8990	30	ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
25	I	8990	9600	700	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
26	I	9960	9960	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
27	I	11040	12100	1030	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
28	I	11040	11300	220	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
29	I	11300	11300	50	ALIGNMENT CROSSING RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
30	I	11300	12100	810	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
31	I	12100	12100	50	ALIGNMENT CROSSING LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
32	I	12100	126200	520	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
33	I	12620	12620	30	ROAD CROSSING RHS TO LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
34	I	12620	13550	960	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
35	I	15650	16060	410	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
36	I	16950	16950	50	ALIGNMENT	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
					CROSSING RHS	1 CABLE					
37	I	16950	17100	160	LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
38	I	17100	17100	50	ALIGNMENT CROSSING LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
39	I	17100	17120	20	DIAGANALLY ROAD CROSSING LHS TO RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
40	I	17120	17630	490	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
41	I	17630	17630	50	ALIGNMENT CROSSING LHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
42	I	17930	17930	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
43	I	19150	19150	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
44	I	20670	20670	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
45	I	23150	24320	1070	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	ELEVATED	NO
46	I	24320	24320	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
47	I	24330	24330	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	ELEVATED	YES
48	I	24330	24850	570	RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	U/G	YES
49	I	25490	25490	100	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	U/G	NO
50	I	25950	26190	140	ALIGNMENT RHS	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PARALLEL	U/G	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
51	I	27200	27200	50	ALIGNMENT CROSSING	288 FIBER, DUCT-40MM, 1 CABLE	BGL-0.60M	OFC	PERPENDICULAR	U/G	NO

TABLE 5.48: OPTICAL FIBRE CABLE OF AIRTEL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	1240	1320	80	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
2	I	1320	1320	30	ROAD CROSSING LHS TO RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
3	I	1320	1400	80	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
4	I	1400	1400	30	ROAD CROSSING LHS TO RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
5	I	1400	2010	530	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
6	I	2010	2010	30	ROAD CROSSING LHS TO RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
7	I	2010	2590	660	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
8	I	2590	2590	30	ROAD CROSSING RHS TO LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
9	I	2590	2660	70	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
10	I	2590	2760	170	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
11	I	2980	3420	440	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
12	I	3420	3420	30	ROAD CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
					LHS TO RHS	1 CABLE					
13	I	3420	3860	440	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
14	I	5250	5300	50	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
15	I	5280	5330	20	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
16	I	5330	5330	30	ROAD CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
17	I	6920	7910	990	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
18	I	7910	7910	30	ROAD CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
19	I	7910	8340	430	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
20	I	8340	8340	100	ALIGNMENT CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
21	I	8340	8750	440	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
22	I	8750	8750	30	ROAD CROSSING LHS TO RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
23	I	8750	8980	200	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
24	I	8750	8980	200	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
25	I	9000	9650	650	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
26	I	9950	9950	100	ALIGNMENT CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
27	I	9965	9965	50	ALIGNMENT CROSSING LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
28	I	11100	12100	1000	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
29	I	12100	12100	300	ROAD CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
30	I	12100	12150	50	LHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
31	I	12100	12710	520	RHS	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PARALLEL	ELEVATED	NO
32	I	17950	17950	100	ALIGNMENT CROSSING BOTH SIDE	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES
33	I	24350	24350	100	ALIGNMENT CROSSING	96 FIBER, DUCT-40MM, 1 CABLE	BGL-0.70M	OFC	PERPENDICULAR	ELEVATED	YES

TABLE 5.49: OPTICAL FIBRE CABLE OF TATATELECOM

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
1	I	1250	1780	550	LHS	96 FIBER, DUCT-110MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
2	I	1780	1780	30	ROAD CROSSING RHS TO LHS	96 FIBER, DUCT-110MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
3	I	1780	2310	510	RHS	96 FIBER, DUCT-110MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
4	I	2310	2310	30	ROAD CROSSING RHS TO LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
5	I	2310	2460	140	RHS	96 FIBER, DUCT-110MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
6	I	2310	2450	140	LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
						2 CABLES					
7	I	2450	2450	30	ROAD CROSSING	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
8	I	2450	2490	40	RHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
9	I	2490	2490	30	ROAD CROSSING	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
10	I	2490	2740	250	LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
11	I	2490	4400	1910	RHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
12	I	2750	4400	1650	LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
13	I	4400	4400	30	ROAD CROSSING	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
14	I	5050	5050	100	ALIGNMENT CROSSING ON BOTH SIDE	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
15	I	5250	7900	2690	RHS	96 FIBER, DUCT-40MM, 3 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
16	I	5250	7900	2670	LHS	96 FIBER, DUCT-40MM, 3 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
17	I	7900	9640	1720	LHS	96 FIBER, DUCT-40MM, 3 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
18	I	7900	9640	1720	RHS	96 FIBER, DUCT-40MM, 3 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
19	I	9950	9950	100	ALIGNMENT CROSSING ON BOTH SIDE	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Req'd
20	I	11050	11300	200	RHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
21	I	11050	11790	660	LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
22	I	11790	11790	30	ROAD CROSSING LHS TO RHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
23	I	11790	12140	300	RHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
24	I	16900	17520	590	RHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
25	I	17520	17520	30	ROAD CROSSING RHS TO LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
26	I	17520	17600	80	LHS	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PARALLEL	ELEVATED	NO
27	I	17950	17950	100	ALIGNMENT CROSSING ON BOTH SIDE	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
28	I	19180	19180	100	ALIGNMENT CROSSING	96 FIBER, DUCT-40MM, 2 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES
29	I	24320	24320	100	ALIGNMENT CROSSING ON BOTH SIDE	48 FIBER, DUCT-40MM, 3 CABLES	BGL-1.50M	OFC	PERPENDICULAR	ELEVATED	YES

5.6 LAND REQUIREMENT FOR THE CORRIDOR, DEPOT STATIONS, PARKING, MULTI MODEL STATIONS

5.6.1. Main Components

Land will be required for the following main 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.

5.6.2. Land for Elevated stretches

No land at surface is required permanently for elevated section, except for small areas for entry/exit structures, traffic integration and other maintenance utilities at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road. Wherever stations are proposed off the road, land for station building is also required permanently.

5.6.3. Land for Underground stretches

No land at surface is required permanently for underground section, except for small areas for entry/exit structures, traffic integration and ventilation shafts/other maintenance utilities at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road. All the underground stations are planned with island platforms.

5.6.4. Land for Switch-over Ramps

Switchover ramps are required for transition from the elevated to underground section and vice versa. The ramp covers a stretch at ground for the whole width of structure for two tracks. The length of ramp above ground depends on the existing ground slope and the gradient provided on Metro alignment (normally 3% to 4%). Thus the ramp is to be located in an area where sufficient road width is available or in an open area.

For Thane Ring Corridor, an area of 10620 sqm has been proposed between proposed Kopri sub urban station and Railadevi for locating underground to elevated ramp. Further, an area of 4920 sqm parallel to creek has been proposed near Thane Junction Railway Station for locating elevated to underground ramp.

At depot entries area of 3200 sqm has been proposed for locating elevated to At-grade ramp at Kasarvadavali depot.

5.6.5. Land for Traffic integration

Govt. land has been proposed for integration with Rail system, Metro corridor and Bus system.

5.6.6. Land for Maintenance Depot

About 20.7 Hectares (including 4.5 Hectares for Property Development) State Govt. land for Depot has been proposed for corridor near Kasarvadavali.

5.6.7. Land for TSS, RSS, ASS and DG Sets

Total of two RSS have been proposed on the corridor at Gandhi Nagar and Shivaji Chowk. An area of 3000 sqm has been proposed for each RSS. ASS and DG Sets are required at all stations.

5.6.8. Summary of Land Requirement

Abstract of land requirements for different components of corridor is given in **Table 5.50**.

TABLE 5.50: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
Central Govt	Alignment / Stations, ancillary buildings & Misc.	0.4368	0	0.1115
	Parking cum PD	0	0	0
	Total	0.4368	0	0.1115
State Govt	Alignment / Stations, ancillary buildings & Misc. RSS, etc	5.6470	0	1.8363
	Depot	0	0	0
	Parking cum PD	0.7150	0	0
	Casting Yard	0	50	0
	Total	6.3620	50	1.8363

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
Private	Alignment / Stations, ancillary buildings & Misc., RSS, etc	2.5748	0	1.9355
	Depot& entry/exit	18.6343	0	0
	Parking cum PD	0.64	0	0
	Total	21.8491	0	1.9355
Grand Total		28.6479	50	3.8833

5.7 OWNERSHIPS DETAILS OF THE LAND REQUIRED FOR THE CORRIDOR

5.7.1. Permanent Land Requirement

Land is required permanently for entry/exit, Viaduct, stations and ramps etc. Permanent requirement of Land for stations for Corridor is tabulated in **Table 5.51**. Permanent requirement of Land for running section, ramps etc. for Corridor is tabulated in **Table 5.52**.

5.7.2. Temporary Land Requirement

Land is required temporarily at the time of construction of viaduct, underground stations by cut & cover, TBM shafts etc. Temporary requirement of Land for Corridor is tabulated in **Table 5.53**.

5.7.3. Temporary Construction Yard

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.

Also, large numbers of pre-cast tunnel segments are required for construction of tunnels for which a large Open area is required for setting up of casting yard. As far as possible, this area will be in temporary construction depot.

Since the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose is identified throughout the corridor, in the vicinity of the stations on temporary acquisition basis. 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.

About **50 Hac** land for Thane Ring Corridor has been proposed for construction yards along the corridor. At the time of construction, depending upon the need, area requirements, the location and size can be reassessed and temporary land acquisitions can be made accordingly.

TABLE 5.51: PERMANENT LAND REQUIREMENT FOR STATION

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To						
1	In Mental Hospital Area	TJN-1	27302	108	7788	Govt. (State)	Station Construction (New Thane)	8G+0,2G+2	10	3425
2	Near TMC Office on SG Barve Road	TJN-4	1610	1650	436	Govt. (State)	Station Construction (Raila Devi)	G+2	1	1770
3	Near Abhyudaya Co. op Bank on Road No.22	TJN-6	4249	4395	820	Private	Station Construction (Lokmanya Nagar Bus Depot)	5G+1	5	724
4	Near Lokmanya Bus Depot Area	TJN-7	4400	4414	412	Govt. (State)	Station Construction (Lokmanya Nagar Bus Depot)	G+0	1	144
5	Near N S Industry	TJN-10	5477	5597	743	Private	Station Construction (Shivai Nagar)	G+0,7G+1,2G+2	10	2942
6	Near Neelkanth Girija on Pokharan Road No.2	TJN-14	6738	6812	1162	Private	Station Construction (Neelkanth Terminal)	Nil	0	0
7	Near Neelkanth Girija on Pokharan Road No.3	TJN-14A	6812	6894	2217	Govt. (State)	Station Construction (Neelkanth Terminal)	Nil	0	0
8	Near Glaxo Smith Kline on Pokharan Road No.2	TJN-15	7598	7745	457	Private	Station Construction (Gandhi Nagar)	Nil	0	0
9	Near Kashinath Ghatekar Natyagraha	TJN-17	8996	9068	442	Private	Station Construction (Dr. Kashinath Ghanekar Natyagraha)	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To						
10	Near Renault Service Station on Waghbil Road	TJN-20	11584	11733	842	Private	Station Construction (Dongripada)	7G+0,3G+1,G+2	11	2358
11	Near Shriji Splender on Brahmand Road	TJN-28	16696	16847	991	Private	Station Construction (Patlipada)	G+0	1	190
12	Near Radodi Vahan Police on Saket Balkum Road	TJN-32	23834	23911	444	Private	Station Construction (Shivaji Chowk)	Nil	0	0
13	Near Radodi Vahan Police on Saket Balkum Road	TJN-33	23838	23984	3132	Govt. (State)	Station Construction (Shivaji Chowk)	Nil	0	0
14	Near Existing Thane Junction	TJN-38	25781	25976	4368	Govt. (Central)	Station Construction (Thane Junction)	8G+0,2G+1	10	1115
15	Near Existing Thane Junction	TJN-39	25781	25900	2096	Private	Station Construction (Thane Junction)	G+1,G+2,2G+3, 2G+4, G+5	7	5597

TABLE 5.52: PERMANENT LAND REQUIREMENT FOR RUNNING SECTION

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To						
1	In Mental Hospital Area	TJN-2	318	1180	16804	Govt. (State)	Ramp Construction	2G+0, 25G+0 approx (Hutment) & 2G+1	29	10198
2	Near Chhatrapati Shivaji Dwar	TJN-3	1221	1354	323	Private	Viaduct Construction	2G+0,G+1	3	171
3	Near Wagle Circle	TJN-5	2684	2800	1155	Private	Viaduct Construction	2G+0,G+2	3	1184
4	Near Sai Sailyam Society	TJN-8	5300	5322	395	Govt. (State)	Viaduct Construction	Nil	0	0
5	Near Sai Sailyam Society	TJN-9	5322	5355	249	Private	Viaduct Construction	Nil	0	0
6	Near Shree Siddhi Vinayak Eng.	TJN-11	5727	5857	1031	Private	Viaduct Construction	G+0,4G+1,G+3,G+5	7	3188
7	Near Cosmos Hill	TJN-12	5993	6069	220	Private	Viaduct Construction	Nil	0	0
8	On Upvan Lake Road	TJN-13	6452	6667	1887	Govt. (State)	Viaduct Construction	G+0	1	118
9	Near Glaxo Smith Kline on Pokharan Road No.3	TJN-16	7822	7932	1394	Govt. (State)	Viaduct Construction	Nil	0	0
10	Near Glaxo Smith Kline on Pokharan Road No.4	TJN-16A	7974	8075	296	Private	Viaduct Construction	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To						
11	On existing Patlipada Flyover, Ghodbunder Road	TJN-18	11128	11293	478	Private	Viaduct Construction	Nil	0	0
12	Near Ritu Nissan Ghodbunder Road	TJN-19	11347	11584	481	Private	Viaduct Construction	4G+0,9G+1	13	1147
13	Near Hotel Jalaja on Waghbil Road	TJN-21	11875	12095	504	Private	Viaduct Construction	4G+0,2G+1	6	449
14	Near Tata Consultancy Surdives on Waghbil Road	TJN-22	15209	15426	2273	Private	Viaduct Construction	7G+0	7	341
15	Opposite Rodas Enclave on Parklane	TJN-23	15550	15744	580	Private	Viaduct Construction	Nil	0	0
16	Near Harab on Parklane	TJN-24	15916	16123	2039	Private	Viaduct Construction	Nil	0	0
17	Near TMC Garden	TJN-25	16157	16287	235	Private	Viaduct Construction	G+0	1	183
18	Near TMC Garden	TJN-26	16396	16470	1346	Private	Viaduct Construction	Nil	0	0
19	Near TMC Garden	TJN-27	16470	16575	1713	Govt. (State)	Viaduct Construction	Nil	0	0
20	Near Canopus Cabra Galaxy on Brahmand	TJN-29	16925	16952	92	Private	Viaduct Construction	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To						
	Road									
21	Near Orchids international school on Brahmand Road	TJN-30	17346	17483	306	Private	Viaduct Construction	2G+0	2	16
22	Near J Kumar Site office on Saket Balkum Road	TJN-31	23743	23838	848	Govt. (State)	Viaduct Construction	Nil	0	0
23	Near Umrao Patil Garden	TJN-34	23984	24300	4735	Govt. (State)	Viaduct Construction	G+0	1	103
24	Near Commissnor office, Shivaji Chowk	TJN-35	24348	24836	6526	Govt. (State)	Viaduct Construction	10G+0	10	533
25	Near Ambedkar Society	TJN-36	24881	24934	143	Private	Viaduct Construction	G+0	1	865
26	Near NG Bedekar College of Commerce	TJN-37	24965	25102	8183	Govt. (State)	Ramp Construction	25G+0 Approx. (Hutment) & G+1	26	2072
27	Kasarvadavali Depot		649	1178	6343	Private	Depot Entry & Exit (Kasarvadavali)	Nil	0	0
28	Kasarvadavali Depot		1178	2328	180000	Private	Depot (Kasarvadavali)	Nil	0	0
29	Near TMC Office on SG Barve Road	Parking-1	1610	1650	650	Govt. (State)	Parking (Raila Devi)	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To						
30	Near Abhyudaya Co.op Bank on Road No.22	Parking-2	4340	4389	2100	Private	Parking (Lokmanya Nagar Bus Depot)	Nil	0	0
31	Opposite Vijay Group on Waghbil Road	Parking-3	13715	13765	2000	Private	Parking (Waghbil)	Nil	0	0
32	Near brahmand PH.II CHS Ltd.	Parking-4	17689	17747	3000	Govt. (State)	Parking (Azad Nagar Bus Stop)	Nil	0	0
33	Near Saket Shopping Center On Saket Balkum Road	Parking-5	22948	23018	3500	Govt. (State)	Parking (Rabodi)	Nil	0	0
34	Near Radodi Vahan Police on Saket Balkum Road	Parking-6	23863	23960	2300	Private	Parking (Shivaji Chowk)	Nil	0	0
35	Near Glaxo Smith Kline on Pokharan Road No.2	RSS-1	7540	7600	3000	Private	RSS (Gandhi Nagar)	Nil	0	0
36	Near J Kumar Site office on Saket Balkum Road	RSS-2	23770	23821	3000	Private	RSS (Shivaji Chowk)	Nil	0	0

Chapter – 6

STATION PLANNING

6. STATION PLANNING

6.1. STATION PLANNING - BASED ON SITE CONDITIONS

The proposed Metro Rail System has been planned to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations have been located by an interactive process influenced by ridership forecasts, existing major settlements, major roads, interchange requirements with other modes of transport, station spacing, alignment, utilities, traffic and pedestrian requirements, station spacing, etc. The stations locations along with their chainages and inter-station distance are presented in **Table 6-1**.

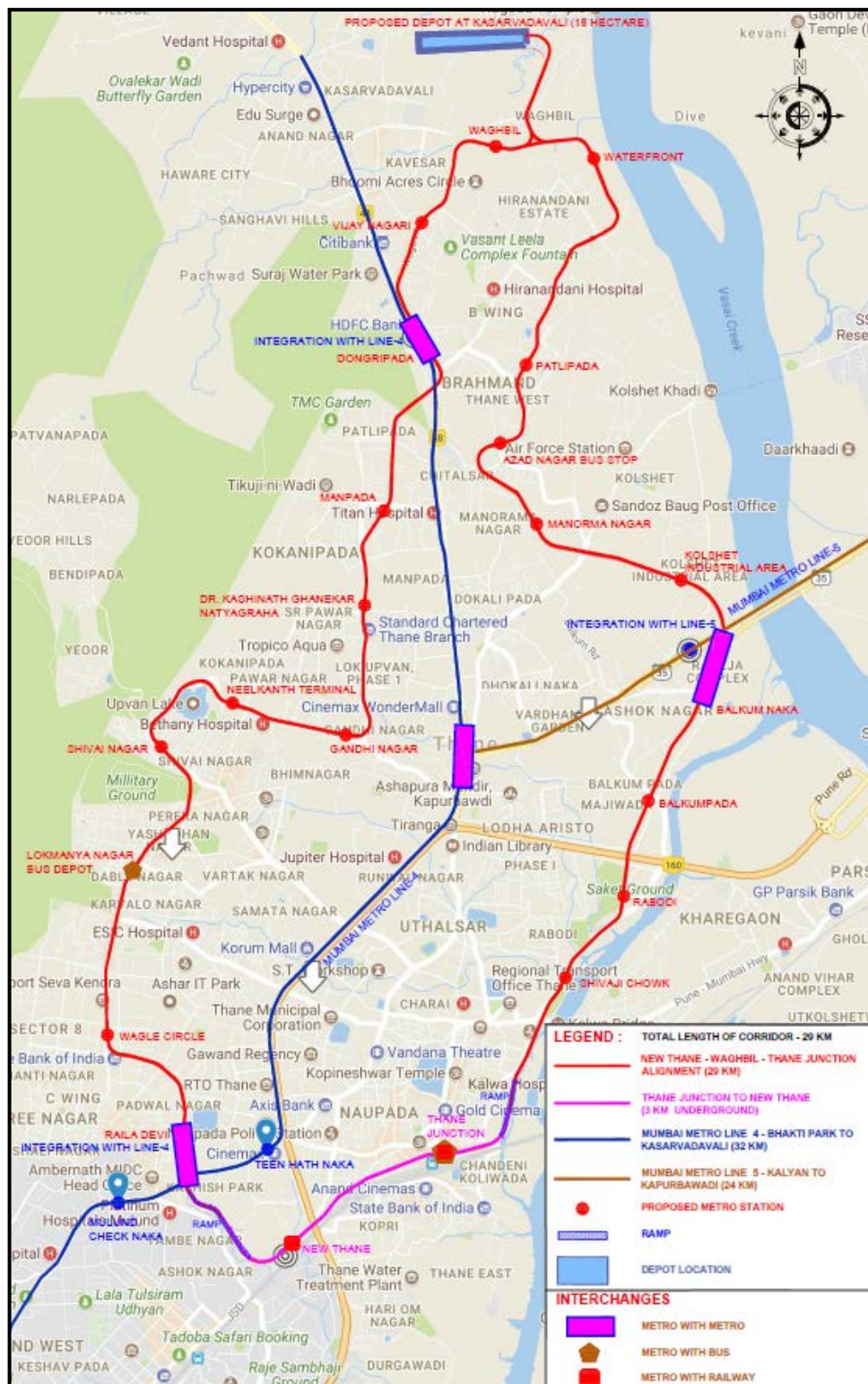
TABLE 6-1: INTER-STATION DISTANCE AND TYPE OF PROPOSED STATIONS

SN	Station Name	Chainages (m)	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
1	New Thane	0	-	0	Underground
2	Raila Devi	1664	1664	1664	Elevated
3	Wagle Circle	2903	1239	2903	Elevated
4	Lokmanya Nagar Bus Depot	4291	1388	4291	Elevated
5	Shivai Nagar	5520	1229	5520	Elevated
6	Neelkanth Terminal	6774	1254	6774	Elevated
7	Gandhi Nagar	7634	860	7634	Elevated
8	Dr. Kashinath Ghanekar Natyagraha	9032	1398	9032	Elevated
9	Manpada	9792	760	9792	Elevated
10	Dongripada	11622	1830	11622	Elevated
11	Vijay Nagari	12372	750	12372	Elevated
12	Waghbil	13611	1239	13662	Elevated
13	Waterfront	14685	1074	14685	Elevated
14	Patlipada	16734	2049	16734	Elevated
15	Azad Nagar Bus Stop	17581	847	17581	Elevated
16	Manorma Nagar	18616	1035	18616	Elevated
17	Kolshet Industrial Area	19954	1338	19954	Elevated
18	Balkum Naka	21118	1164	21118	Elevated
19	Balkumpada	22098	980	22098	Elevated
20	Rabodi	22986	888	22986	Elevated
21	Shivaji Chowk	23873	887	23873	Elevated
22	Thane Junction	25841	1968	25841	Underground

6.1.1. STATION AREA CHARACTERISTICS

The catchment areas for all stations, issues and concerns, potential improvements are summarized below:

FIGURE 6-1: THANE METRO RING CORRIDOR AND STATION LOCATIONS



6.1.2. THANE METRO RING CORRIDOR

1. New Thane Station

New Thane is the first station of the proposed Metro Corridor. It is an underground station near proposed Kopri Sub Urban Station and lies in Mental Hospital area. This will be an interchange station of proposed Metro and existing Sub-urban rail system. The catchment area of station include Anand Nagar, Lok Kedar Cooperative Housing Society, Lok Everest Housing Society, Spandan Hospital, etc.

Issues & Concerns	Potential for Improvements
- The station area is in Mental Hospital land. At present no infrastructure facilities are available - Station Area needs to be redeveloped	- Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT. - Dedicated pedestrian friendly facilities like footpath and cycle tracks. - Connectivity Roads to station area
	
	
Proposed location for the station	Residential area near station location
	
Station Location in Mental Hospital	Surrounding areas near location

2. Raila Devi Station

Raila Devi is an elevated station near Modella Chowk along the proposed Metro Corridor. The major catchments areas around the station location are Padwal Nagar, Raghunath Nagar, D'Souza Wadi, Kamgar Colony, Wagle Estate Post Office, etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities results in pedestrian vehicular conflict • On street Parking reduces effective carriage way width • Lack of PT/IPT stops and dedicated bays for Buses and Auto	• Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT • Dedicated pedestrian friendly facilities like footpath and cycle tracks • On Street Parking and encroachments may be removed
	
	
Proposed station location on SG Barve road	Modella Chowk & Check Naka
	
SG Barve road	SG Barve road connecting Modella Chowk

3. Wagle Circle Station

Wagle Station is the third station along the proposed corridor. It is proposed near Wagle Circle and is an elevated station surrounded by industrial area. The catchment area of station includes Shanti Nagar, Wagle Industrial Area, Shree Nagar, Kailash Nagar, CP Talav, Brodma, Sathe Nagar, etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated NMT friendly facilities • Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment.
	
	
Location of proposed station	Station location on Road no. 22
	
SG Barve road connecting Wagle Circle	Surrounding areas near station location

4. Lokmanya Nagar Bus Depot Station

This is an elevated station near Lokmanya Nagar and is the fourth station along the proposed Metro Corridor. This station will have Multi Modal integration integration with the existing TMT Bus Depot to have integration between both the modes. The catchment area of station are Lokmanya Nagar, Lokmanya Nagar Bus Depot, Karvalo Nagar, Panchpakhdi, Yashodhan Nagar, Ambewadi, etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays	• Dedicated pedestrian friendly facilities • Parking areas and dedicated bays for pick up/ drop facilities • Integration of Metro and Bus Stop
	
	
Proposed location for the station	TMT Bus Depot
	
Station Location on Road No. 22	Surrounding areas near station location

5. Shivai Nagar Station

It is the fifth station along the proposed Metro Corridor on Pokhran Road No. 1. It is an elevated station near Shivai Nagar. The station caters to the areas of Shivai Nagar, Devdaya Nagar, Shanti Industrial Estate, Deshpande Industrial Estate, etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road further adding to pedestrian vehicular conflict • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated bays for pick up/ drop facilities for all mode • Dedicated pedestrian friendly facilities
	
	
Surrounding areas near Station Location	Pokhran Road No.1
	
Station Location on Pokhran Road No.1	Land use around station location

6. Neelkanth Terminal Station

It is the sixth station and an elevated station along the proposed Metro Corridor on Pokhran Road No.2. The catchment area of station are Neelkanth Terminal area, Laxmi Narayan residency, Bethany Hospital, etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities results in pedestrian vehicular conflict • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location • Pedestrian Safety is a concern	• Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT • Dedicated pedestrian friendly facilities



Pokhran Road no.2



Approach road near the proposed Station



Surrounding areas near the proposed Station



Station Location on Pokhran Road no.2

7. Gandhi Nagar Station

It is an elevated station near Gandhi Nagar area on Pokhran Road No.2 and is the seventh station along the proposed Metro Corridor. The catchment area of station are Gandhi Nagar, Jawahar Nagar, Vasant Vihar, Dharamvir Nagar, Bhim Nagar, Kapurbawdi, SV Nagar, etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location • Pedestrian Safety is a concern	• Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment. • Dedicated pedestrian facilities
	
	
Proposed location of the station	Smt. Gladys Alvares Road near station Location
	
Water Tank on Smt. Gladys Alvares Road	Surrounding areas near location

8. Dr. Kashinath Ghanekar Natyagraha Station

This is an elevated station along the proposed Metro Corridor. The catchment area of station are Manpada, Pawar Nagar, Kokanipada, Lok Gram, Vasant Nagar etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated NMT friendly facilities • Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment.
	
	
Location of proposed station	Smt. Gladys Alvares Road near proposed Location
	
Vehicular movement near proposed Location	Surrounding areas near location

9. Manpada Station

This is an elevated station and lies between Tikuji Ni Wadi & Smt. Gladys Alvares Road. The catchment area of station are Bhavani Nagar, Dharamvir Nagar, Kokanipada, Manpada, Hill Garden etc.

Issues & Concerns	Potential for Improvements
• Lack of connectivity to station location • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated pedestrian friendly facilities • Dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment and help maximize ridership of the proposed system
	
	
Approach road near the station	Proposed station Location
	
Link Road connecting station location	Mixed Land use around station location

10. Dongripada Station

This is the tenth station and an elevated station of the proposed Metro Corridor on NH-48. The station will have integration with Dongripada Station of Mumbai Line-4. The catchment area of station includes Dongripada, Patlipada Hiranandani etc.

Issues & Concerns	Potential for Improvements
• Located along National Highway • Connectivity and passenger interchange to planned considering the Line 4 and high speed traffic movement • PT/IPT stops do not have dedicated bays • Encroachments and On-street parking due to adjacent land uses causes reduction in efficient roadway width	• Dedicated bays for pick up/ drop facilities for IPT • Continuous encroachment free footpath facilities • Dedicated bays for pick up/ drop facilities • Grade separated pedestrian for crossing and passenger dispersal
	
	
Surrounding area near location	Ghod Bunder road near the proposed Location
	
Proposed location for the station	Vehicular movement on Ghod Bunder road

11. Vijay Nagari Station

This is an elevated station along the proposed Metro Corridor near Waghvali Naka and Vijay Group. The catchment area of station are Waghbil, Waghvali Naka, etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities results in pedestrian vehicular conflict • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location • Pedestrian Safety is a concern	• Proper parking areas and dedicated bays for pick up/ drop facilities for PT/IPT • Dedicated pedestrian friendly facilities like footpath and cycle tracks



Proposed location for the Station



Waghbil Road along proposed Station



Waghbil Road



Existing surrounding areas

12. Waghbil Station

This is the twelfth station of the proposed Metro Corridor. It is an elevated station near Waghbil Gaon. The catchment area of station are Waghbil Gaon, Gondhalwadi, Kavesar etc.

Issues & Concerns	Potential for Improvements
At present no access to station location	- Access to station location to be planned - Parking areas and dedicated bays for pick up/ drop facilities - Planning of dispersal facilities - Dedicated pedestrian facilities



Proposed location of the station



Waghbil Road



Waghbil Road near proposed station



Surrounding areas near proposed location

13. Waterfront Station

This is an elevated station along the proposed Metro Corridor near Hiranandani Estate Bus Stop and Waghbil Gaon. The station caters to Hiranandani Estate, Rodas Enlave, Bayers House, etc.

Issues & Concerns	Potential for Improvements
• Located along DP road • At present no road connectivity to station location	• Road network to be developed • Dedicated NMT friendly facilities • Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment.



Location of proposed station



Link road near the proposed station location



Surrounding areas near location



Approach road near location

14. Patlipada Station

This is the fourteenth station and an elevated station along the proposed Corridor lying near Brahmand- Patlipada Link Road. The catchment area of station are Brahmand, Varcha Gaon, Kolshet Gaon, Kiran Mill Colony, etc.

Issues & Concerns	Potential for Improvements
At present no road connectivity to station location	- Road network to be developed - Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT - Dedicated pedestrian friendly
	
	
Proposed location near Brahmand Patlipada Link Road	Proposed location of station
	
Surrounding areas near location	Dumping site near station location

15. Azad Nagar Bus Stop Station

This is an elevated station along the proposed Metro Corridor on Brahmand Road near Azad Nagar Bus Stop. The catchment area of station are Azad Nagar, Brahmand Phase 3, Varcha Gaon, Kolshet Gaon, Indofill Industries Limited, etc.

Issues & Concerns	Potential for Improvements
• Lack of passenger dispersal facilities • PT/IPT stops do not have dedicated bays • Located Along DP Road	• Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes • Dedicated pedestrian facilities



Surrounding areas along the station



Proposed station location



Land use near location



Proposed location near Brahmand Road

16. Manorma Nagar Station

This is the sixteenth station and an elevated station along the proposed Metro Corridor near Manorma Nagar area. The catchment area of station are Manorma Nagar, Sandoz Baug, Dhokali, New Ganesh Nagar, etc.

Issues & Concerns	Potential for Improvements
• Encroachments along the Station Area - needs to be removed • At present no Road connectivity • Located Along DP Road	• Dedicated NMT friendly facilities. • Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities



Location of proposed station on DP road



Akbar Camp Road near proposed location



Surrounding areas near location



Link road connecting station location

17. Kolshet Industrial Area Station

This is an elevated station near Bayer Crop Science Limited and Balkum Pipeline Road. The catchment area of station are Balkum Nagar, Ashok Nagar and surrounding areas etc.

Issues & Concerns	Potential for Improvements
• At present no Road connectivity • Located along proposed DP Road	• Adequate connectivity to be planned • Dedicated NMT friendly facilities. • Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment.



Location of proposed station on DP road Approach road near the proposed station



Surrounding areas near location Existing green field at station location

18. Balkum Naka Station

This is an elevated station along the proposed Metro Corridor on Balkum Road near Dadlani Park and Valu City. The catchment area of station are Ashok Nagar, Balkum Nagar, Raheja Complex, Ganesh Bawadi, etc.

Issues & Concerns	Potential for Improvements
• Poor connectivity to Station Area • No basic infrastructure available for vehicular and passenger access and dispersal	• Adequate connectivity to be planned • Dedicated NMT friendly facilities. • Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment.



Location of proposed station on DP road



Existing green field at station location



Surrounding areas near location



Proposed station location area

19. Balkumpada Station

This is the nineteenth station and an elevated station near Pipeline road and Balkumpada area. The station caters to Balkumpada, Majiwada, Yashaswi Nagar, Lodha Complex, Siddharth Nagar, etc.

Issues & Concerns	Potential for Improvements
• No basic infrastructure available for vehicular and passenger access and dispersal • Located Along DP Road	• Adequate connectivity to be planned • Dedicated NMT friendly facilities. • Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment.



Location of proposed station on Saket road	Saket Road crossing proposed DP Road
Saket Road	Surrounding areas near location

20. Rabodi Station

This is an elevated station near Saket- Kalwa Road. The catchment area of station includes Saket Tower, Vrindavan Society, Shreerang Society, Rabodi, Kharegaon etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities • PT/IPT stops do not have dedicated bays • Poor road infrastructure	• Adequate connectivity to be planned • Dedicated NMT friendly facilities. • Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment.



Location of station on proposed DP Road



Approach road near the proposed station



Land use along station location



Surrounding areas near location

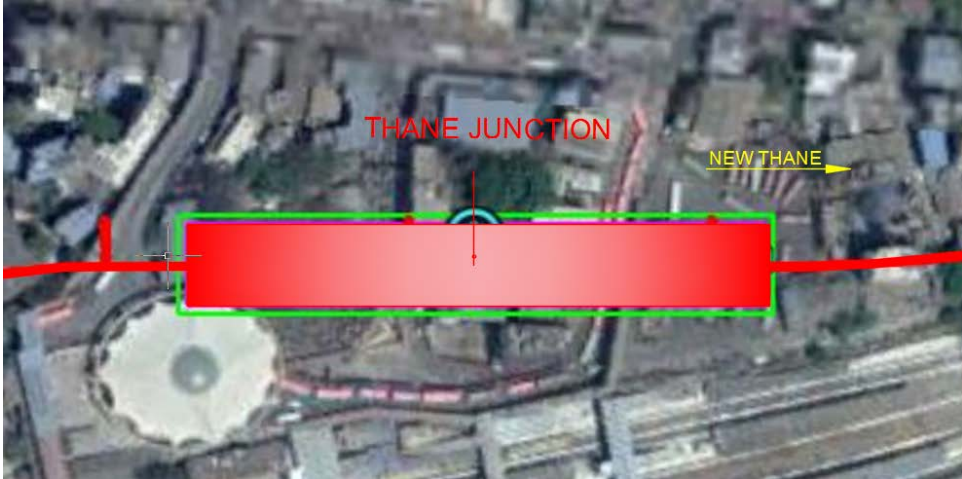
21. Shivaji Chowk Station

This is the twenty first station along the proposed Metro Corridor near Thane Central Jail. It is an elevated station. The catchment area of station are Shivaji Chowk, Manisha Nagar, Sahyadri Society, Kalwa Naka Bus Stop, Kranti Nagar, Kalwa, etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities • PT/IPT stops do not have dedicated bays • Poor road infrastructure	• Adequate connectivity to be planned • Dedicated NMT friendly facilities. • Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment.
	
	
Location of proposed station	Surrounding areas near proposed station
	
Land use along station location	Saket Balkum Road near the proposed station

22. Thane Junction

This is an underground station near existing Thane Sub-Urban station and CIDCO Bus Stop. This station will have interchange with Thane Junction and CIDCO Bus Stand. The catchment area of station are existing Thane Sub Urban Station, CIDCO Bus Stop, Naupada, Kopri, Gawate Wadi, Vitawa, etc.

Issues & Concerns	Potential for Improvements
• Lack of NMT facilities. • On-street parking causes reduction in efficient roadway width. • PT/IPT stops do not have dedicated bays which causes congestion at carriageway. • Limited ROW - pedestrian vehicular conflict	• Dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities • Seamless integration fbetween proposed metro, Railway station and CIDCO Bus Stand
	
	
Existing Bus stand near Thane station	Proposed location & Bus Shed near location
	
Existing situation of proposed station location	Existing auto stand & pedestrian pathway near exiting Thane station

6.1.3. STATION PLANNING

i. Planning Parameters

NBC (National Building Code) & NFPA 130 (Standard for Fixed Guide way Transit and Passenger Rail Systems) are used for station designing & planning.

ii. Station Planning – Coverage

The station planning is determined by the following factors:

- Operational requirements.
- Station entry/exit location
- Utilities such as fire fighting systems, ventilation, water requirements etc
- Structural requirements
- Flexibility in design to allow stations to respond to site specific requirements

The essential quality in a good station layout is the provision of adequate space for efficient movement of passengers between ground level entrances on to the trains and vice versa in the most direct, simple and logical way.

iii. Salient Features of a Typical Station

Station entrances provide the link between station concourse and the surrounding streets. Station entrances are located with particular reference to passenger catchment points and also cater for inter modal interchange which includes buses, IPTs, pick/drop by private mode etc. Important criteria that has been applied in the development of station planning include:

- Sizing of Station Passenger Facilities
- Stipulated Design Standards
- Emergency Evacuation
- Passenger circulation, comfort, ease of use, safety and security
- Operational accommodation (Back of House Areas)
- Electrical and Mechanical Plant and Equipment space requirements

Concourse forms the interface between streets and the platform. This is where all the passenger amenities are provided.

Office accommodation, operational areas and plant room space are provided in the non-public areas of the station.

The platform level has been designed for adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario (emergency).

The location of DG set, Bore Well Pump House, Underground / overhead tank, chiller plant and Pump Houses are preferably proposed to be located in one area at ground level wherever possible.

iv. Planning Norms & Standards

Station Design is dependent on the peak hour traffic load for each station. The platform length is planned for 6 cars/train. The evacuation time for the movement of all passengers in an emergency from platform level to the point of safety is as per NBC 2016 and NFPA 130 Guidelines in the stations. The station planning is also in compliance to the "Guidelines and Space Standards for Barrier Free Built Environment for Disabled and Elderly persons" published by the Ministry of Urban Affairs and Employment India in 1998.

v. Entry/Exit

Entrances to stations have adequate capacity to satisfy predicted passenger flows and emergency evacuation requirement. The position of entrances is determined by the juxtaposition of building location of roadway footpath width, space availability and flow directions of passenger traffic.

The numbers and width of staircases/ escalators are determined by checking the capacity/available width against peak passenger flows rates for both normal and emergency conditions such as delayed train service, fire etc.

vi. Concourse Planning Standards

The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. The stations are divided into public and non-public areas (those areas where access is restricted). The public areas are further subdivided into paid and unpaid areas. The concourse contains automatic fare collection system (AFC) in a manner that divides the concourse into two distinct areas called Paid and Unpaid areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms. The concourse is planned in

such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been proposed in front of the ticketing counters and AFCs gates. The “Non Public Areas” comprise of the Back of House (BOH) areas. The BOH areas consists of System Rooms, Operations, Staff Facilities, Water Supply and Drainage System and Miscellaneous requirements. Passenger handling facilities comprise of stairs/escalators, lifts, ticketing counters/automatic ticket vending machines and ticket gates required to process the peak traffic from street to platform and vice-versa. These facilities are provided in the concourse and they also act as a medium to transfer between Paid and Unpaid areas (these facilities also enable evacuation of the station under emergency conditions, within a set safe time limit). Uniform number of these facilities has been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station based on the peak hour passenger load.

vii. Operational Rooms for Public Use

Ticketing Gates

The ticketing system shall be simple, easy to use/operate, and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and requiring less man power. The requirement of the number of gates is based on the peak hour passenger traffic at the station. Uniform space has been provided at all stations where gates can be installed in the unpaid area of the concourse. Ticketing gates provides a means of transfer between paid and unpaid area of the concourse. Ticketing gates’ requirement has been calculated taking the gate capacity as 28 persons per minute per gate (85% of the Maximum Practical Capacity which is taken as 35 persons per minute per gate). In the design year output capacity of 35 passengers is assumed because of passenger’s familiarity with the system. At least two ticketing gates are provided at any elevated station.

- The gate design will depend upon;
- Check in and checkout (distance fare): implying bi-directional gates
- Fare media: smart card, magnetic or paper ticket.
- The most popular gates are with sliding glass panels (“pavel” design)
- Special gates are designed for;

- Widened ticket gates for Disabled persons access,
- Customers with luggage,
- Customers with strollers

The total number of gates also includes one service gate, one emergency exit door in case of breakdown, one separate gate for disabled in Elevated stations.

Ticket Counters and Ticket Vending Machines (TVMS)

It is proposed to deploy manual ticket issuing counters in the beginning of the operation of the line. At a later stage, automatic TVMs would be used, for which space provision will be made at the concourse. The number of TVMs required is governed by the peak hour passenger traffic, the fare policy and the ticketing. Depending on the composition of monthly pass/smart card users and single ticket users, the number of TVMs could change. Adequate provision has been kept at the stations for the TVM and Ticket counters in the unpaid area of the concourse and is suitably located for the ease of usability of the passengers. As a general thumb rule, it is proposed to provide 5 to 7 TVM's for stations with high traffic and 2 to 5 TVM's for other stations(**Figure 6.2**)

FIGURE 6-2: TICKET VENDING MACHINES AT STATIONS



Shinjuku Station Tokyo



MTR Wall mounted TVM with
maintenance corridor in the back – Paris

Shinjuku Station - Tokyo

MTR Wall Mounted TVM – Paris

Ticket Office

The number of Ticket Offices is determined by the passenger traffic and the operation policy. A minimum of 2 ticket office per station in the stations with high traffic, and 1 ticket office per station in the stations with low traffic have been planned (**Figure 6.3**)

FIGURE 6-3: TICKET OFFICE AT STATIONS



viii. Platform Planning Standards

The length of the Platform is 140meter. This allows for the length of 6 car train and a stopping tolerance for the rail corridor Platforms. The nominal platform width measured from the platform edge to any continuous (longer than 2000 mm) fixed structure shall be a minimum of 3000 mm. The minimum distance from the platform edge to any isolated obstruction e.g. columns, shall be 2500 mm (an isolated obstruction shall not be longer than 2000 mm). This clearance shall be maintained for safety reasons, irrespective of passenger flows. The platform width greater than the minimum may be required at stations with large passenger flows. The platform edge shall have a safety margin of 600 mm wide with a non-slip surface and a yellow warning strip of 100 mm wide of contrasting texture. The platform ends shall be provided with a 1200 mm wide security gate and be installed with a Pressure Mat Alarm system.

Platform widths Calculation:

The platform width shall be determined by the peak minute flow, allowing for two missed headways. The crush load is taken as the sectional load between two stations. For an island platform, the area between the boundaries of the two platforms is included in the calculation.

The process to derive the platform width calculations are detailed below:

Disruption of time of service = Two missed headways

Peak Minute Peak Direction Boarding = Peak hour Peak direction boarding/50. The peak minute flow taken in the calculations is assumed to be 20% higher from the average minute flow as derived from the hourly passenger volume. This takes into account the peaking minute during the peak hour flow of the passengers.

Platform congregation during disrupted time of service: Peak minute Peak direction boarding X Disrupted Time

Platform Width = {Platform Occupant Load} X 0.2/Platform length

Markings on the platform and ramps to assist and control the flow of passengers for boarding and alighting with a step free access from/to the trains shall be provided. Tactile Markings shall also be provided for guiding paths and warning strips for vision impaired persons to ease the travel for Persons with Disabilities. The built platforms shall also provide for bright colour contrast for low vision persons; large lettering and information displays and digital signage; lifts with lowered control panel with Braille and raised control buttons and auditory signals, wide doors and grip rails on the sidewalls of the elevator car; resting areas for senior citizens and disabled persons; well-lit platform corridors along with public announcement system. Inside the coaches, there will be designated spaces for wheelchair users, audio announcement with dynamic display and sensory door closing mechanisms. Space occupied by stairs, escalators, structure, seating, platform supervisor's accommodation etc. is not be included as part of the platform area. Platforms shall have a clear head room of at least 3000 mm to structures and platform signs to a width of at least 2000 mm from the platform edge over their entire length. Suspended signs, fittings, and fixtures shall have a minimum clearance of 2100 mm above finished floor.

ix. Emergency Evacuation Standards

The Requirement is to evacuate people from a station platform to the point of safety, initially the next level below or above and then on to street level without hindrance.

The principles to be followed are:-

The maximum distance on the platform to a point at which means of egress route leaves the platform shall not exceed 100 m. The provision in the station layouts from the remote point on the platform to an exit route has been kept within 50 meter.

The time required walking from the farthest point on a platform to the escalator or stair landing is considered to be half a minute. Walking speed as per NFPA 130 has been taken as 37.8 meter/minute.

A Check shall be made to ensure that sufficient capacity exists at the level to which passengers are evacuated as being a place of ultimate safety so that people can move freely away from stairs and escalators as they arrive. The emergency is assumed to be occurring in one direction of travel only at any given point of time.

For ensuring adequacy of platform area, stair widths and requirement of additional 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 (or full train load if the section load exceeds a full train load) expected to be evacuated from the peak direction at the station in case of an emergency. Also, waiting passengers congregated during this disrupted time of service (two missed headways) in the off-peak direction to be added in the evacuation from the platform to concourse in case of underground stations and concourse to ground in both underground as well as elevated stations.

x. Operational Rooms (BOH Areas)

Back of House (BOH) areas comprise of "Public" and "Non Public Areas". The BOH areas consist of System Rooms, Operations, staff facilities, Water Supply and Drainage System and Miscellaneous requirements.

Some of the areas and their functions are detailed below:

Station Control Room

The station control room is required to control and monitor the stations' equipment (fire-fighting systems, ventilation, etc.). It is generally located in the concourse of each station. It is recommended that the operator can easily access any part of the station from this office. This room is fitted with a dialog box for passenger information.

Ticket Office

The Ticket Office can also be used to inform passengers. If the main Ticket Office is located next to the Station master control room, it will be fitted with a self-closing door between these two rooms. The room will require special protection (as armored glass, metal doors, etc.).

TVM back-store room

For security reasons, the Ticket Vending Machines should be equipped with a back store room. The TVM back-store room is preferably located near the Ticket Counters.

Security/Police Room

This room is located in each station and is used by the security staff. It is preferable that this room is located at the concourse, in the public operation area allowing

watching over the public. This room could be fitted with specific equipment in relation to the role of security staff.

Water Storage

The Design of the Water tank is based upon the assumption of 35 liter/person for raw and treated water. The capacity of the Water Tank is provided as 50 cum approximately(as per NBC 2016) for each elevated station and that for the UG station, it is taken as 2 lakh litres. However, when commercial areas are present within metro stations, firefighting facilities shall need augmentation as per NBC 2016.

xi. Escalator Design

The following regulations and standards shall form the basis for the design of escalator system.

- American National Standard Institute (ANSI)
- American Society of testing Materials (ASTM)
- International Electro technical Commissions (IEC)
- Indian Standard (IS)
- European Norm (EN)
- National Electrical manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)

Design Criteria

The escalators will be heavy duty “public” service escalators capable of operating safely, smoothly and continuously in either direction, for a period of not less than 20 hours per day, seven days per week, (except special holiday which may be operated 24 hours a day) within the environmental conditions prevailing within the well way and at the location where the escalators are installed. The maximum allowable passenger load of each step should not be less than load equivalent of three 65 kg person per step. The escalators will be equipped with energy saving system. Speed of escalators will be in the range of 0.6-0.75 m/s for normal operation. The energy saving system will reduce speed of escalators to standby speed mode of 0.20 m/s during low traffic hour. The number of flat steps at the upper landing should be in proportion to the vertical rise of the escalator. For 6.1 m to 18.3 m rise, minimum four flat steps should be provided and for a rise up to 6.1

m manufacturers' standards should be used (2-3 flat steps). The design of the escalators which act as emergency stairways should meet all the criteria requirements in NFPA 130. The design of the escalators will be such that they can be used as fixed staircases under a condition of power failure, activation of stop button or activation by safety/protection devices. When the escalators are stationed, no slipping, jerking, sliding and vibration should occur. Escalators will be equipped with protective barriers, where necessary.

Interfacing requirements:

The following escalators interface will be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault
- Emergency
- Elevator Requirements
- Standards, Codes and Regulations

xii. Elevator Design

The following regulations and standards will form the basis for the design of elevator system.

- American National Standard Institute (ANSI)
- American Society of testing Materials (ASTM)
- International Electro technical Commissions (IEC)
- Indian Standard (IS)
- European Norm (EN)
- National Electrical manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)

Design Criteria

Lifts will be of the goods/passenger public service type and rated at minimum 180 starts per hour. Lifts will be of proven technology and designed to have low energy consumption, low operational costs and will provide environment friendly passenger service. Lifts will be rope traction type capable of operating safely and smoothly without jerking under all loading conditions, for a period of not less than 20 hours per day (except special holiday which may be operated 24 hours a day),

seven days per week within the environmental conditions prevailing within the hoist-way and at the location where the elevators are installed. Lift will be capable of carrying minimum loading of 750 kg, and may be sized for comfortably taking an injured person on a stretcher with room for the stretcher bearers to place the stretcher in the lift without difficulty. The design of the lift will take into consideration fire prevention, elimination of dust and dirt traps, and easy access for cleaning and routine maintenance. The drive machine, its associated machinery and all necessary control equipment of lifts at stations will be installed within the lift shaft without any lift machine room. Intercom will be provided inside the lift car to communicate with the Station Operation Room of the station where lifts are installed. The leveling accuracy at the landing served, under no load and full load condition in either up and down direction, will be made within + 5 mm. The speed of lift will be capable of reaching the uppermost discharge point in not more than one minute. The time will be calculated from the time the doors are fully closed at the lowest discharge point to the time that they begin to open at the uppermost discharge point. The minimum speed will be not less than 1.0 m/s irrespective of the travel distance. Lifts will be equipped with facilities for physically challenged people, in accordance with the relevant standards.

Interfacing Requirements:

The following shall be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault
- Emergency Status.

xiii. Stairs Requirements

- A central handrail is provided where stair width is 4.5 m or more.
- Risers per flight: 3 minimum, 12 maximum
- All Steps in a flight of Stairs have the same dimensions
- Tread width :300mm; Rise : 150mm
- Length of intermediate landing: lesser of 2m or width of stairs
- Handrail: 0.9m high, 50mm diameter, 45mm clearance to wall.
- Step noses will be rounded and color contrasted
- Minimum Stair width for assembly building: 2000mm

xiv. Commercial Areas for Retail Shops/Kiosks/ATM's

Retail shops in the stations could provide additional financial income. The expected level of passenger traffic in the stations provides great potential for a high commercial value for the retail shops. Here the station area is small so such Kiosk/shops may be provided outside the station where parking provision exist.

xv. Roof and Elevations

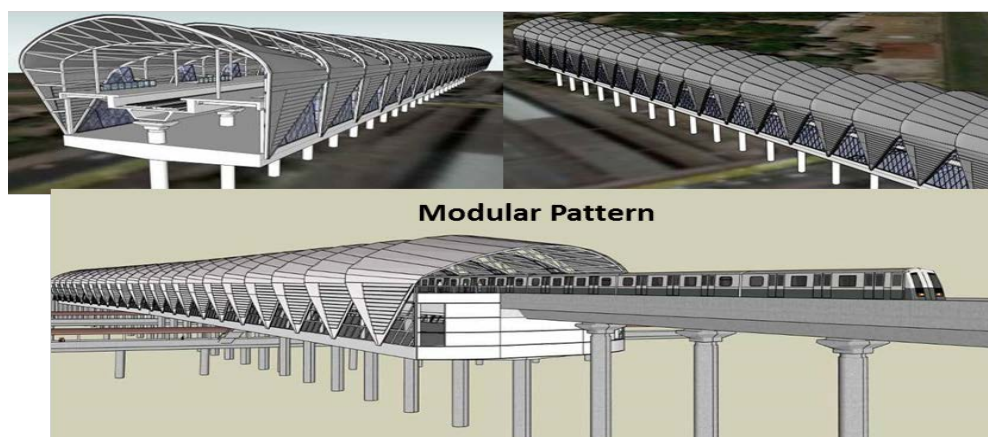
The roof is the most visible part of the station from the surroundings. At approximately 18 to 26 m height, the roof will be the iconic signature of the station identity. It has to reflect the modern and contemporary values of the new line, while being human scaled and properly sized to offer visual comfort for users.

Two types of roof (**Figure 6.4**) concept for elevated stations are proposed;

The single shell: A set of triangle modules of 15 m span, slightly inclined on the top, and chasing the soft northern light, while being closed to the south side, to protect from the sunlight and harsh shower of monsoon season.

In addition, the modular pattern could be easily adapted to the curvy layout of many of elevated structures.

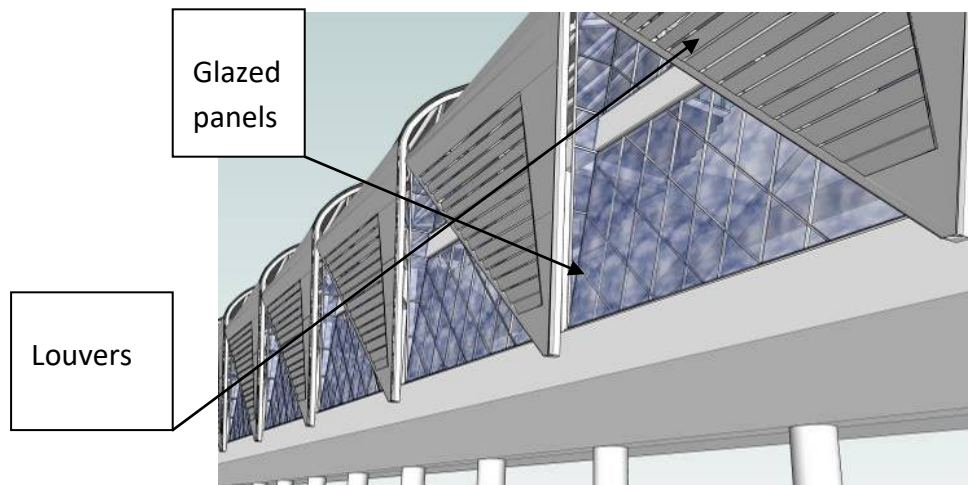
FIGURE 6-4: ROOF TYPES



Natural ventilation on platforms and concourse area is ensured through louvers embodied in the lateral side of each module.

In the spare space between two modules, a glazed façade could be erected to protect laterally from the elements. Further detailing during implementation can improve some of the opacity of the glazed panels to the natural light and air flows.

FIGURE 6-5: LOUVERS FOR VENTILATION



xvi. PLANNING OF METRO STATIONS

The conceptual station planning are the adaptations of the typical stations finalized keeping in view the projected traffic, station requirements, site conditions, minimal land acquisition, method of construction and overall cost optimization. Since land is at a premium throughout the corridor, the process of reconciling the land that is actually required for the station development has had a major influence upon the design process and important elements of the stations such as entry/exits, concourse, platforms etc have been designed and marked for each station to overcome land acquisition problems. But, wherever the vacant land parcels have not been found available, land acquisition has been proposed for placing the necessary utilities/facilities. The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation. The stations have been provided with an internal environment suitable for a world class Light Rail system by incorporating the experience of international best practices. The stations have been planned in such a way that they are easily operated, maintained and can be upgraded in future. Accommodation for staff and plant rooms is provided at both platform and concourse levels within areas that are entirely separate from the public access. The internal arrangement for the stations is evolved in such a way that Back of House accommodation is organized, so that the rooms of a similar operational use are placed along a common corridor and plant accommodation is clearly distinct from habitable rooms. The detailed descriptions for the elevated station typology are detailed in subsequent section.

xvii. Typical Elevated Station: 140m x 21.95m Cantilevered Structure

The size of the elevated station has been kept as **140m x 21.95m**. The stations are generally located on the road median. Total length of the station is 140m. All the stations are two-level stations. The passenger areas on concourse level is concentrated in the middle of the station, with 2 staircases, escalators & elevators leading from either side of the road. The total width of the station is restricted to 21.95m. It is planned to be a cantilevered structure thereby keeping flexibility for provision of a wider carriageway in future below the concourse with 3m wide central median. 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, UPS & battery room, signaling equipment room, communication equipment room, TSS Room, auxiliary substations, security room, refuse store & cleaners Room, staff room, etc. The public zone is further divided into paid and unpaid areas. Public toilets, communication closets have been provided in the Platform Level.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5m has been provided under the concourse. Concourse floor level is about 8m above the road. Consequently, platforms are at a level of about 14.74m from the road.

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

In station 3m wide staircase is provided on either side of the platform along with two escalators on each side of the platform. Provision of 1 lift has been proposed.

Platform roofs that can invariably make a structure look heavy; have been proposed to be of steel frame with aluminium cladding to achieve light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station

building. The rest of the station structure is supported on a single column, which lies unobtrusively on the central verge. The section and plans for this typology is presented in **Figures 6-6**. The room schedule for this typology is given in **Table 6-2**

TABLE 6-2: ROOM SCHEDULE FOR ELEVATED STATION(140MX21.95M)

Room No.	Room Name	Room Size (m)		Area Provided (Sq.m)
A-0.1	Station Control Room	10.44	3.68	38.50
A02.1	Excess Fare Office	3.75	2.0	7.50
A02.2	Excess Fare Office	3.75	2.0	7.50
A03.1	Ticket Office	2.81	6.12	17.22
A03.2	Ticket Office	2.81	7.95	22.33
C-01	Signaling Equipment Room	5.38	5.84	28.01
C-03	Communication Equipment Room	9.23	7.95	73.37
P-01,02	Auxiliary Substation	VARIES	VARIES	250.95
P-03	UPS Battery S & T Room	7.97	5.45	43.53
-	Clean Gas Room	5.84	3.00	17.50
O-02	Paid Area	VARIES	VARIES	858.19
O-03.1	Unpaid			269.80
O-03.2	Unpaid			269.80
O-04	Security Room	4.0	2.725	10.92
O-08.1 F	Toilet Female	3.19	3.57	10.73
O-08.2 F	Toilet Female	2.75	3.57	10.43
O-08.1 M	Toilets Male	3.56	4.69	16.74
O-08.2 M	Toilets Male	3.56	4.69	16.74
O-09.1	Toilets (H)	2.76	2.28	6.30
O-09.2	Toilets (H)	2.76	2.28	6.30
O-11.1	Janitor's Room	3.19	2.17	6.90
O-12 & O-14	Cleaners Room & Refuse Store	2.70	3.87	10.44
O-13	Staff Room	3.90	3.87	15.093
O-18.1	Platform A			446
O-18.2	Platform B			446
PD-1		VARIES	VARIES	48.83
PD-2		VARIES	VARIES	106.70

xviii. Typical Underground Station: 190m x 23.55m

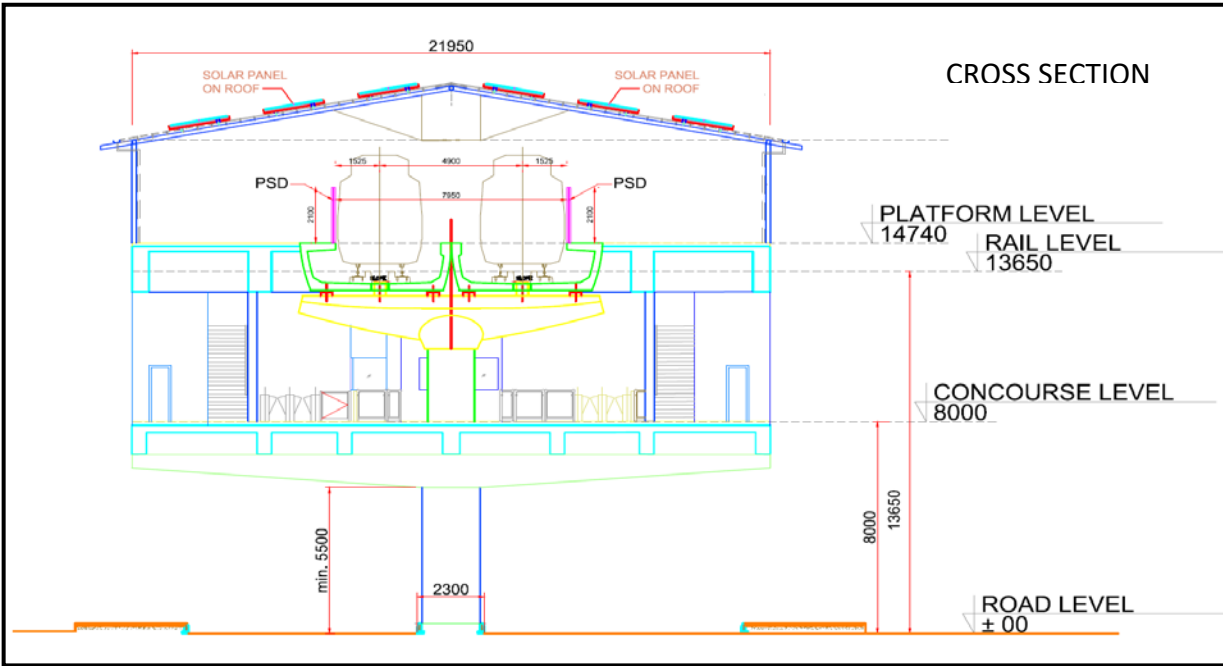
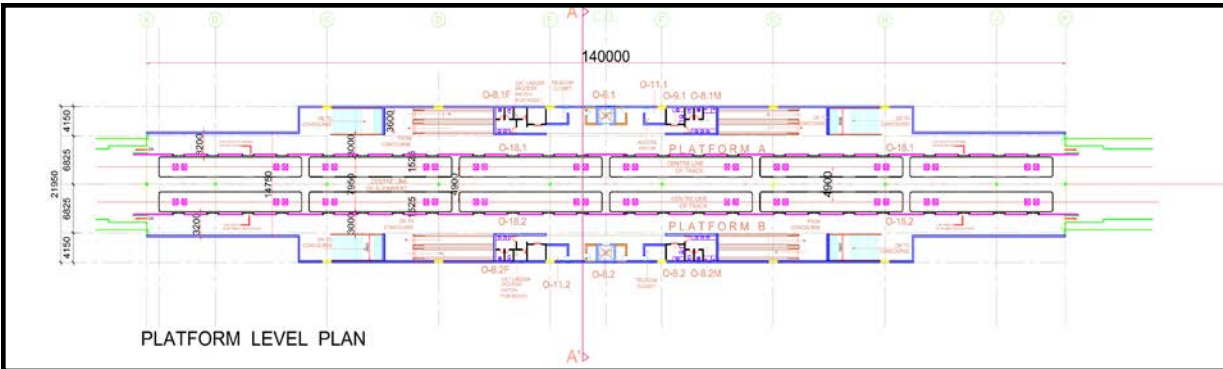
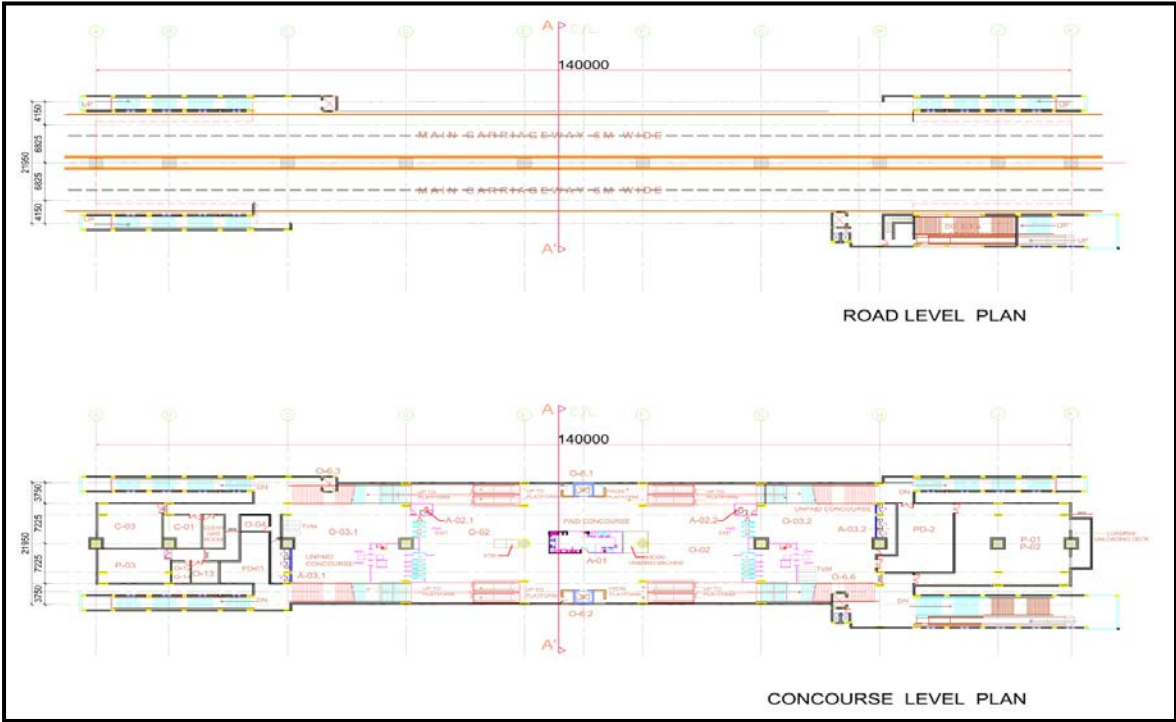
The typical Underground station having size 190m x 23.55m overall. The station have been planned for 6 car coach having the platform length 140m. The construction of station will be of cut and cover method. The room schedule for this typology is given in **Table 6-3**

TABLE 6-3: ROOM SCHEDULE FOR UNDERGROUNDSTATION (190mx23.55m)

Room No.	Room Name	Room Size (m)		Area Provided
A-0.1	Station Control Room	7.20	6.225	44.82
A02.1	Excess Fair Office	2.50	2.50	6.25
A02.2	Excess Fair Office	2.50	2.50	6.25
A03.1	Ticket Office	2.50	4.50	11.375
A03.2	Ticket Office	2.50	4.320	10.80
A04.1	Secure Suite	3.50	2.84	9.94
A04.2	Secure Suite	2.70	6.40	17.28
A05.1	Ticket Office Store & Safe	2.50	2.34	5.925
A05.2	Ticket Office Store & Safe	2.50	1.85	4.625
O-08 M	Toilet(Male)	3.105	4.10	12.71
O-08 F	Toilet(Female)	2.50	4.10	10.25
O-08.1 M	Staff Toilet(Male)	1.80	3.15	5.67
O-08.1 F	Staff Toilet(Female)	2.50	2.75	6.875
O-09	Toilet for Physically Disabled	1.80	3.00	5.40
O-10 F	Locker Room	2.80	3.70	10.36
O-10 M	Locker Room	2.80	2.50	7.00
O-11	Janitor's Room	3.20	1.90	6.08
O-16.1	Fire Escape Staircase	8.10	3.90	31.6
O-16.2	Fire Escape Staircase	8.10	3.90	31.6
O-17.1	Fireman Staircase	2.30	5.50	12.65
O-17.2	Fireman Staircase	1.50	11.36	17.04
O-19.1	Refuse Area	3.765	5.625	21.17
P-03	UPS Room	10.195	6.34	64.63
C-01	Signalling Room	3.20	4.40	14.08
C-03	Communication Room	9.785	5.625	38.16
O-16.1	Fire Escape Staircase	8.10	3.90	31.6
O-16.2	Fire Escape Staircase	8.10	3.90	31.6
M-03/M-04	Water Pump Room	3.00	6.375	19.12
M-09.1	Mechanical Equipment	Varies	Varies	487.19
M-09.2	Mechanical Equipment	Varies	Varies	523.01

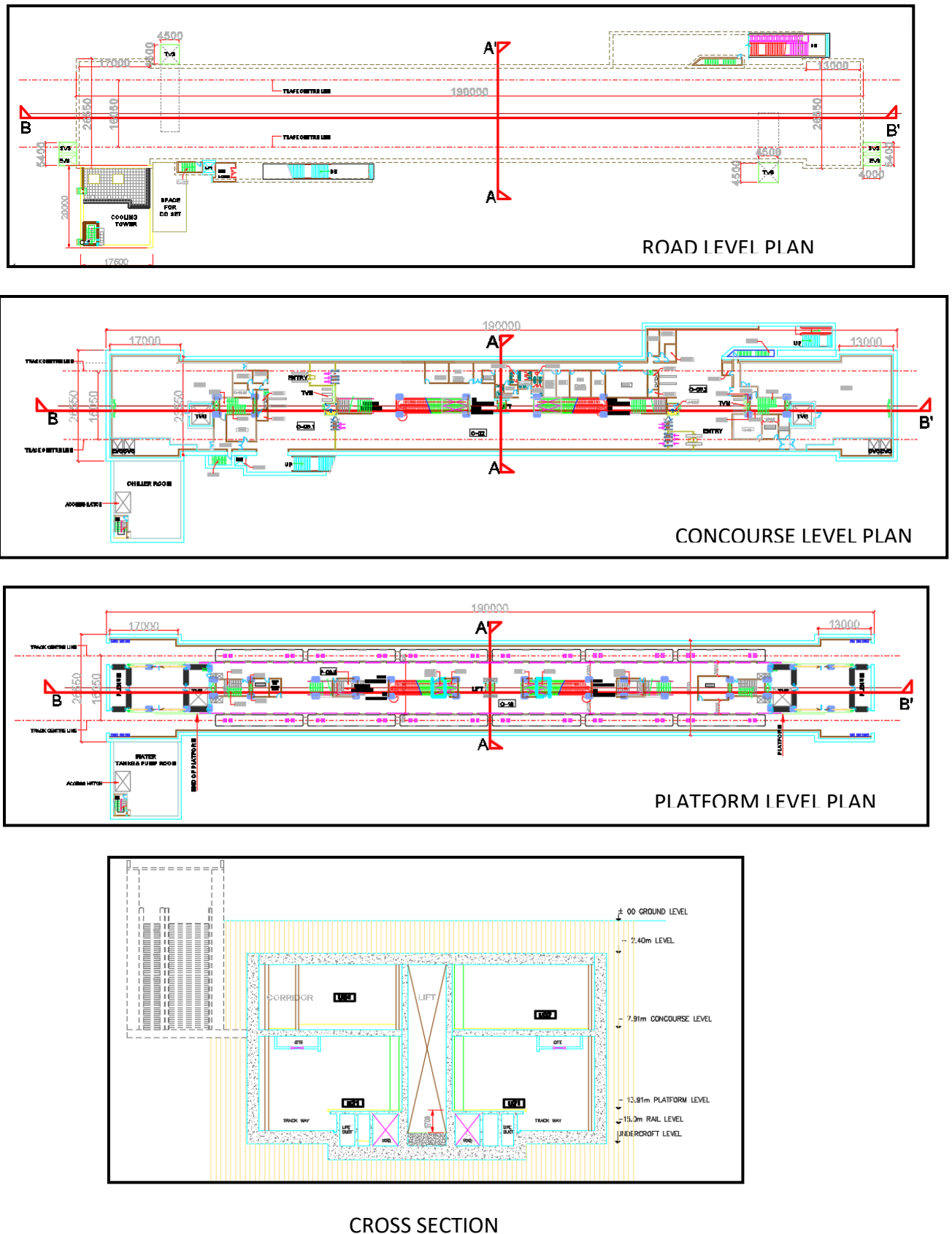
A typical elevated station of Thane Metro is presented in **Figure 6-6**.

FIGURE 6-6: TYPICAL ELEVATED STATION



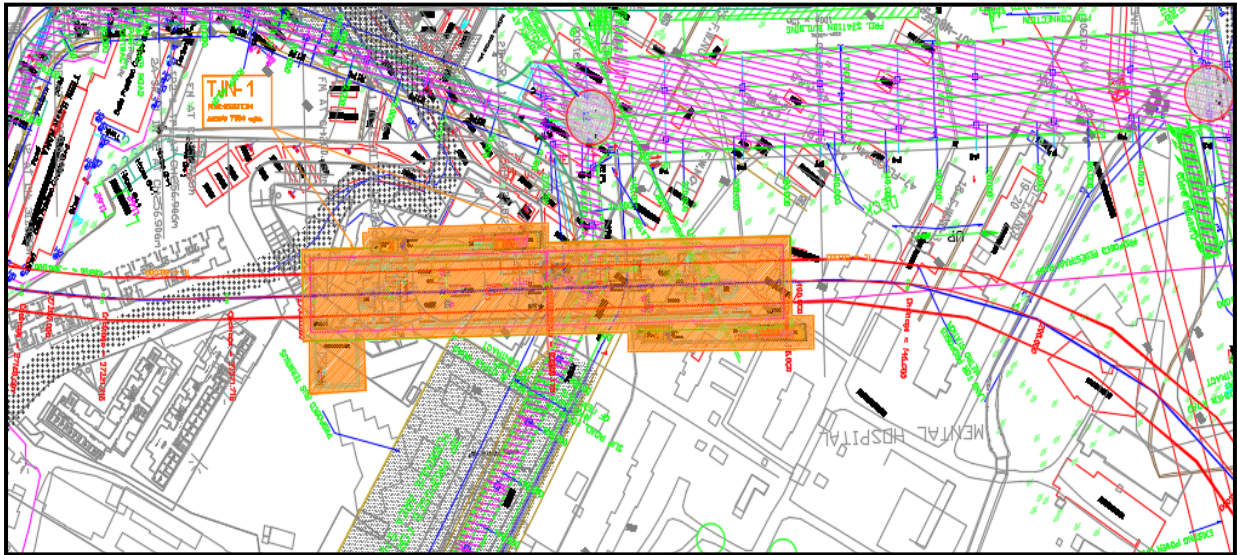
Typical Underground station of Thane Metro is presented in **Figure 6.7**.

FIGURE 6-7: TYPICAL UNDERGROUND STATION

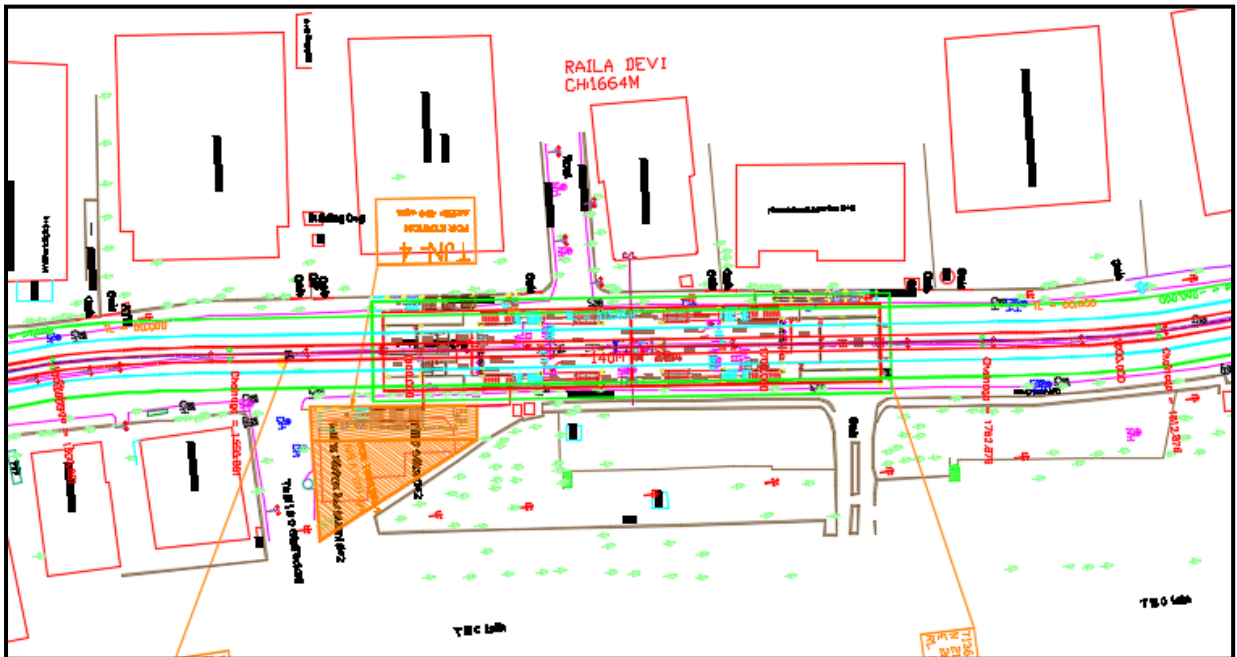


6.1.4. STATIONS ON SITE

1. NEW THANE



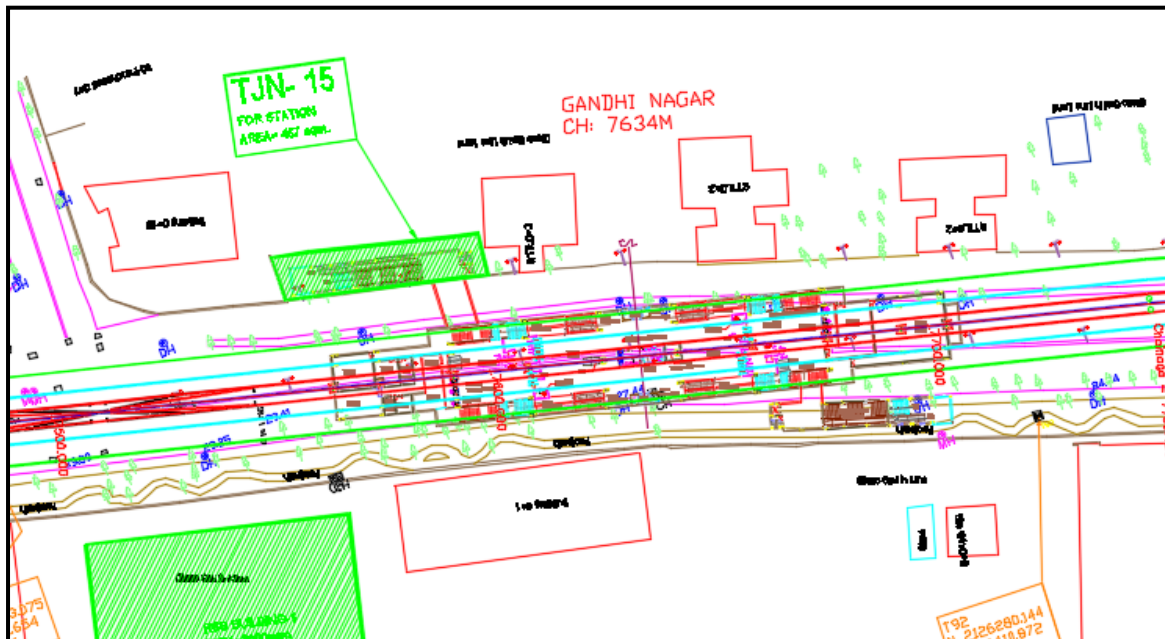
2. RAILA DEVI



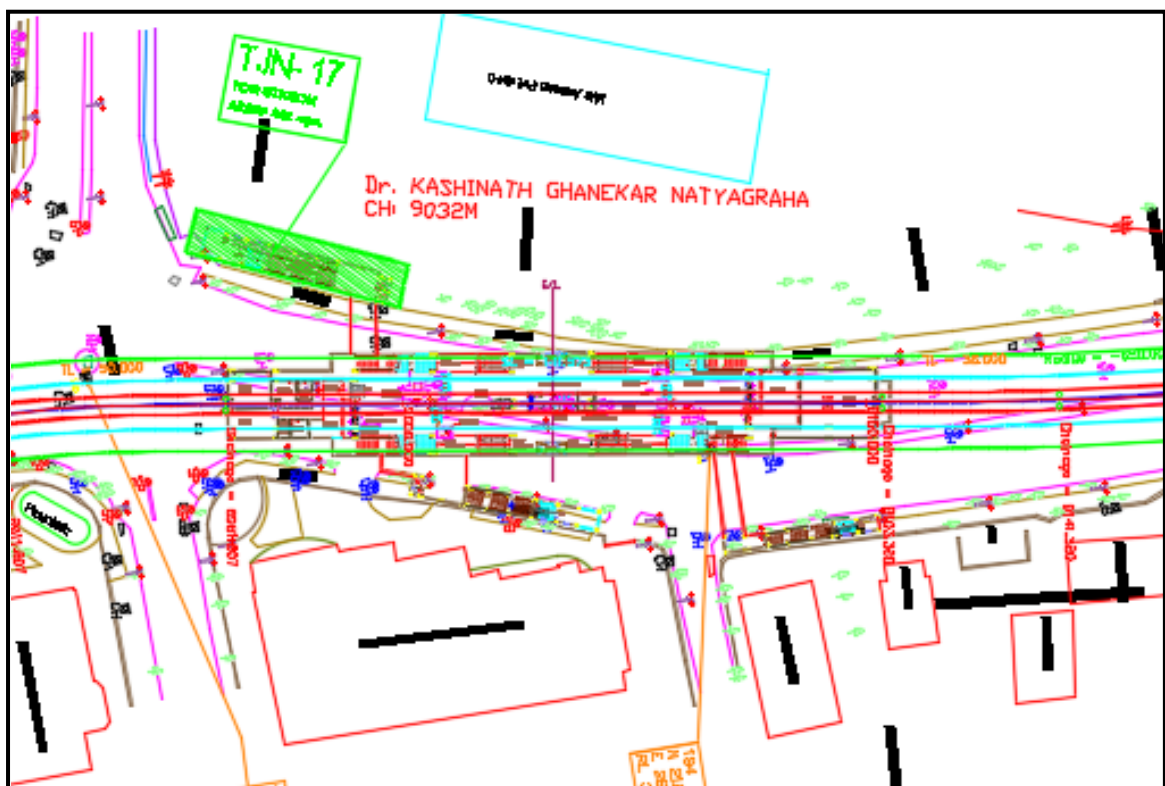
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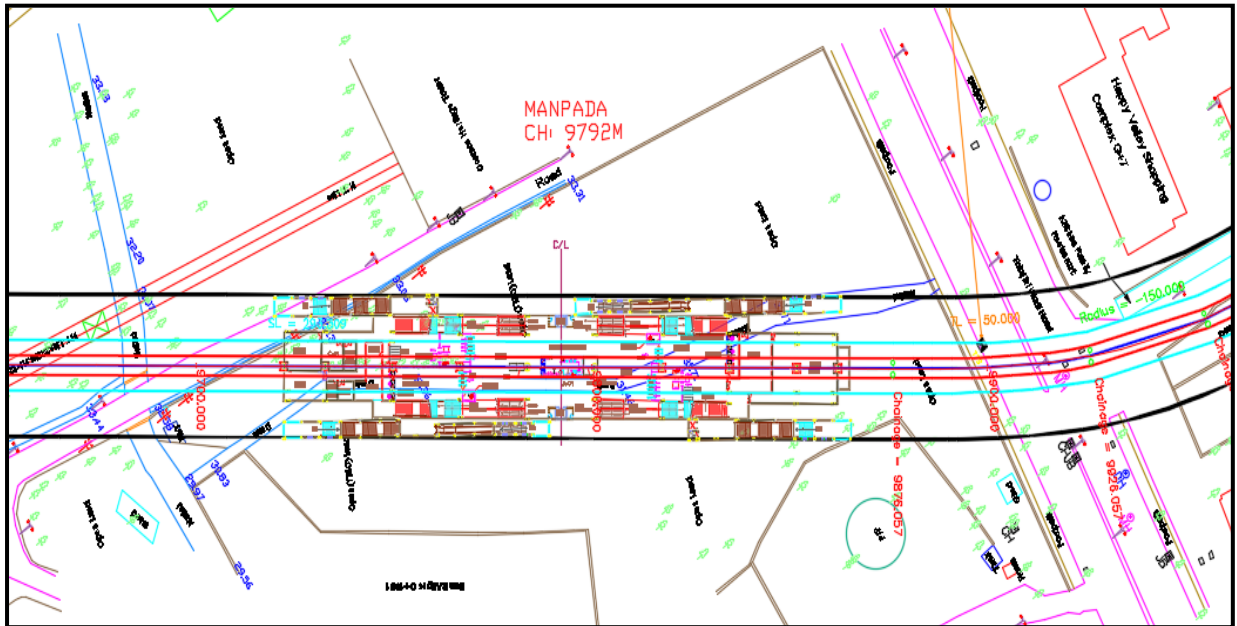
7. GANDHI NAGAR



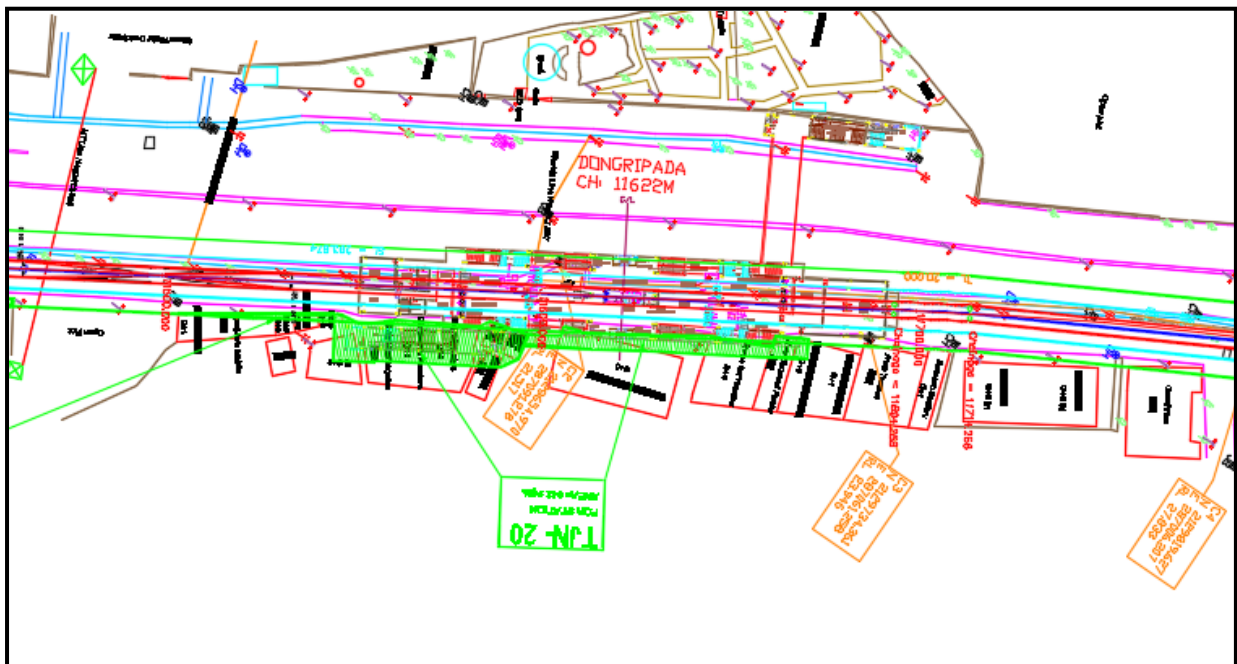
8. DR. KASHINATH GHANEKAR NATYAGRAHA



9. MANPADA



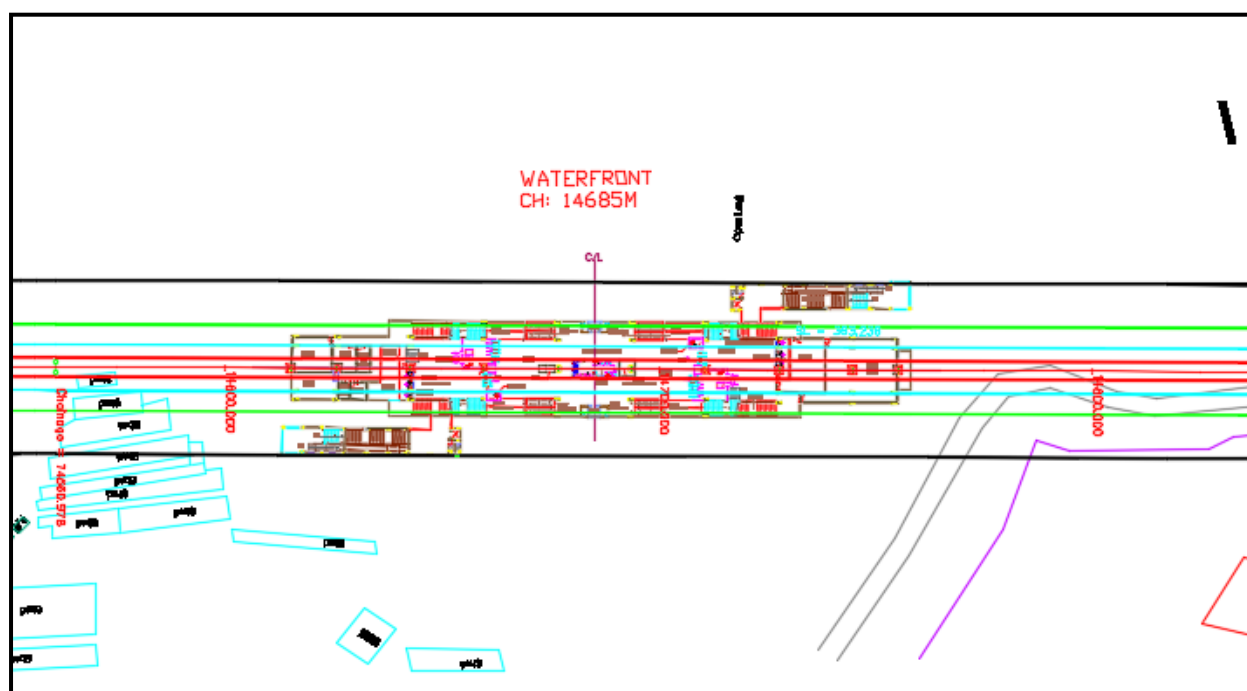
10. DONGRIPADA



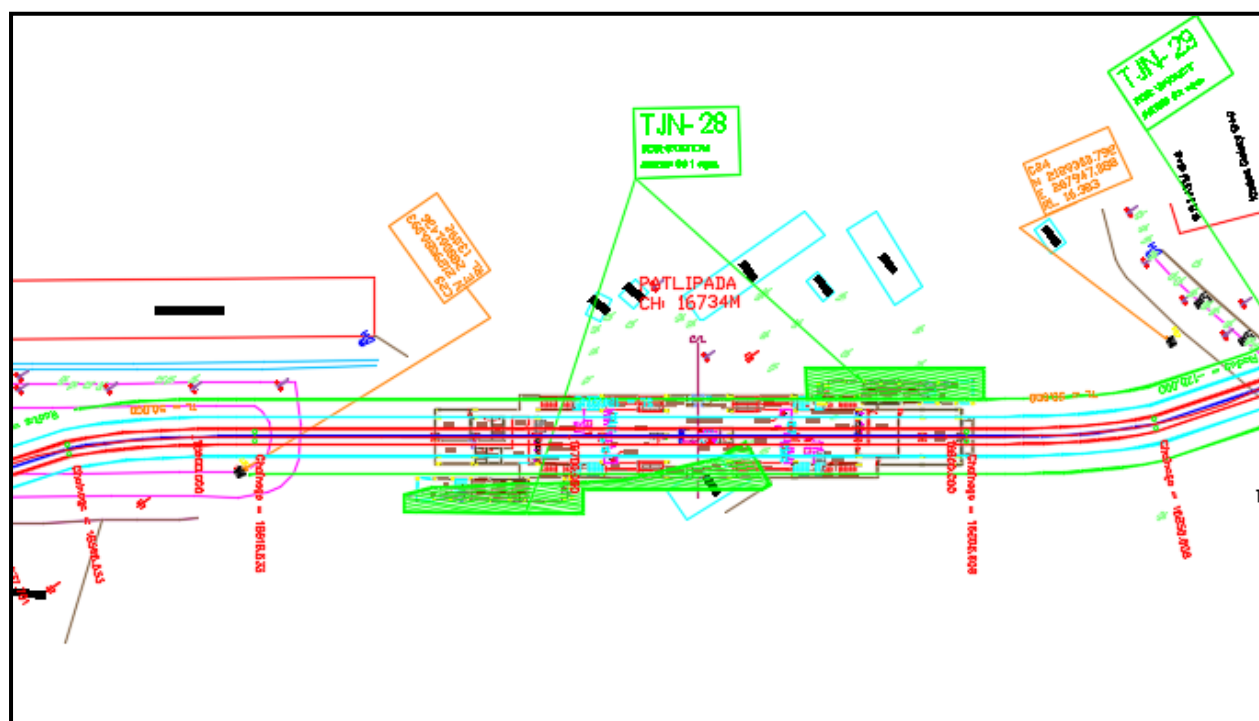
[illegible]

The drawing is a complex site plan or map. At the top center, it is labeled "WAGHBIL CH 13611M". To the right of this, there is a green hatched area labeled "FOR PARKING AREA - 2000 S...". Below the main title, there are several colored lines representing different types of boundaries or roads. A blue line runs horizontally across the middle, with "TL = 50.000" written above it. Another blue line runs vertically through the center, with "13700.000" written to its right. A red line runs diagonally from the bottom left towards the center, with "13540.812" written next to it. There are also other numbers like "13540.812" and "13540.812" scattered around. Various symbols and icons are used throughout the drawing, including small squares, circles, and rectangles, some of which are labeled with letters like "A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", "M", "N", "O", "P", "Q", "R", "S", "T", "U", "V", "W", "X", "Y", "Z". Some areas are labeled "Open Land". There is a scale bar at the bottom left indicating distances from 0 to 10 meters.

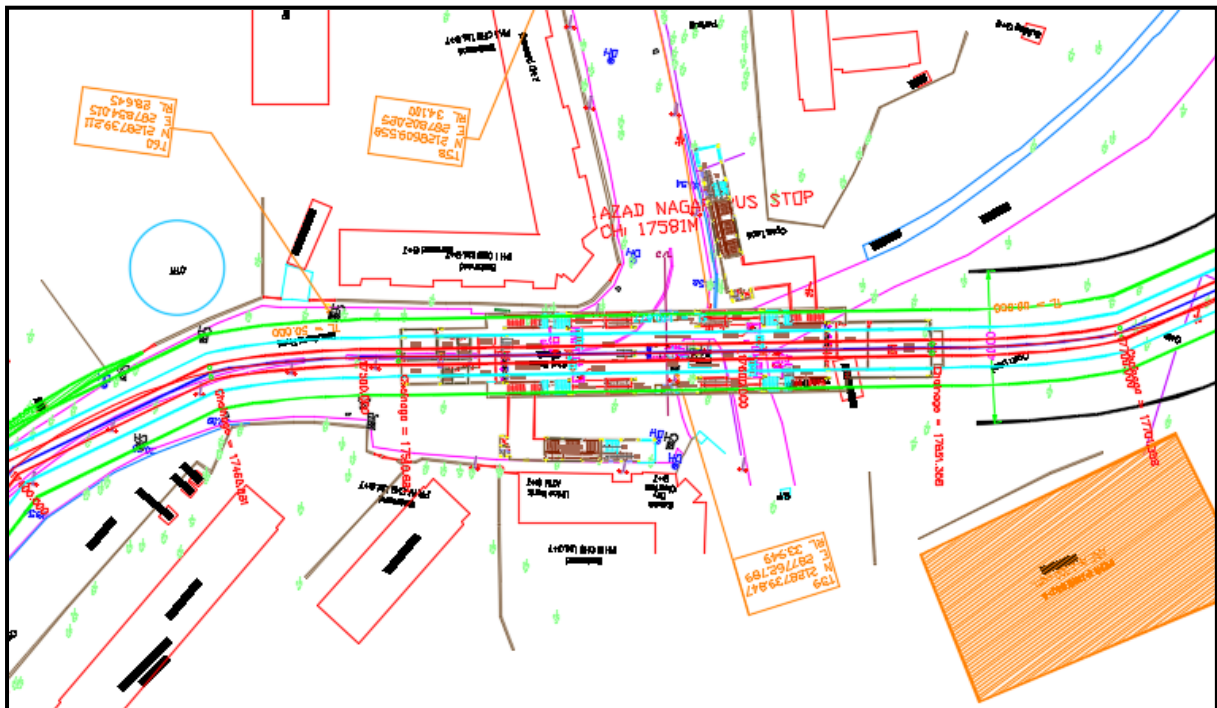
13. WATERFRONT



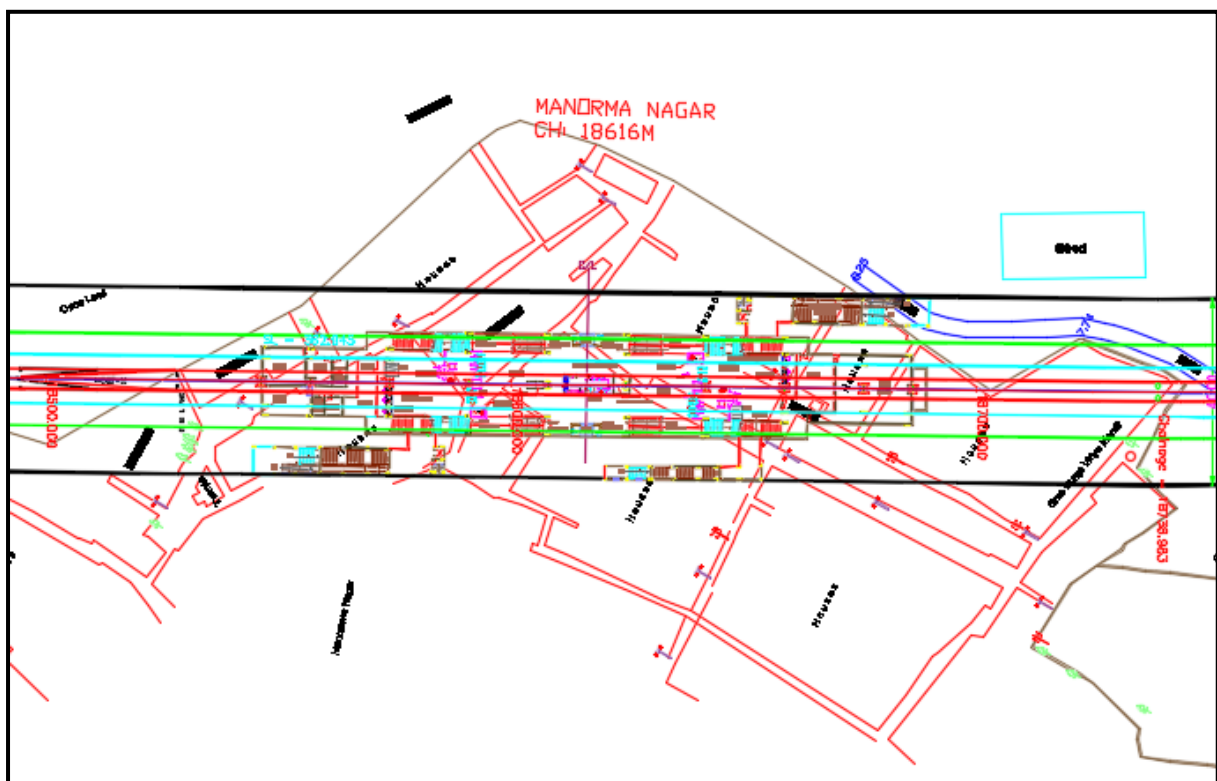
14. PATLIPADA



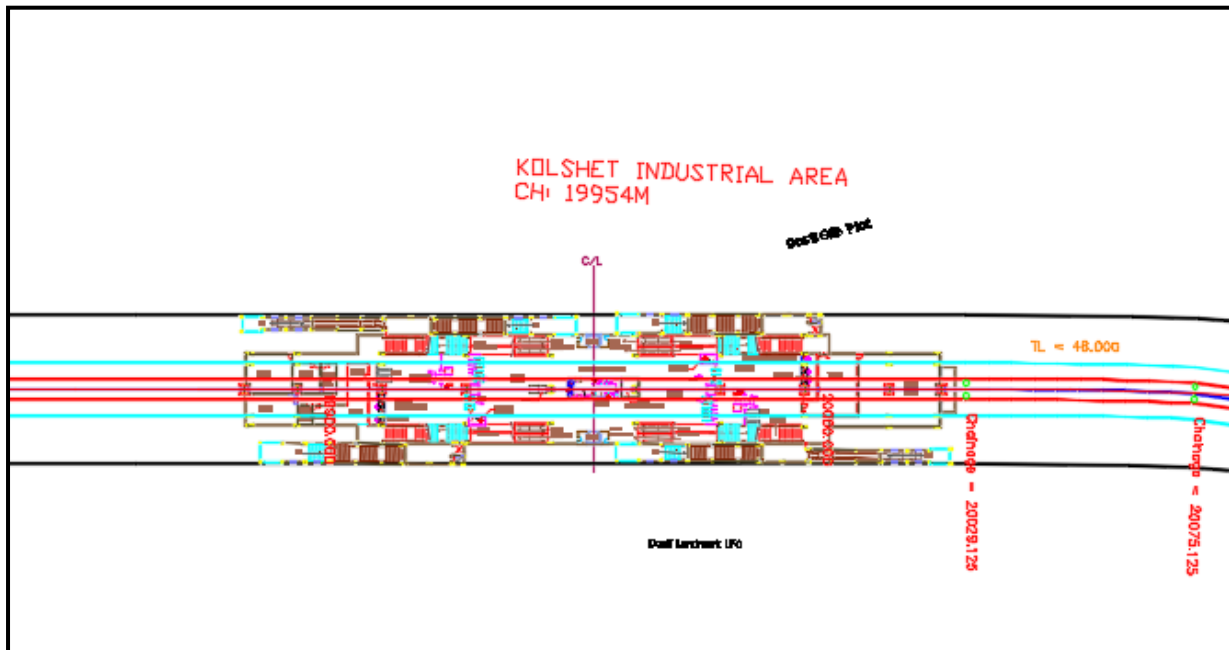
15. AZAD NAGAR BUS STOP



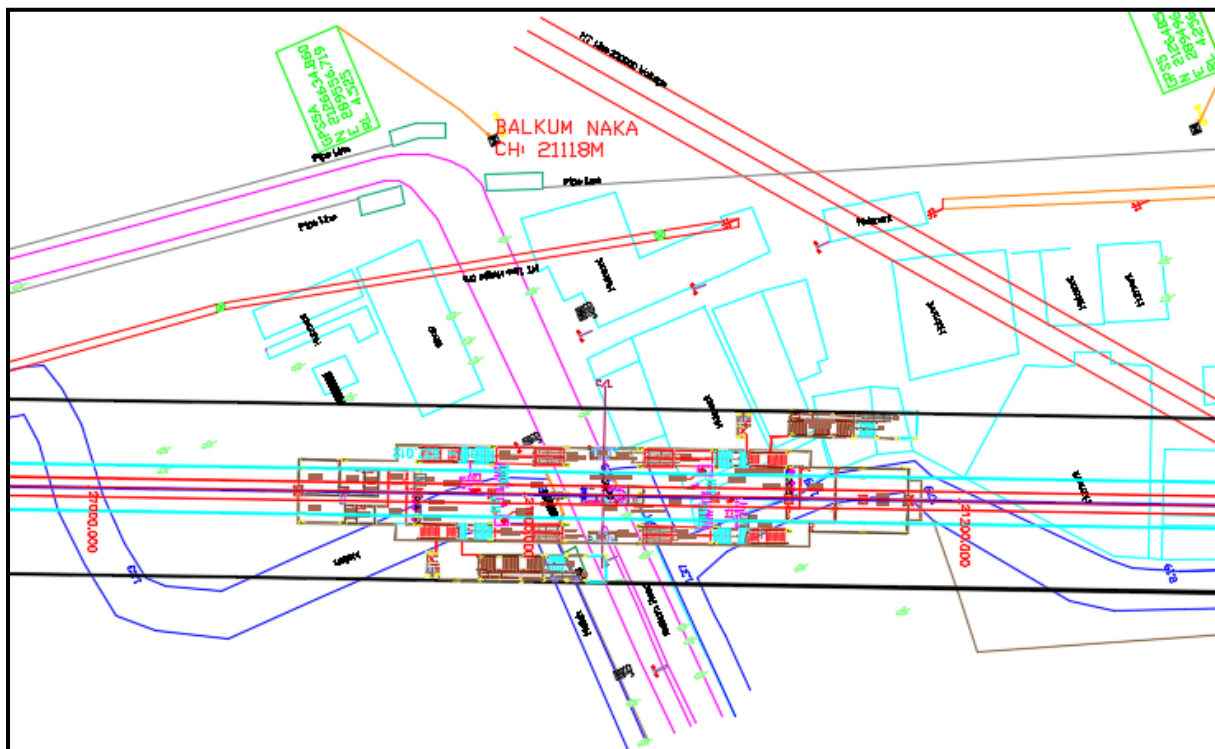
16. MANORMA NAGAR



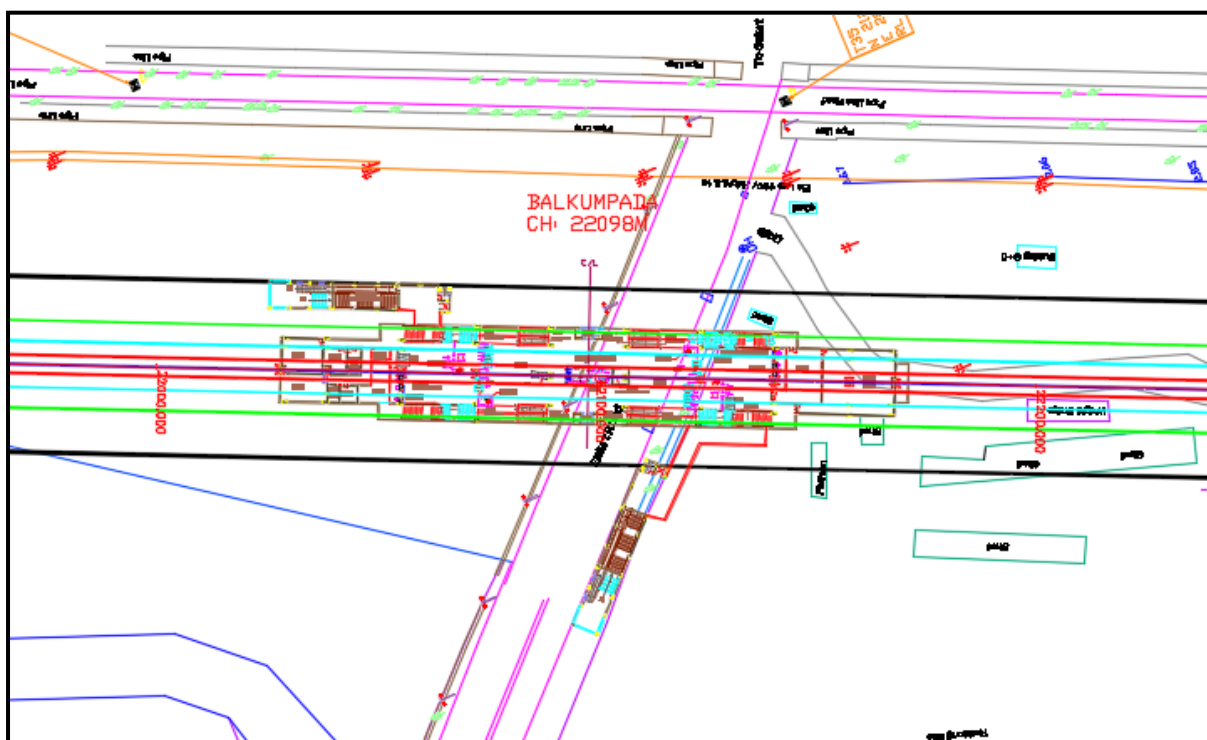
17. KOLSHET INDUSTRIAL AREA



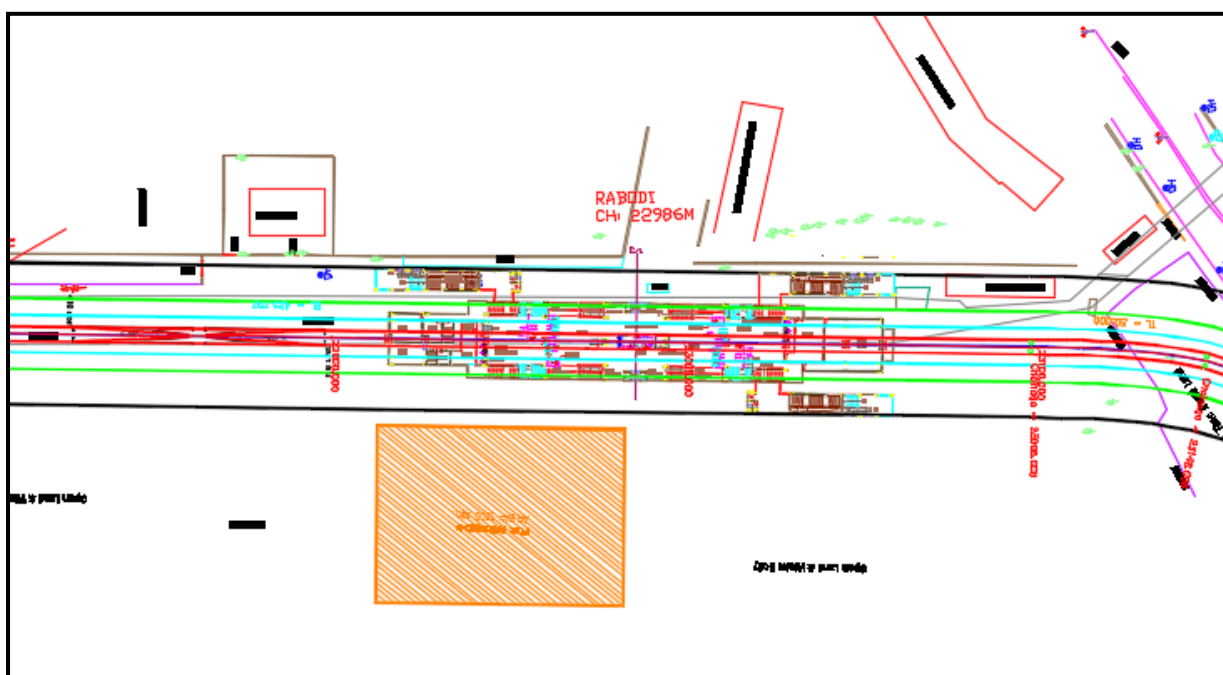
18. BALKUM NAKA



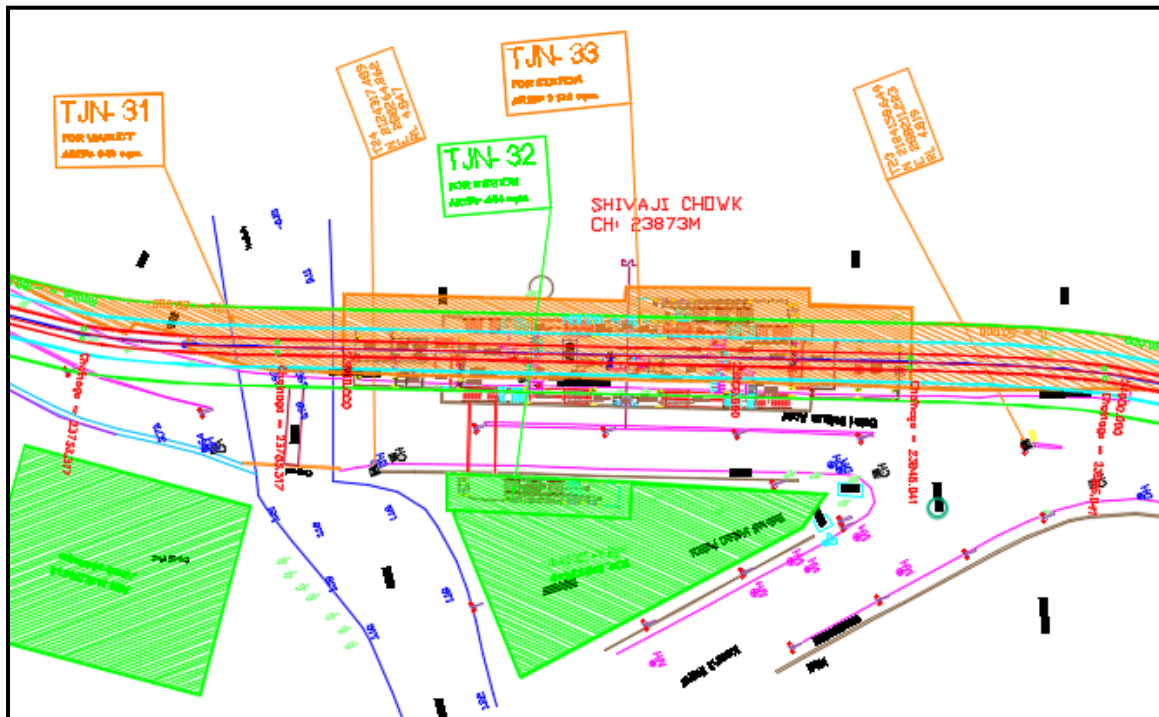
19. BALKUMPADA



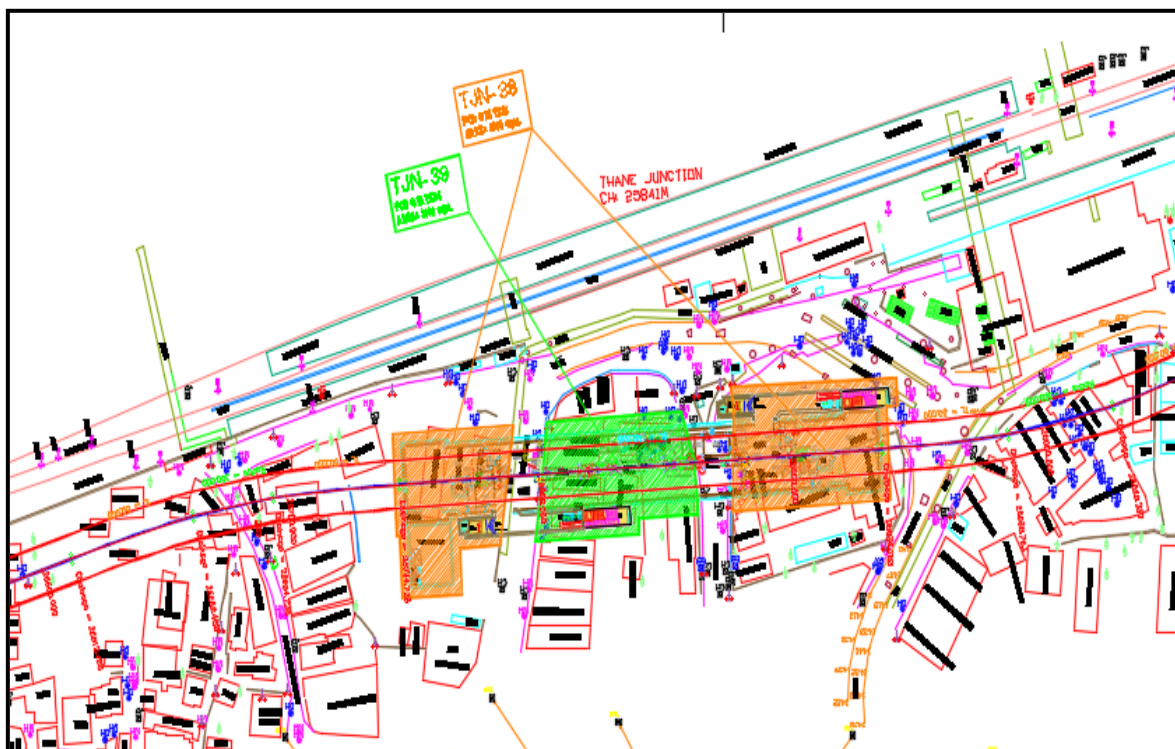
20. RABODI



21. SHIVAJI CHOWK



22. THANE JUNCTION



6.2. STATION AREA PLANNING FOR NON-MOTORIZED VEHICLE AND PEDESTRIANS FACILITIES

The following pedestrian facilities and non motorized vehicles facilities have been planned near the station influence area.

The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

The station entry/exit have been planned keeping in view the major growth centers/activity areas. The entry/exit has been designed to integrate the station with existing/ proposed bus stops/bus bays, pick-drop zones and IPT services within walking distance.

Pick and drop zones and bays for feeder modes like buses, IPT have been proposed near the station.

Dedicated linkages have been proposed like subways, skywalks, covered walkways etc. at interchange stations which reduces the passenger travel time and pedestrian load on the roads.

All the footpaths in the metro station influence zone have been planned to be upgraded to desired level of comfort and also proposed new within the stations vicinity areas. The existing road shoulder areas and service lanes also have been augmented/ strengthened in the design wherever possible to utilize the complete ROW to cater to the future traffic volume

A minimum of 1.8m wide footpath has been proposed on the local roads whereas a continuous footpath of 2 m width on the major roads to provide accessibility to people on wheel chairs.

The vendors if any on the footpaths shall be removed and desired accessibility to metro stations will be provided. Junctions and intersections have been proposed with proper pedestrian crossings. In the design, table top crossings has been proposed wherever possible, otherwise ramps with gentle slope ranging from 1:5-1:7 have been designed for pedestrians.

FIGURE 6-8: PEDESTRIAN FACILITIES PROVIDED NEAR THE PROPOSED STATIONS

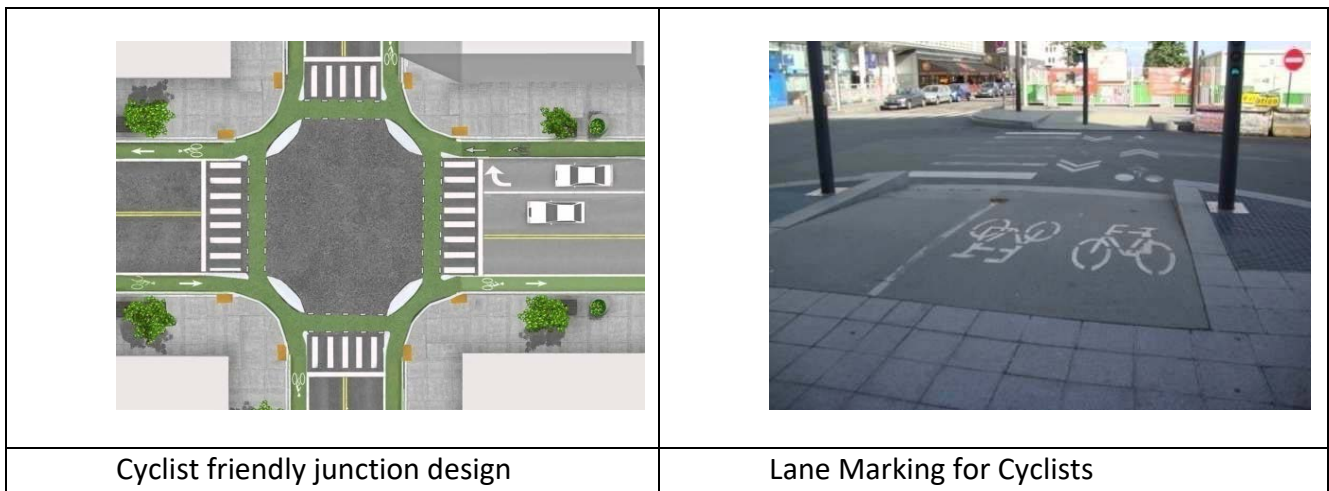
	
Table top crossing for pedestrians	Ramp from footpath to carriageway for easy movement
	
Footpath and Cycle Track Facilities	Footpath for Pedestrian Movement

For non-motorized vehicles like bicycle, rickshaw etc, separated NMV lane have been planned within the station influence area for smooth circulation based on the availability of land.

The design has been incorporated with a 2-m continuous strip of cycle track on both sides of the road around stations in accordance to available RoW.

The cycle track will be differentiated by colour, markings and material for uninterrupted movement.

FIGURE 6-9: NMT FACILITIES AT STATION AREA



6.3. ACCESSIBILITY FOR DIFFERENTLY ABLED

Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons-1998 and revised in 2013 by Ministry of Home and Urban Affairs and other international best practices have been considered.

User-friendly mass transport system can ensure accessibility to persons with differently abled, people travelling with small children or carrying luggage and the elderly persons. The following measures will be considered while planning of metro stations for such persons:

A metro route map in Braille/raised numbers shall be maintained at the enquiry/ticketing window. In each car, there shall be an announcement and provision of a visual display of the names of stations en route.

Tactile Guiding Paver (Line-Type) and Tactile Warning Paver (Dot-Type) shall be installed from station entry up to the platform boarding/alighting place for visual impaired persons wherever is needed.

At least one of the ticket gates shall allow a wheelchair user through and have a continuous line of guiding paver for people with visual impairments.

Public dealing counters (Information or help desks) shall be close to the terminal entrance, and highly visible. They shall be clearly identified and accessible to both those who use wheelchairs and those who stand.

Staircase, lift and ramp shall be planned for persons with learning differently abled, intellectual differently abled, and elderly persons. Location shall be clearly visible from the pedestrian route. Lifts shall have both visual and audible floor level indicators.

In emergency situations, audible alarms with 'voice instructions' 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). **Figure 6.10** shows various differently abled features as proposed in the station.

FIGURE 6-10:VARIOUS DIFFERENTLY ABLED FEATURES IN/AROUND STATIONS

	
Tactile Guiding Tiles for Way finding	Station Entry symbols for all users
	
Signage for accessible washroom	Way finding signage

6.4. PARKING ON STATIONS

Dedicated parking provision for station are key factors in determining success of a Metro system. Parking provisions along pedestrian facilities like footpath and feeder systems would encourage more commuters to use the transit system who could safely park their vehicles at the nearest station, walk to the station or rely on feeder

connectivity. The tentative station wise parking facility area for personal vehicles and bicycle as planned along corridor is presented in **Table 6.4.**

TABLE 6-4: DETAILS OF PARKING FOR THANE METRO CORRIDOR

S. No.	Station/Location	Parking Area in Sqm
NEW THANE TO NEW THANE (Ring Corridor)		
1	Raila Devi	650
2	Lokmanya Nagar Bus Depot	2100
3	Waghbil	2000
4	Azad Nagar Bus Stop	3000
5	Rabodi	3500
6	Shivaji Chowk	2300
Total along the Corridor		13550

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity other than walking to the station. For catchment area of about 0.5-1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-Wheeler and auto-rickshaws. Areas beyond the 2-km catchment will require regular feeder bus services to reach the metro station. Adequate arrangements have been provided for receiving and dispatch of PT/ IPT at all stations. Parking for these stations have been already located in the Alignment Plan.

Chapter – 7

INTERMODAL INTEGRATION

7. INTERMODAL INTEGRATION

7.1 INTERMODAL INTEGRATION WITH EXISTING MODES

The concept of inter-modal integration with the modes is to provide last mile connectivity to the commuters residing/working in the MRTS influence zone. The MoHUA has also laid down policy guidelines to include this important aspect of last mile connectivity in the DPRs for the MRTS systems. This connectivity is expected to be achieved through proper access to the metro stations by city buses, intermediate public transport (auto rickshaws and cycle rickshaws) and pedestrian facilities etc.

Inter-modal integration explores the coordinated use of two or more modes of transport for efficient, speedy, safe, pleasant and comfortable movement of passengers in urban areas. It provides convenient and economical connection of various modes to make complete journey from origin to destination.

The inter-modal integration with existing modes have been planned at MRTS stations for efficient passenger movement. The proposals have been formulated for facilitating traffic dispersal and circulation facilities based on the following considerations:

- Dedicated linkages have been proposed like subways, skywalks, covered walkways etc upto existing bays which will reduce the passenger travel time and pedestrian load on the roads.
- Availability of total carriageway and footpath widths required to cater to the proposed traffic volumes to be augmented through strengthening of road shoulder areas and relocation of vendors/hawkers, on-street parking and all encroachments from the service/ access roads.
- Designated space for embarking and disembarking for vehicular traffic (pick-drop zones) and existing modes like Buses, IPTs and NMT have been proposed.
- Proper design of circulation area has been planned to adjoin the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.

Based on above, intermodal integration plans for selected metro stations of have been prepared and presented in **Annexure 7.1 to 7.5**.

7.2 FEEDER SERVICES PLANNING AT STATIONS

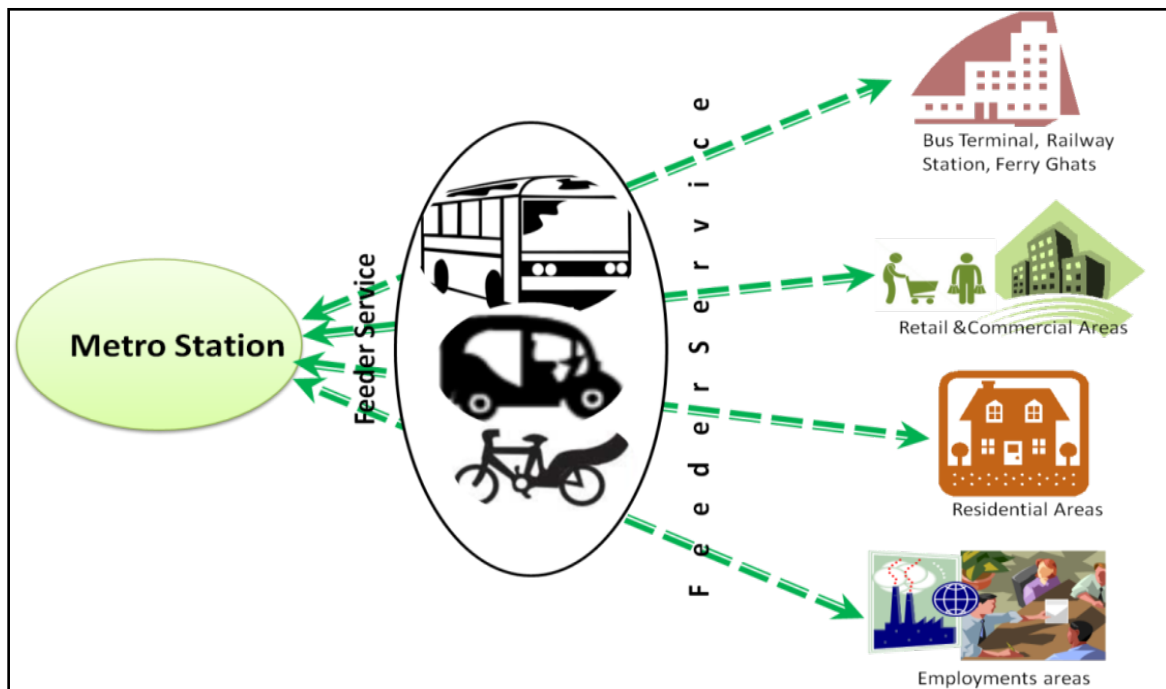
7.2.1 Feeder Modes

The planning of seamless transport integration facilities at the influence zones of various metro stations is of utmost importance. Feeder services to the proposed MRTS network are essential for convenient and quick transfer of passengers. As all commuters will not be living within walking distance of the proposed network, proper planning for feeder services will be necessary.

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity to the metro station. For catchment area of about 0.5-1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-wheeler and cycle / auto-rickshaws. Areas beyond the 2-km catchment will require feeder buses to reach metro station.

The feeder service facilities are proposed at metro stations to connect the trip generation/ attraction areas in the influencing zones. **Figure 7.1** shows the concept of provision of feeder services to a MRTS system. The facilities of footpaths, feeder buses and bicycles (bike sharing) have been planned for peak hour passenger demand.

FIGURE 7.1: CONCEPT OF FEEDER SERVICES AT MRTS STATION



7.2.2 Feeder Bus Service

The feeder buses shall be of high quality, ultra-modern and customer oriented that can deliver fast, comfortable and cost-effective urban mobility. Easy-to-board (low floor), attractive and environmentally friendly mini buses with air conditioning having capacity of 35 (seating + standing) (for minibuses) are proposed for feeder system.

The facilities of feeder buses have been estimated for peak hours of various horizon years 2025, 2035 and 2045. Boarding/alighting at metro stations have been used to determine the bus fleet requirement. Boarding/alighting at metro stations in various horizon years is given in chapter 3 of this report. Modal split of access modes have been assumed to assess the bus fleet and bicycles requirement. The assumed modal split is shown in **Table 7.1**. The feeder bus fleets requirement are presented in **Table 7.2**. The total number of buses required are 72, 83 and 86 in the year 2025, 2035 and 2045 respectively. The feeder route planning has been identified at almost all stations as presented in **Figure 7.2**. Total 17 feeder routes have been planned for Thane Metro corridor. The proposed feeder routes have also been integrated with the nearby metro stations.

TABLE 7.1: ASSUMED MODAL SPLIT

Mode	Assumed Modal Split
Car	5%
2W	15%
Auto	30%
Bus	30%
Cycle	20%

7.2.3 Public Bicycle Sharing Service

This service will be provided for the passengers for 1 km to 2 km of the Metro stations influence area. A bicycle sharing system is the service in which bicycles are made available for free and shared use to Metro passengers on a short-term basis. The main purpose is to allow passengers to depart or arrive at Metro stations. The requirement of bicycles along the Thane Metro corridor is estimated and is presented in **Table 7.3**.

TABLE 7.2: FEEDER BUS FLEET REQUIREMENT FOR THANE

sn	Metro Station	Route No.	Route	LENGTH km	Reqd No. of Buses in Peak Hour		
					2025	2035	2045
1	New Thane	R1	New Thane To Sunapur Bus Stop Via Eastern Expressway, Goregaon-Mulund Link Road	5.5	5	5	5
		R2	New Thane To Vadkarrop Via Mental Hospital Road, Lal Bahadur Shastri Marg, Raghavendra Swamiji Marg	3.6	3	4	3
2	Raila Devi	R1	Raila Devi To Sunapur Bus Stop Via Balrajeshwar Road, Mulund Coloney Road	6.5	5	5	5
		R2	Raila Devi To Maha Nagar Palika Via Rd No. 12, Mahanagar Palika Road	3.0	2	2	2
3	Lokmanya Nagar Bus Depot	R1	Lokmanya Nagar Bus Depot To Central Maidan Via Acharya Atre Marg	4.0	5	6	5
		R2	Lokmanya Nagar Bus Depot To Savarkarnanagar Via Vithal Mandir Marg	2.0	3	3	3
4	Gandhi Nagar	R1	Gandhi Nagar To Kalwa Station Via Pohkaran Road No.2, Eastern Expressway, Chahu Bhiva Marg	2.2	2	3	2
		R2	Gandhi Nagar To Divya Devi Nagar Via Dividaya Society Road Phase-1	3.0	3	3	3
5	Dongripada	R1	Dongripada To Bhayander Pada Via Ghodbunder Road	4.5	7	10	10
		R2	Dongripada To TMC Garden Via Ghodbunder Road, Tikuji Ni Wadi Road	3.0	4	6	7
6	Waterfront (TCS)	R1	Waterfront (TCS) To Anand Bus Depot Via Forest Avenue Road	3.0	7	10	12
8	Balkum Naka	R1	Balkum Naka To Bhiwandi Railway Station Via Balkum Road, SH 35	2.5	1	1	2
		R2	Balkum Naka To Teen Haat Naka Via Old Agra Road, Eastern Expressway	3.7	1	1	2
9	Rabodi	R1	Rabodito Reti Bunder Circle Via Kalwa Bridge, Mumabi Pune Road	4.0	6	6	6
		R2	Rabodi To Willman Company	2.0	3	3	3
10	Thane Junction	R1	Thane Junction To Gavanpada Publuic Garden Via Maharaja Agrasen Chowk, Advani Chowk, Chikhladevi Road	3.5	6	6	7
		R2	Thane Junction To Ambedkar Nagar Via Thane Belapur Road	5.0	9	9	9
			TOTAL		72	83	86

FIGURE 7.2: PROPOSED FEEDER ROUTE MAP ALONG METRO CORRIDOR

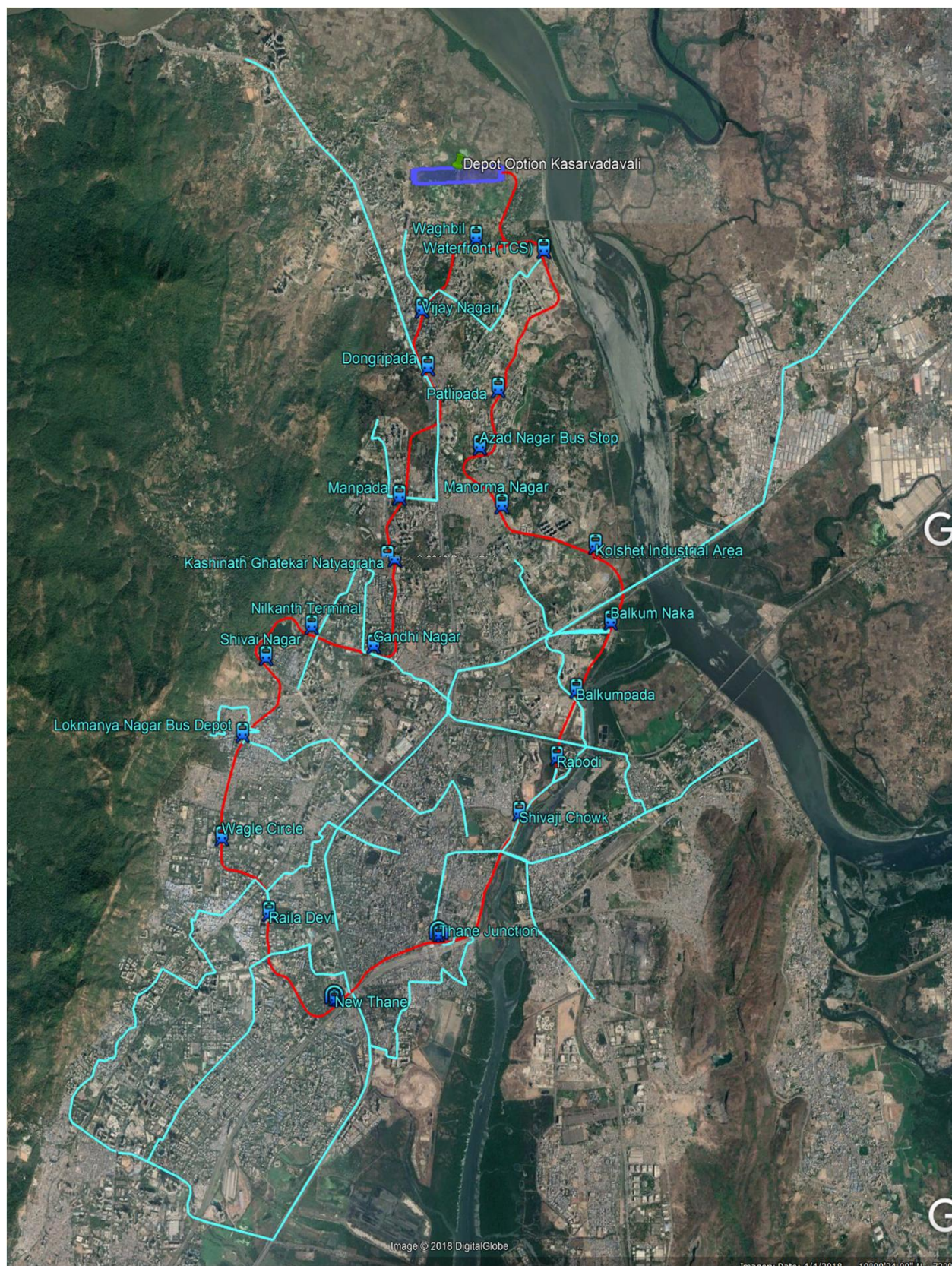


TABLE 7.3: BICYCLE SHARING SCHEME FOR Metro CORRIDOR

Sn	Metro Station	Reqd No. of Bicycles in Peak Hour		
		2025	2035	2045
1	New Thane	54	52	44
2	Raila Devi	38	34	33
3	Lokmanya Nagar Bus Depot	67	72	63
4	Gandhi Nagar	45	54	50
5	Dongripada	74	92	110
6	Waterfront (TCS)	56	72	82
8	Balkum Naka	16	17	18
9	Rabodi	72	76	71
10	Thane Junction	81	85	91
	TOTAL	503	554	562

7.3 PHYSICAL INFRASTRUCTURE REQUIREMENT FOR INTERMODAL INTEGRATION

Physical infrastructure facilities have been planned to facilitate easy transfer of commuters between different modes of transport. Seamless mobility is proposed to remain connected between different transport modes i.e. MRTS, city bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

- Demarcations of designated bus bays have been proposed with proper shelter near station entry/ exits by utilizing road shoulder areas.
- Demarcations of planned IPT/private pick and drop facilities, wherever land is available have been proposed. Most of the passengers use IPT / taxis for short distances.
- Relocation of vendors/hawkers and removal of all encroachments from the station precinct.
- Off – street parking lots be identified to avoid on-street parking
- Continuous, encroachment free and well-maintained footpaths of 1.8m to 3 m width as per land availability have been planned near the station area.
- Proper road markings, Zebra crossings, & table top crossings have been provided near the station influence area.

The physical infrastructure requirement for intermodal integration facilities and passenger traffic dispersal at all stations along the metro corridor have been proposed on the basis of availability of land and suitably incorporated in station plans.

In case of skywalks and subways, the following facilities are suggested for differently abled and senior citizens:

- Footbridge ramps with appropriate resting places/ landings
- Within the subway, a handrail set 850mm-900mm above the walking surface should be provided.
- To assist visually impaired people, tactile paving/ tiles and a colour contrast should be provided at the top and bottom of the flight of steps and these areas should be well lit.
- Elevator/lift should be provided on both the entrances/exits and should have minimum internal dimensions of 1400mm x 1400mm.
- All Lifts to have Braille buttons and audio announcement systems.

7.4 RECOMMENDATIONS FOR INSTITUTIONAL, PHYSICAL, FARE, OPERATIONAL AND TECHNOLOGY INTEGRATION

Some of the essential features of an integrated multi-modal urban transport system are the physical integration of public transport services, fares, ticketing, infrastructure provision, management, pricing, and integration of transport authorities.

7.4.1. Physical Integration

Physical integration refers to the provision of jointly used transport facilities & equipment to provide seamless mobility. Integration of physical space, network planning and physical infrastructure have been planned to facilitate easy transfer of commuters between MRTS, city bus system, feeder bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

Augmentation of carriageway and footpath in station vicinity to cater to traffic volumes has been proposed through strengthening of road shoulder and relocation of vendors/hawkers, on-street parking and all encroachments.

7.4.2. Operational Integration

This involves application of management techniques to optimize the allocation of transit resources and coordinate services. The techniques/principles of network integration include:

- Coordinated Routing and Scheduling- in which high-capacity, such as metro system is considered as trunk system and buses act as feeder to the metro.

Accordingly, the integrated route network may be planned by generating feeder bus routes for selected MRTS station.

- Rationalization of redundant services- wasteful duplication of transit service by competing systems may be eliminated and resources redeployed to reduce headways on existing routes and extend services into new areas.
- Network coordination and access- in which access facilities may be provided for non-motorized transport (pedestrians and cyclists) and private transport to support and enhance the public transport operations, to achieve overall network integration.

The service integration takes into account all modes implying the services will be complementary to each other within the station area.

7.4.3. Fare Integration

The basic principle behind fare integration is that one ticket provides access to all modes of transport even when managed by different operators. Choice of fare structure is a very important part of public transport planning. It directly influences operators' revenue. At its simplest, integration of fares, allows a person to make a journey that involves transfers (within or between different transport modes) with a single ticket that is valid for the complete journey, modes being buses, trains, MRTS, taxis, parking, etc. The major benefits of fare integration are as follows:

- It encourages people to use public transport by simplifying the transfer between transport modes and by increasing the efficiency of the services
- Provides a common ticket across the modes
- Improves the experience of seamless mobility

Smartcard ticketing systems enable commuters to carry one durable card for use on all transit modes. A single multipurpose ticket makes using multiple transport modes much simpler and less time consuming. In turn, this facilitates the multimodal travel behaviour that is encouraged by operators and transport planners. In this regard, smartcard ticketing is proposed to facilitate a genuinely seamless multimodal transport system for Thane city.

7.4.4. Information Integration

Creating the possibility to get information about the entire journey and not having to enquire at different sources. To take an informed decision during travel, real-time access to information is of strategic importance.

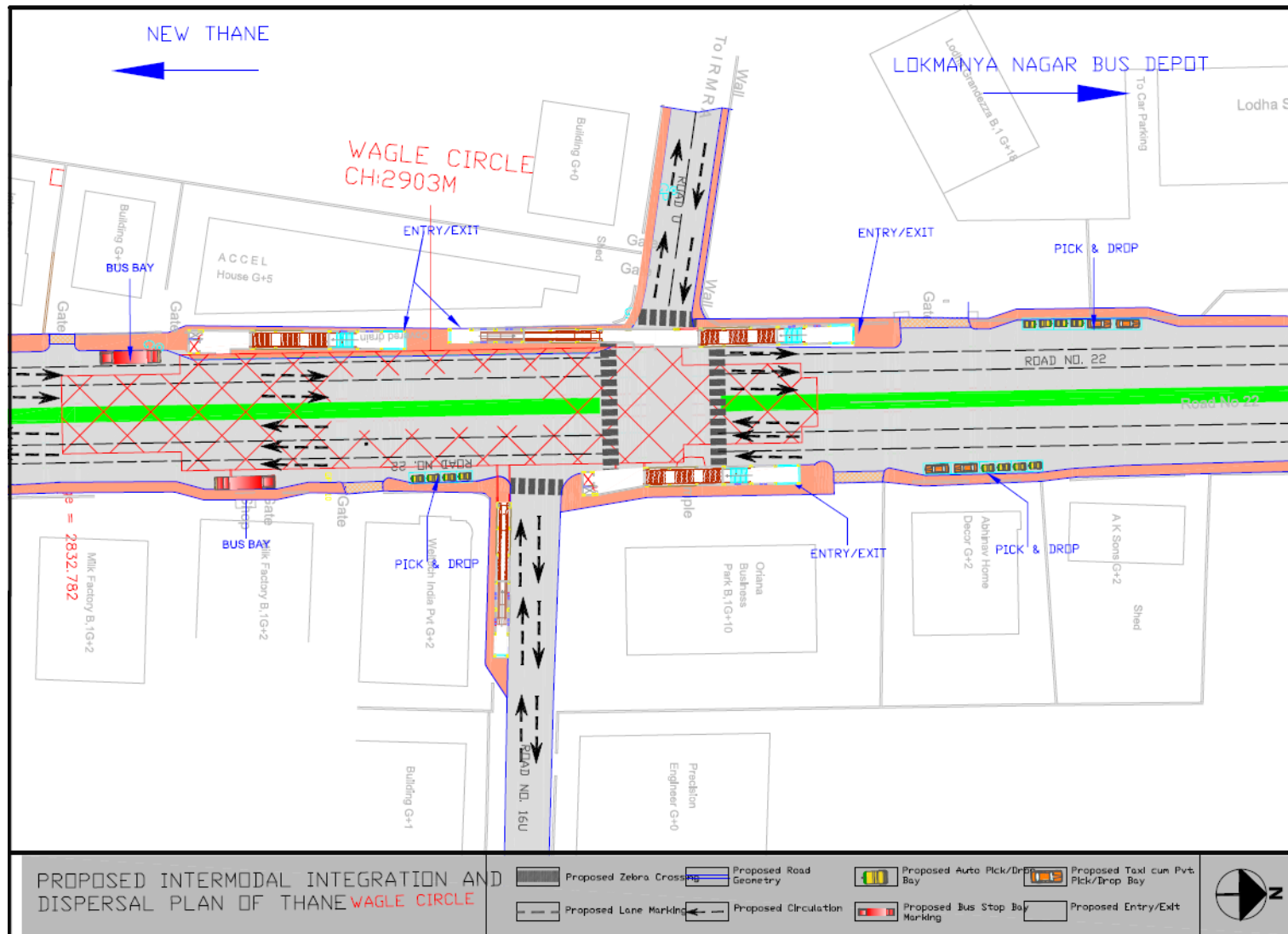
Information integration deals with the Information on routes, schedules, fares, and transfer points for all transit modes and services throughout the urban area, which

is provided by a centralized source. Information services include route maps, timetables, fare schedules, and promotion materials, uniform street signs and vehicle identification, display at stops, transfer points and major stations, and telephone inquiry answering service. Providing integrated information during journey before and in between is important, to make them attractive. Information integration for all transit modes in the city is proposed for the urban public transport network.

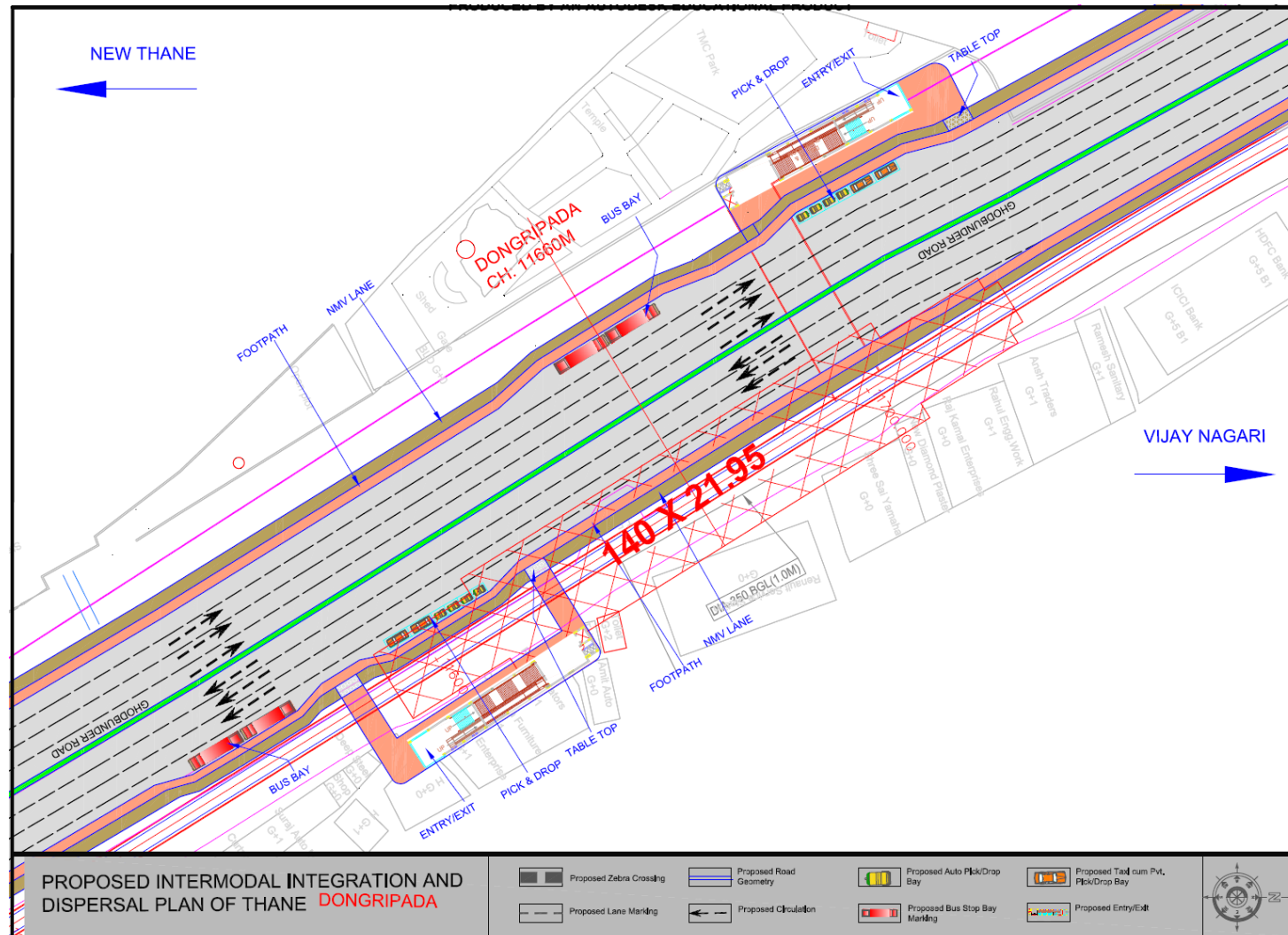
7.4.5. Institutional Integration

City growth strategies are usually guided by documents like land use plans, development plans and master plans etc. and the urban transport models are determined by parameters like existing road network, public transport and its related infrastructure, personal vehicles, licensing mechanism and authorities, land ownership, fare structure of public transport, Intelligent Transport System (ITS) mechanism, traffic enforcement agencies and traffic law enforcing mechanisms, goods and freight movement and their operators, road safety and accident management system etc. All these agencies which prepare these policy documents and oversee governing these functions generally work independently and usually there is no co-ordination between them. It is recommended that an umbrella agency may be created to monitor and integrate these multiple bodies in order to ensure smoother functioning of all aspects related to urban transport.

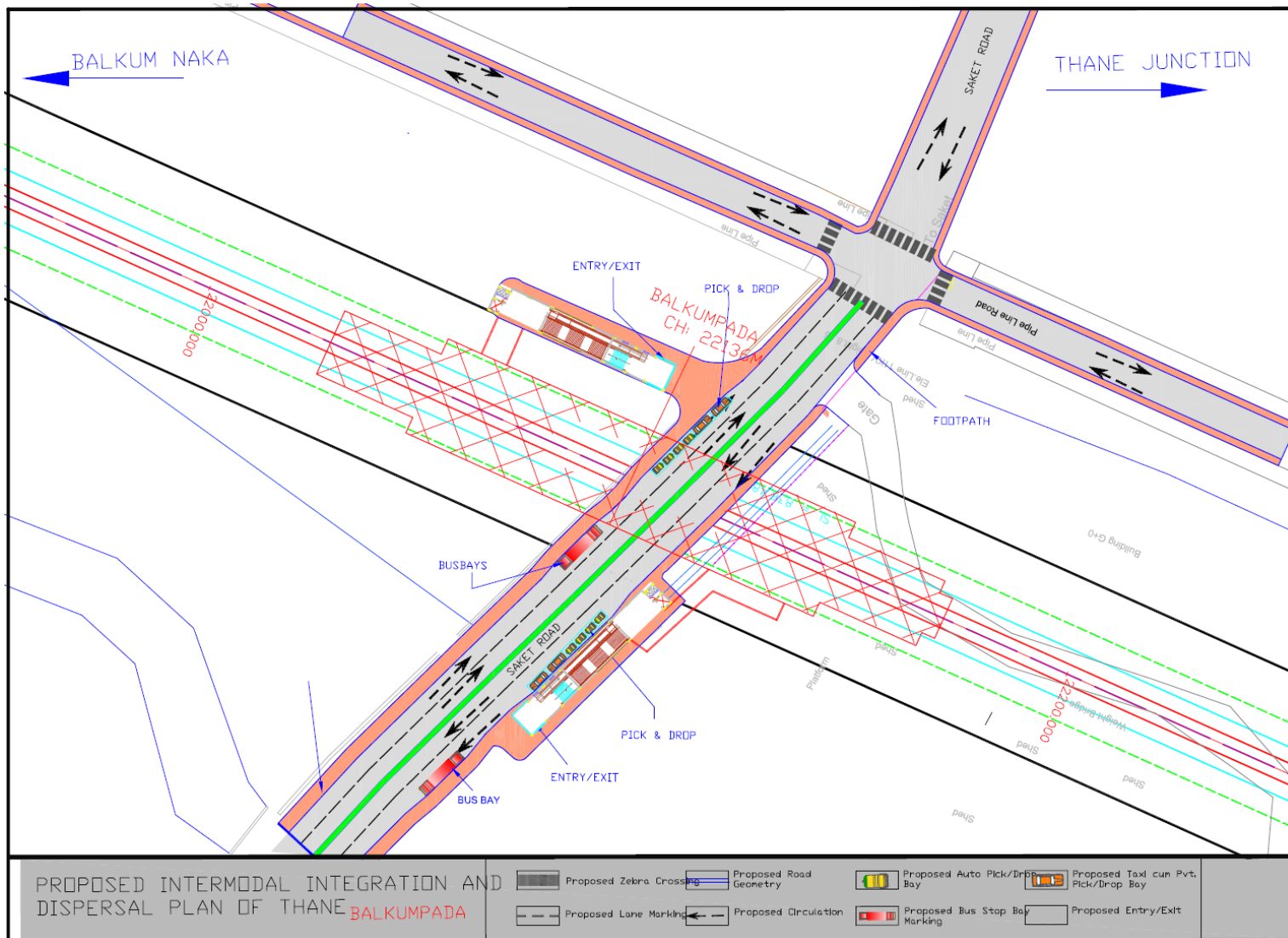
ANNEXURE 7.1. CONCEPTUAL TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF WAGLE CIRCLE



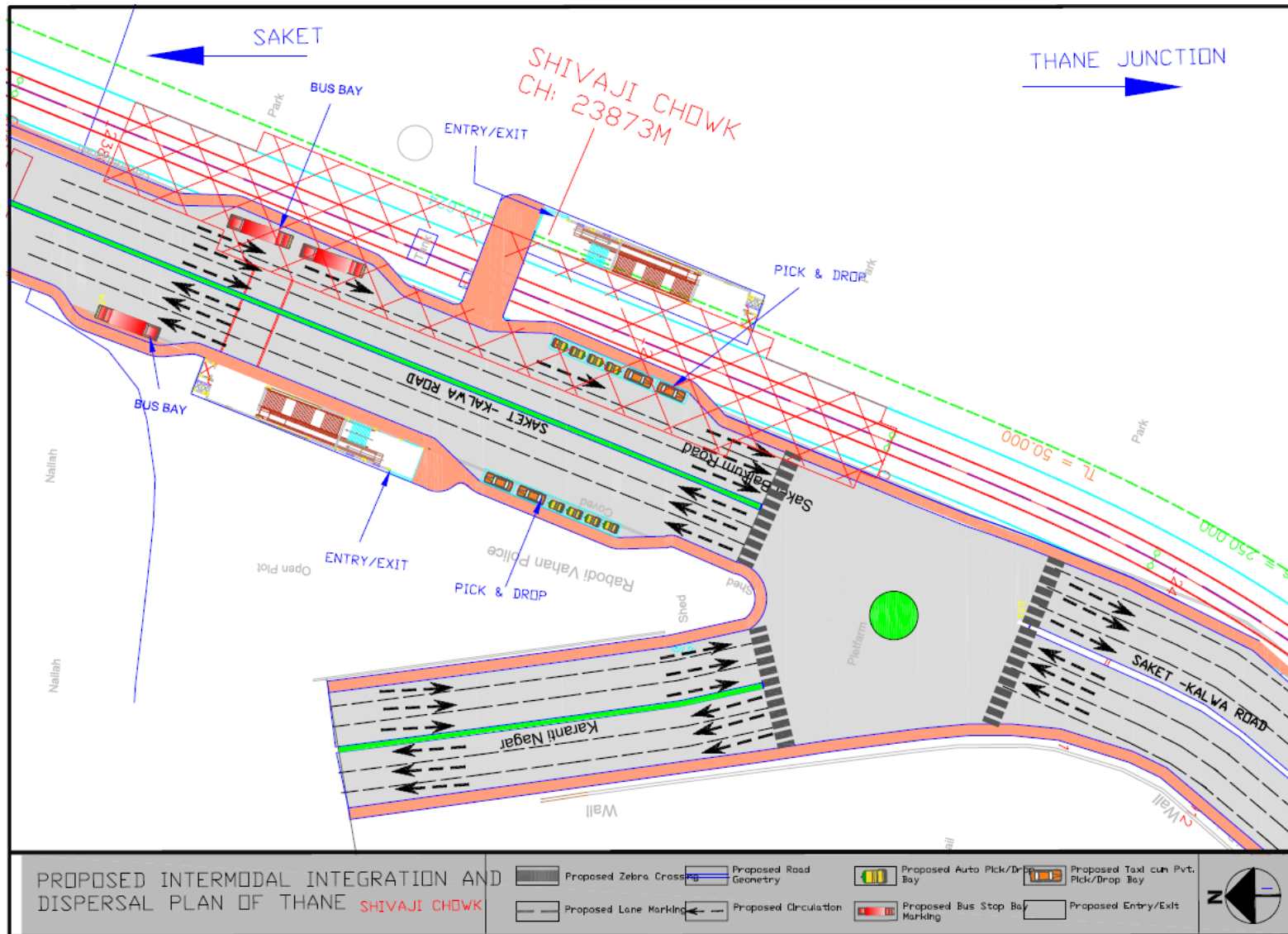
ANNEXURE 7.2. CONCEPTUAL TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF DONGRIPADA



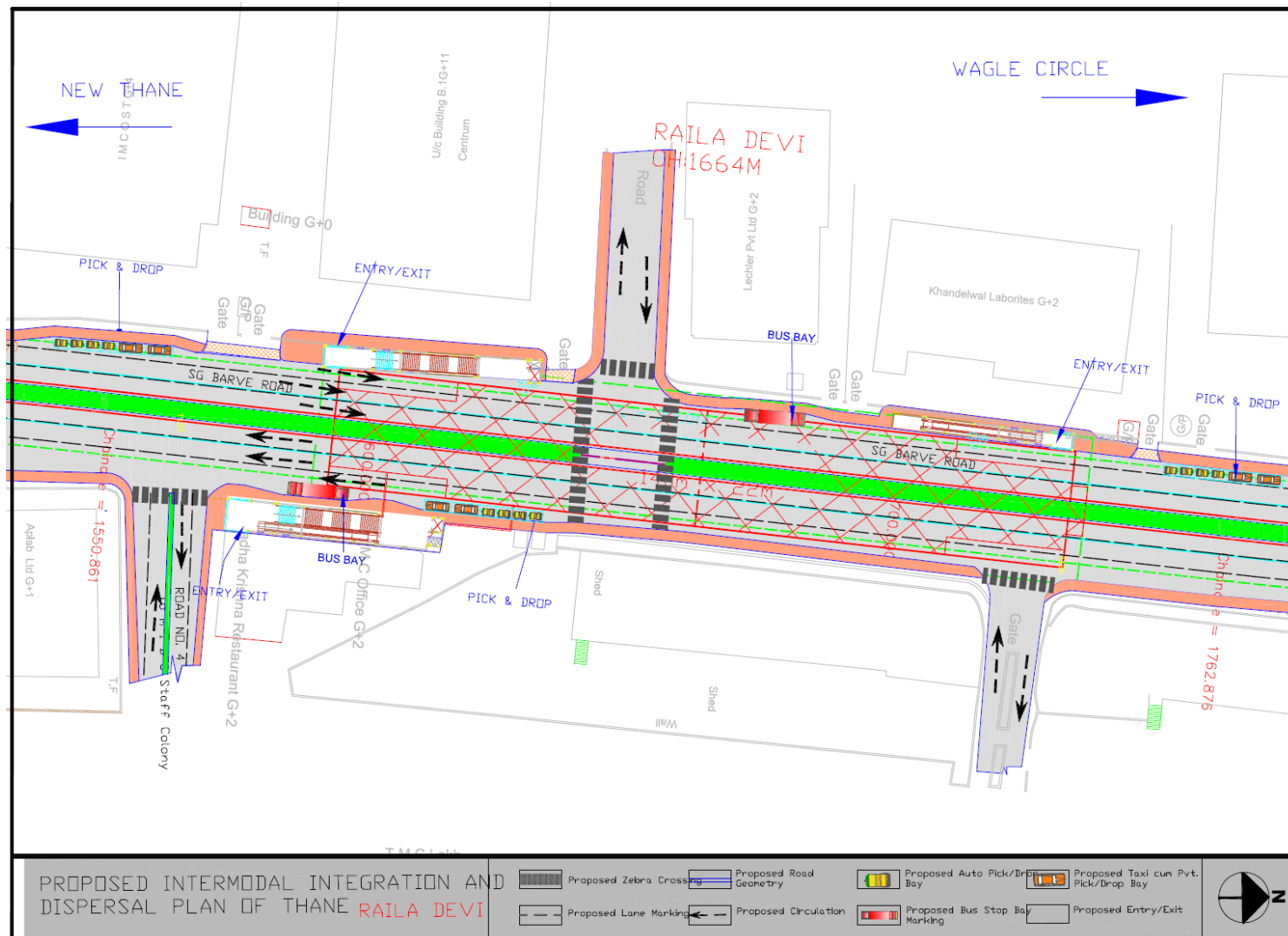
ANNEXURE 7.3. CONCEPTUAL TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF BALKUMPADA



ANNEXURE 7.4. CONCEPTUAL TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF SHIVAJI CHOWK



ANNEXURE 7.5. CONCEPTUAL TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF RAILA DEVI



Chapter – 8

TRAIN OPERATION PLAN

8. TRAIN OPERATION PLAN

8.1 SYSTEM OPERATION APPROACH

Train operation plan for proposed New Thane to New Thane(Ring Corridor) via Dongripada & Thane Junction has been envisaged based on the ridership assessment/ data. The design peak hour peak direction traffic (PHPDT) is 28000. The selected system should have high reliability and adequate capacity to carry required number of passengers to meet peak hour peak direction trips (PHPDT) demand. The underlying operation philosophy is to provide Mass Rapid Transit Services at economical cost with fixed Infrastructure and Rolling Stock planning.

- The frequency of Train services shall be optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency shall be provided during lean period so as to keep the option of this service attractive during lean period as well.
- The frequency of services shall be regulated to meet the growing traffic demand in horizon years.
- Basic unit selected is two motor car and one trailer car.

The train operation plan for the proposed corridor will be based on the following salient features:

- Running of services for 16 hours of a day (6:00 hrs to 22:00 hrs) with a station dwell time of 20-30 seconds.
- Scheduled speed of 34 KMPH.
- Make up time of 5 to 10% with 8-12% coasting.
- No. of services to ensure comfortable journey for commuters even during peak periods.

8.2 DESIGN TRAFFIC DEMAND

Design Peak hour peak direction traffic demands (PHPDT) for the purpose of planning of services on the proposed corridor for years 2029, 2035, 2045 and 2051 are indicated below in **Table 8.1**.

TABLE 8.1: YEAR WISE DESIGN PEAK HOUR PEAK DIRECTION TRAFFIC (PHPDT)

2029	2035	2045	2051
17000	21000	26000	28000

Based on the travel demand assessment as indicated in the table above, the train operation plan for the corridor has been formulated.

8.3 TRAIN FORMATION

To meet the above projected traffic demand, the train operation plan has been formulated considering the Rolling stock of 2.9 m wide coaches. The train composition, capacity and headway required for the operation in the proposed corridor of Thane Metro is given below:

i. Composition

The car composition to be adopted for Thane MRTS is given below-

- DMC : Driving Motor Coach
- TC /MC: Non Driving Trailer Coach/Motor Coach
- 3-Car Rake Composition: **DMC-TC-DMC**
- 6-Car Rake Composition: **DMC-TC-MC-TC-MC-DMC**

Every coach shall be fully interchangeable with any other coach of same type.

ii. Capacity

For the purpose of calculating rake requirement of rolling stock, passenger carrying capacity is considered as below in **Table 8.2**.

TABLE 8.2: CARRYING CAPACITY OF COACHES

Description	Driving Motor Car (DMC)			Trailer Car (TC)/ Motor Car (MC)			3 Car Train			6 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136	286	286	286
Standing	102	204	272	110	220	293	314	628	837	644	1288	1716
Total	145	247	315	160	270	343	450	764	973	930	1574	2002

Normal - 3 Per/sqm, **Crush**- 6 Per/Sqm, **Dense Crush** – 8 Per/Sqm of standee area

iii. Headway

To meet the above projected traffic demand, the possibility of running trains with 6 car rake composition at different headways has been examined. The traffic capacity and demand have been matched by suitable regulation of headways.

The infrastructure and the train operation plan for the corridor are proposed to be designed for 6 car rake composition.

Based on above, the headway and capacity provided for Thane metro corridor for the various horizon years is as below in **Table 8.3**.

TABLE 8.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED

ITEMS	2029	2035	2045	2051
CARS/ TRAIN	3,6	3,6	3,6	6
HEADWAY IN SEC.	212.0	225.0	200.0	200.0
TRAINS/HR	17(12,5)	16 (5,11)	18(3,15)	18
CAPACITY CONSIDERED (6 PASSENGER/SQM)	17038	21134	25902	28332
CAPACITY CONSIDERED (8 PASSENGER/SQM)	21686	26887	32949	36036
DESIGN PHPDT	16800	21000	26000	28000

The train operation plan is formulated such that the traffic demand for majority of the sections of the corridor is met with the passenger loading@6 passengers/m². However, in the sections where the planned capacity is less than the section load, capacity can be met by carrying standees @ 8 passengers/ m² or higher which have been deliberately planned for peak hour train operation for optimum utilization of Rolling stock

8.4 TRAIN OPERATION PLAN

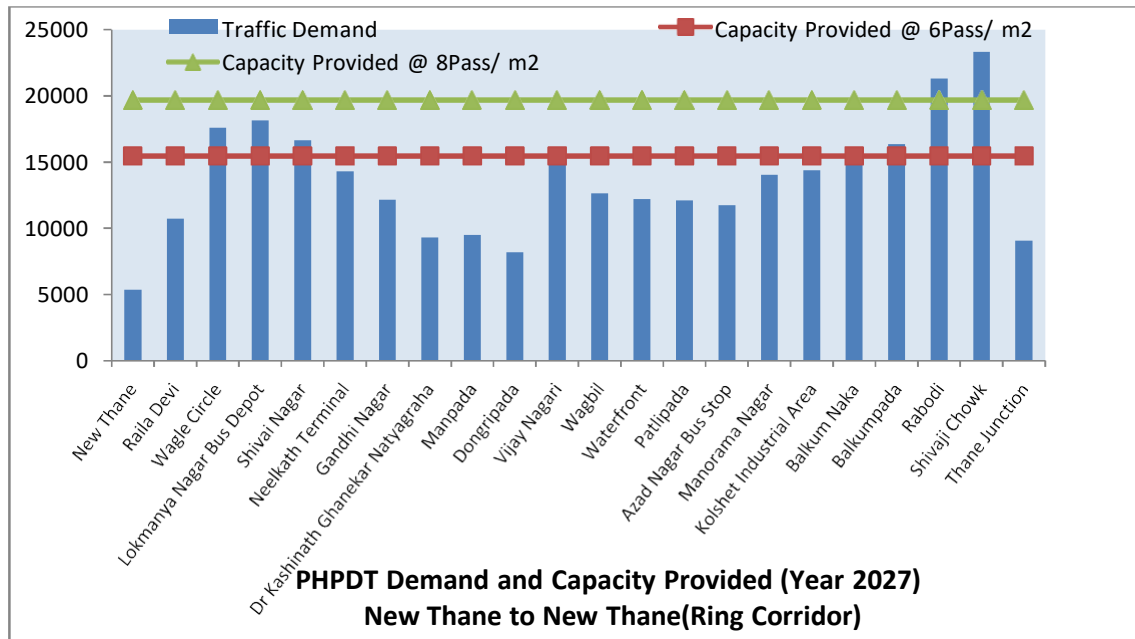
Train operation for the different horizon years for New Thane to New Thane(Ring Corridor)via Dongripada & Thane Junction has been formulated such that there is optimum utilization of the rolling stock and the empty running of trains is reduced.

- Year 2029**

Train operation plan for the corridor in year 2029 is planned with 3 & 6 car rake composition and 212 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 17038@ 6 passengers/m² of standee area

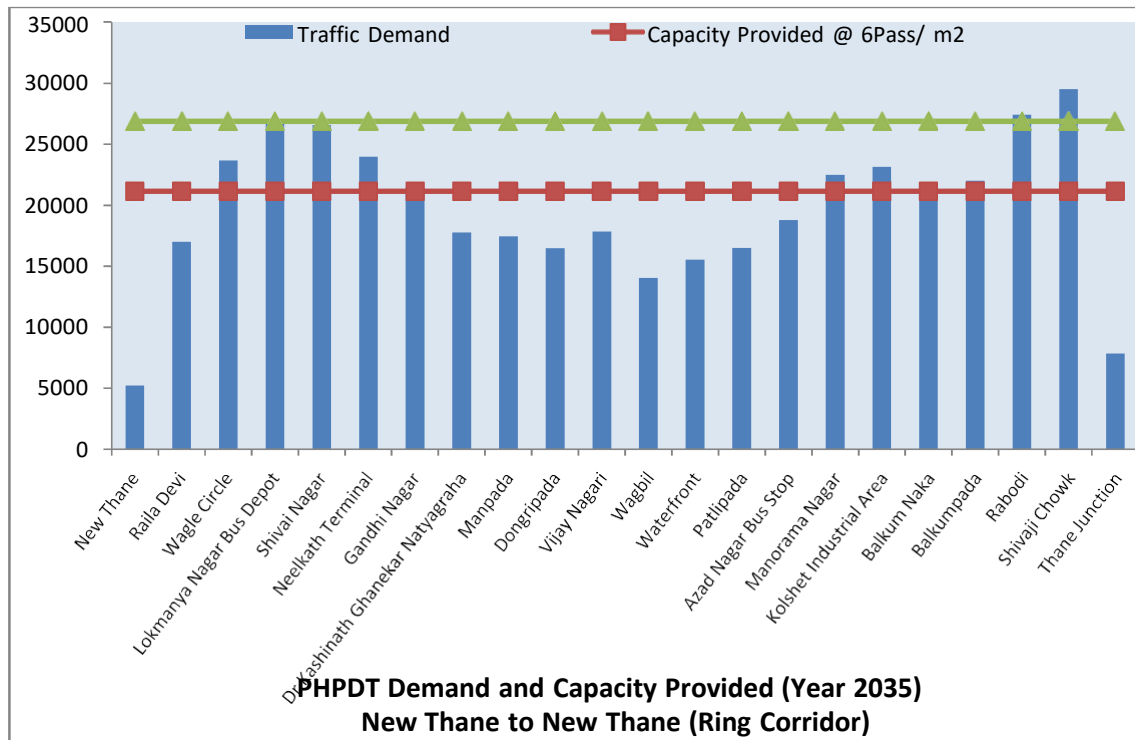
(Capacity of 21686@ 8 passengers/m² of standee area under dense loading conditions). The demand and capacity for the year 2027 is shown in **Figure 8.1** below.

FIGURE 8.1: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2027)



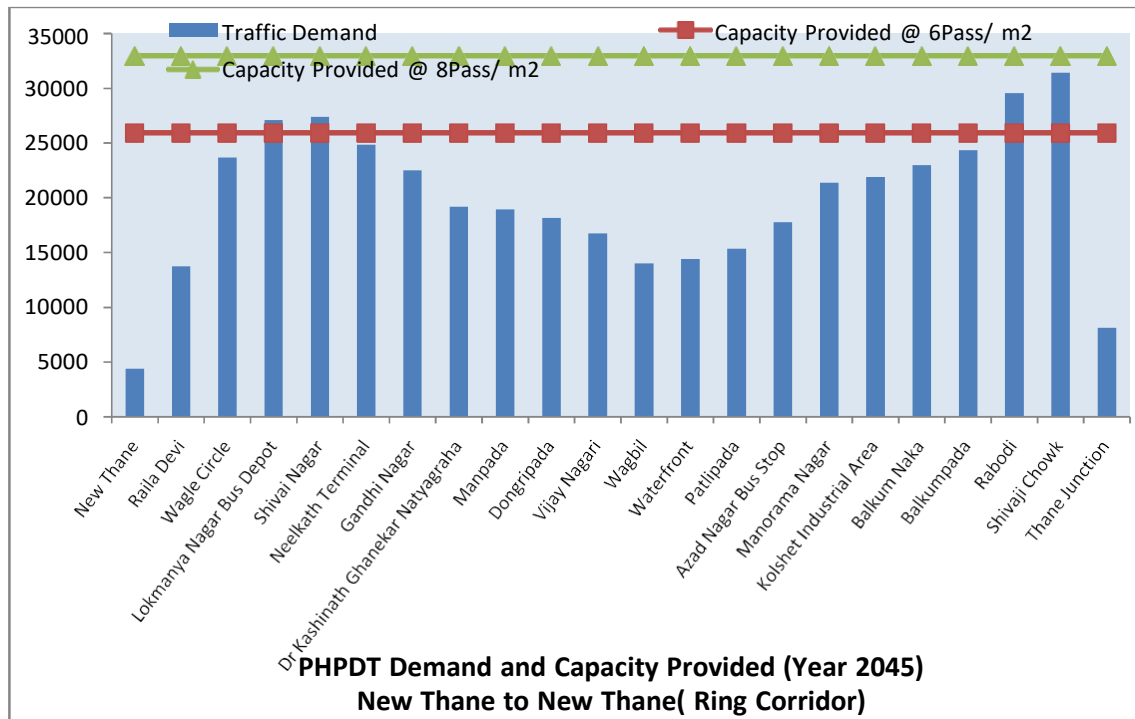
- Year 2035**

Train operation plan for the corridor in year 2035 is planned with both 3 & 6 car rake composition and 225 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 21134@ 6 passengers/m² of standee area (Capacity of 26887@ 8 passengers/m² of standee area under dense loading conditions). The demand and capacity for the year 2035 is shown in **Figure 8.2** below.

FIGURE 8.2:PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2035)

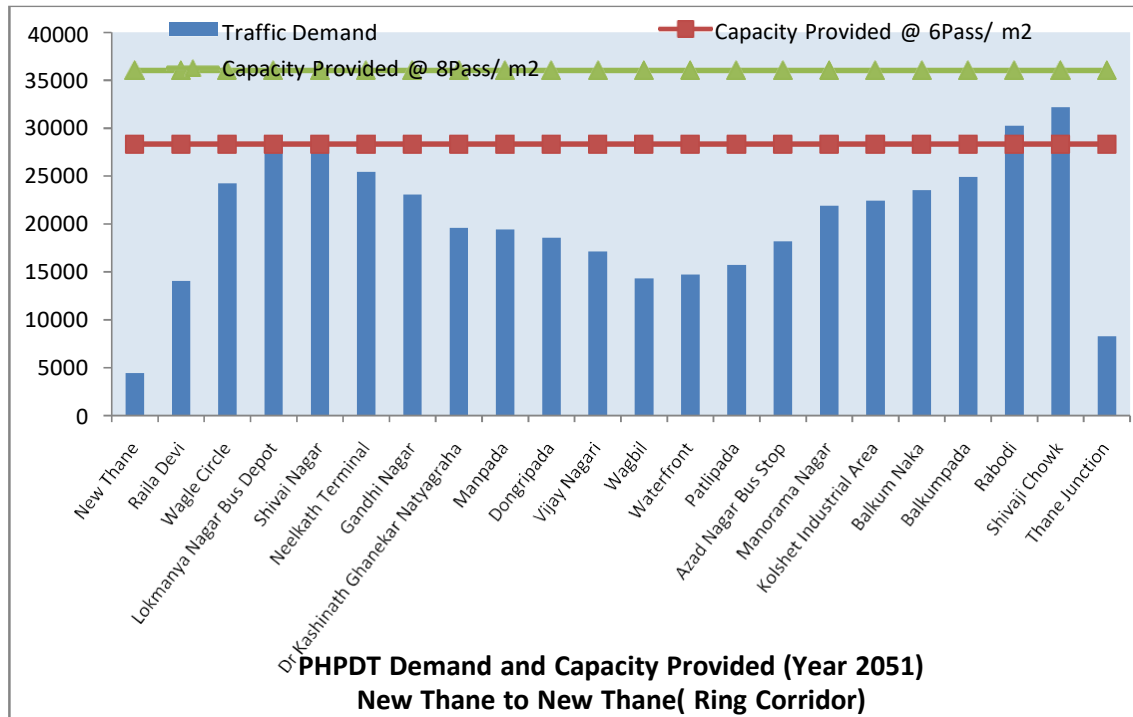
- Year 2045**

Train operation plan for the corridor in year 2045 is planned with 3 & 6 car rake composition and 200 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 25902@ 6 passengers/m² of standee area (Capacity of 32949@ 8 passengers/m² of standee area under dense loading conditions). The demand and capacity for the year 2045 is shown in **Figure 8.3** below.

FIGURE 8.3: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2045)

- Year 2051**

Train operation plan for the corridor in year 2051 is planned with 6 car rake composition and 200 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 28332@6 passengers/m² of standee area (Capacity of 36036@ 8 passengers/m² of standee area under dense loading conditions). The demand and capacity for the year 2051 is shown in **Figure 8.4** below.

FIGURE 8.4:PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2051)

Train operation with 6 car rake composition at 200 seconds headway is envisaged for New Thane to New Thane(Ring Corridor)via Dongripada & Thane Junction to meet the design capacity of 28000 PHPDT in the Year 2050.

8.5 SYSTEM FREQUENCY

The services for Thane Metro rail shall be operational for 16 hours of a day (6:00 hrs to 22:00 hrs). No services are proposed between 22:00 hrs. to 6:00 hrs. which are reserved for maintenance of infrastructure and rolling stock.

The frequency of train operation during the peak hours is presented in **Table 8.3**. It is expected that the traffic demand during other time of the day i.e. off peak hours will be less. Thus, less number of trains/hr are planned for operation during lean hours.

The hourly distribution of daily train operation between New Thane to Thane Junction for various horizon years is enclosed in **Annexure 8.1**.

8.6 ROLLING STOCK REQUIREMENT

Requirement of coaches for the corridor is calculated based on following assumptions:

- Coach requirement has been calculated based on headway during peak hours.

- (ii) Schedule speed is taken as **34 KMPH** for the round trip.
- (iii) Turn round time is taken as **3-6 min** at terminal stations.
- (iv) The calculated number of rakes in fraction is rounded off to next higher number.
- (v) Traffic reserve is taken as **5%** to cater to failure of train on line and to make up for operational time lost.
- (vi) Repair and maintenance has been estimated as **10%** of total requirement (Bare+Traffic Reserve).

Based on above assumptions and train operation plan, the rake requirement for the time horizon 2027~2051 are indicated below in **Table 8.4**.

TABLE 8.4: ROLLING STOCK REQUIREMENT

Time horizon Year	Cars/ Train	Headway in Min	Section length km	Bare Rakes Req.	Traffic spare@5%	Maint Spare @10%	Total rake Req.	Total coach Req.
2029	3 & 6	3.5	29.1	42.0	3	5	50.0	150.0
2035	3 & 6	3.8	29.1	52.0	3	5	60.0	180.0
2045	3 & 6	3.0	29.1	64.0	3	6	73.0	219.0
2051	6	3.0	29.1	35.0	2	4	41.0	246.0

8.7 Vehicle Kilometre

Based on the above planning and assuming 340 days service in a year (after considering maintenance period) Vehicle Kilometers have been estimated. Vehicle Kilometers for the proposed train operation for years 2027, 2035, 2045 and 2051 is given below in **Tables 8.5**.

TABLE 8.5:VEHICLE KILOMETER: NEW THANE TO THANE JUNCTION

Year	2029		2035		2045		2051
Section Length	29.101		29.101		29.101		29.101
No of cars per Train	3	6	3	6	3	6	6
No of working Days in a year	340		340		340		340
Number of Trains per day each Way	171	51	71	153	41	202	257
Daily Train –KM	4976.3	1484.15	2066.17	4452.5	1193.14	5878.4	7478.96
Annual Train - KM (10 ⁵)	16.92	5.05	7.02	15.14	4.06	19.99	25.43
Annual Vehicle - KM (10 ⁵)	50.76	30.28	21.07	90.83	12.17	119.92	152.57

Annexure-8.1

HOURLY TRAIN OPERATION PLAN FOR NEW THANE TO NEW THANE(RING CORRIDOR)

Time of Day	Year 2029 (3 & 6 Car)			Year 2035 (3 & 6 Car)			Year 2045 (3 & 6 Car)			Year 2051 (6 Car)	
	Headway (min)	Trains/hr		Headway (min)	Trains/hr		Headway (min)	Trains/hr		Headway (min)	Trains/hr
		3 Car	6 Car		3 Car	6 Car		3 Car	6 Car		6 Car
6 to 7	6.0	8.0	2.0	6.0	3.0	7.0	6.0	3.0	7.0	5.0	12.0
7 to 8	5.0	10.0	2.0	4.6	4.0	9.0	4.3	3.0	11.0	3.8	16.0
8 to 9	3.8	12.0	4.0	3.8	5.0	11.0	3.3	3.0	15.0	3.3	18.0
9 to 10	3.8	12.0	4.0	3.8	5.0	11.0	3.3	3.0	15.0	3.3	18.0
10 to 11	4.0	11.0	4.0	4.0	5.0	10.0	3.5	2.0	15.0	3.3	18.0
11 to 12	4.0	11.0	4.0	4.0	5.0	10.0	3.8	2.0	14.0	3.8	16.0
12 to 13	4.6	10.0	3.0	4.6	4.0	9.0	4.3	2.0	12.0	3.8	16.0
13 to 14	4.6	10.0	3.0	4.6	4.0	9.0	4.3	2.0	12.0	4.0	15.0
14 to 15	4.6	10.0	3.0	4.6	4.0	9.0	4.6	2.0	11.0	4.0	15.0
15 to 16	4.0	11.0	4.0	4.0	5.0	10.0	4.0	3.0	12.0	3.8	16.0
16 to 17	4.0	11.0	4.0	4.0	5.0	10.0	4.0	3.0	12.0	3.8	16.0
17 to 18	3.8	12.0	4.0	3.8	5.0	11.0	3.3	3.0	15.0	3.3	18.0
18 to 19	3.8	12.0	4.0	3.8	5.0	11.0	3.3	3.0	15.0	3.3	18.0
19 to 20	4.0	12.0	3.0	4.0	5.0	10.0	3.5	3.0	14.0	3.3	18.0
20 to 21	5.0	10.0	2.0	4.6	4.0	9.0	4.3	2.0	12.0	4.0	15.0
21 to 22	6.0	9.0	1.0	6.0	3.0	7.0	5.0	2.0	10.0	5.0	12.0
Total No. of Train-Trips per day in either direction		171	51		71	153		41	202		257

Chapter – 9

SIGNALING AND TELECOMMUNICATION

9. SIGNALLING & TELECOMMUNICATION

9.1 SIGNALLING SYSTEM

9.1.1 Design Parameters

The signaling system shall provide the means of an efficient train control ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network. The system will have the following design parameters:

- Design Ridership: 28000 PHPDT
- Standard Gauge: 1435 mm
- Average Speed: 34 KMPH
- Corridor Length: 29 Km
- Total Stations: 22
- Train Configuration: 3 & 6 Car Rake
- Required Headway: 257 seconds

9.1.2 Options for Signalling System

Depending on type of the Railway Network, Main Line or Metro Rail, Signaling & Train Control can be achieved by adopting any of the following Signaling System / Technologies available:

- Automatic Signaling
- ETCS Level – 1
- ETCS Level – 2
- Distance to Go (DTG)
- Communication Based Train Control (CBTC)

While system at S.No. (i) – (iii) have been developed / used for Main Line Railway networks, system at S.No. (iv) – (v) are for Metro Railway Networks. Therefore, to have a fair idea of the Signaling & Train Control system for metro railway, the relative merits & limitations of Distance to Go (DTG) and Communication based train control system (CBTC) are discussed as below:

a) Distance to Go (DTG) Signaling System:

Distance to Go (DTG) signaling system is mainly used for MRTS system and adopted by most of the recently commissioned MRTS system in India viz. DMRC (Delhi Metro) Phase-I, Phase-II, Delhi Airport Metro Express Line, BMRCL Phase-I (Bengaluru Metro), JMRCL (Jaipur Metro) & Chennai Metro.

It has advanced features of Continuous Automatic Train Control (CATC) consisting of sub-system like Automatic Train Supervision (ATS), Automatic Train Protection (ATP) and Automatic Train Operation (ATO). These sub-system are briefly described below:

➤ **Automatic Train Supervision (ATS)**

Automatic Train Supervision (ATS) is used to provide overall control of trains operation and remote control of the station. The main function of ATS is automatic management of train's movement by interfacing with ATP / CBI system for route setting, train supervision and regulation. The system supervises train movements continuously and optimizes train movements in case of abnormalities. ATS system also logs each train movement and displays it on traffic controller work stations and over view display panel at the OCC and also on workstations placed in the Station Control Room (SCR) for Station Controller

➤ **Automatic Train Protection (ATP)**

Automatic Train Protection (ATP) system (both on-board and way-side) in conjunction with Electronic interlocking, track profile and brake characteristics of rolling stock is provided to ensure safe as also optimal train services on the section. ATP system includes continuous transmission of various safety parameters (authorized speed, movement authority etc.) from track to train through coded audio frequency track circuit. This information received from way-side ATP system by on-board ATP system provides Cab signaling i.e display of maximum safe speed, current speed and target speed / distance. Facilities for automatic enforcement of temporary / permanent speed restrictions are also built in to enhance safety during maintenance work.

➤ **Automatic Train Operation (ATO)**

Automatic Train Operation (ATO) operates the trains automatically from station to station within the safety envelope / parameters of ATP & also controls (opens / closes) the train doors. Train Operator (TO) is only required to Close the train doors and press a Start button when train is ready to depart. ATO in conjunction with ATP & ATS, can control / regulate running & dwell time at stations in accordance with headway / timetable regulation and also regulates the automatic reversal/turn back of trains at terminal stations.

➤ **Pros and Cons of DTG (Distance to Go) Signaling System:**

The Distance to Go (DTG) Signaling system provides safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of **150 seconds** with Continuous Automatic Train Control. DTG works on fixed block principle. It needs Audio Frequency Track Circuits (AFTC) for train detection and track to train communication. The reliability of the system depends on the reliability of AFTC.

With the advent of Communication Based Train Control (CBTC) at almost same costs, metro transport authorities / organizations are now favoring adoption of CBTC over DTG based Signaling System for all new projects. World over, for new MRTS projects, while adoption of DTG based system is on a decline, adoption of CBTC based system, because of their advanced features and low life cycle costs, are increasing steadily. In conclusion while DTG based System can be considered technology of the past, CBTC based system can be considered technology for the present & future.

Considering the high cost of Distance to Go (DTG) Signaling system and advent of new technology viz. Communication Based Train Control (CBTC), which supports advance features such as Unattended Train Operation, moving block etc. and is available at almost same cost, Distance to Go (DTG) Signaling system is NOT recommended for Thane MRTS.

b) Communication based Train Control (CBTC) Signaling System:

Communication based Train Control (CBTC) Signaling System is mainly used for MRTS networks. It is the latest Signaling and Train Control Technology catering bidirectional working and is being adopted by modern metros around the world. It is also being adopted by all new MRTS Networks in India viz, **DMRC Phase-III, Kochi Phase-I, BMRCL Phase-II** etc.

Communication based Train Control (CBTC) Signaling System also has ATP, ATS,ATO/UTO functionality and works on the Moving or Virtual Block principle to reduce headways and increase transport capacity. CBTC relies on continuous two-way digital communication between each controlled train and a wayside control centre. On a moving block equipped railway, the line is usually divided into areas or regions, each area under the control of a computer and each with its own radio transmission system. Each train transmits its identity, location, direction and speed to the area computer which makes the necessary calculations for safe train separation (moving authority) and transmits this to the following train.

The radio link between each train and the area computer is continuous so the computer knows location of all the trains in its area all the time. It transmits to each train the location of the train in front and gives it a braking curve to enable it

to stop before it reaches that train. In effect, it can be termed as a dynamic Distance-to-Go system. Axle counters shall be used as secondary train detection system as a fall back system.

As the CBTC based system has very few way side equipment and supports UTO, total life cycle cost of the system shall be substantially lower than other Signaling System due to low Maintenance & Operation (man power) costs.

➤ **Pros and Cons of CBTC Signaling System**

The Communication based Train Control (CBTC) Signaling system provides adequate safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of **90 seconds** with continuous automatic train control. The CBTC Technology is proven now in many Metros around the World and is also suitable for UTO (Unattended Train Operation) / DTO (Driverless Train Operation).

After reviewing all available Signaling & Train Control Signaling Technologies, **Communication based Train Control (CBTC)** system, which is the latest technology available, is recommended for Thane MRTS.

9.1.3 Interlocking System: Computer Based Interlocking (CBI)

Station with Points and Crossings called “Main” or “CBI” stations, will have Interlocking equipment for achieving Computer Based Interlocking (CBI) for operation of points and crossings and setting of routes. Fixed Signals will be provided at Entry & Exit to Interlocking stations.

➤ **Train Depot: Signalling**

All depot lines except the ones used for shunting in workshop shall be interlocked. A workstation each shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard.

➤ **Signalling at Stations with Points and Crossings**

LED type signals for increased reliability and less maintenance efforts shall be provided for Line side signals to protect the points (switches).

9.1.4 Operation Control Centre (OCC)

The OCC shall monitor and control all train operations. During abnormal working, train operation shall fall-back to the fall-back control facilities at interlocked Stations which shall provide the minimum facilities for smooth operations.

OCC operations shall facilitate the safe, secure and reliable operation of planned passenger services and management of unplanned events. The OCC shall be the primary control centre having a backup control centre (BCC) to take over the operation if the OCC is to be evacuated due to unforeseen situation.

The key functions of the OCC shall be, but not limited to, as under:

- (i) Automatic Train Control (ATC);
- (ii) Equipment Control and Monitoring System
- (iii) Communication system management
- (iv) Operation management functions
- (v) Maintenance management functions

9.1.5 Maintenance Philosophy

For efficient operation and functioning of a metro signaling and telecom system, a robust maintenance organization and practices are necessary. Failure in signaling and telecom equipments have to be addressed in preventive and corrective manner. Otherwise, disruptions in Operations and passenger dissatisfaction may arise. The operations and maintenance practices have to be adequately planned with proper defect liability support, spares planning, trained manpower, annual maintenance contract of specific subsystem specifically wherever necessary etc. The spares and maintenance personnel also have to be suitably located all along the metro system to address the failures and remedy the same within a reasonable time.

9.1.6 Standards

Table 9.1 shows the standards that will be adopted.

TABLE 9.1: STANDARDS TO BE ADOPTED FOR SIGNALLING SYSTEM

Description	Standards
CBTC System	IEEE 1474
Grade of Automation	GoA 2
Interlocking	Computer Based Interlocking (CBI) adopted for station having switches and crossing shall be Hot Standby system with object controller conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for increased reliability and less maintenance efforts.
Train Protection System(ATP)	Automatic train protection system conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.

Description	Standards
ATS	Automatic Train Supervision System, movement of all trains to be logged on to a central computer and displayed on workstations in operation control centre (OCC) and at SCR. Remote control of stations from the OCC as well as local control from the interlocked stations. ATS/ATO will conform to SIL2 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Immunity to External Interference.	All data transmission on Optical Fiber Cables/Radio. All signaling cables will be separated from power cables. CENELEC standards EN50121-2&4 and EN50082-2 and EN 50081-2 as applicable for EMI/EMC.
Fail Safe Principles	SIL4 safety levels as per CENELEC standard for signal application.
Fall back system	Digital Axle Counter
Other Items	Suitable International Standards like CENELEC etc. shall be followed as per good industry practices.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of signaling 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.

9.2 TELECOMMUNICATION SYSTEM

9.2.1 Introduction

The telecommunication system acts as communication backbone for Signaling and other system and provides telecommunication services to meet operational and administrative requirements of metro network.

9.2.2 Telecommunication System used in other Metros

The telecommunications system used in different Metros are as given **Table 9.2**.

TABLE 9.2: TELECOMMUNICATION SYSTEM USED IN DIFFERENT METROS

DMRC	Line 1 Phase-I	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 4 155Mbps network Telephone System : EPABX Mobile Radio Communications: Digital Trunk Radio System (TETRA) Public Address (PA) System
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		Centralized Clock System: Digital & Analog Clocks and Time Synchronization System Passenger Information Display System: LED based Network Management & Station Management System CCTV Cameras were provided later on for Security purposes
DMRC	Line 2 Line 3 Phase II	Same as above with Closed Circuit Television: fixed and PTZ Camera and PIDS LED and LCD based.
BMRC	Phase I	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network Telephone System : EPABX Mobile Radio Communications: Digital Trunk Radio (TETRA) Public Address System Centralized Clock System: Digital and Analog Clock System Passenger Information Display System: LED & LCD based. Network Management & Station Closed Circuit Television System : Fixed and PTZ Camera with monitors
Hyderabad Metro	Phase I	Digital Transmission System (DTS) - Optical Fiber Cable - IP based system with Layer 2 , Layer 3 and Access switches with OF interfaces Telephone System: EPABX Mobile Radio Communications: Digital Trunk Radio (TETRA) Public Address System Centralized Clock System: Digital and Analog Clock System Passenger Information Display System: LED & LCD based. Central Fault Reporting system (CFRS) Closed Circuit Television: fixed and PTZ Camera
JMRC	Phase I	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network Telephone System : EPABX Mobile Radio Communications: Digital Trunk Radio (TETRA) Public Address System Centralized Clock System: Digital and Analog Clock System

		Passenger Information Display System: LED & LCD based. Network Management System Closed Circuit Television: fixed and PTZ Camera
CMRL	Ph1	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 16 Telephone System: Hybrid PBX Mobile Radio Communications: Digital Trunk Radio System (TETRA) Public Address/Voice Alarm (PA/VA) System Centralized Clock System: Digital & Analog Clocks and Time Synchronization System Passenger Information Display System: LCD based Network Management & Station Management System CCTV SCADA

9.2.3 Proposed Telecommunication System and Transmission Media

The state of the art latest technology being used in different metros worldwide, is proposed to be used for the Thane MRTS.

Digital Transmission System (DTS)

➤ Optical Fiber Cable – Main Telecommunication bearer

IP, GE (Giga Ethernet) based system is proposed for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall be arranged in two different cables for path diversity. Considering the channel requirement and keeping in view the future expansion requirements a minimum 144 Fiber, optical fiber cable is proposed to be laid in ring configuration with path diversity. Additional OFC can be considered to be provided if there is a demand for leasing Fiber from Telcos / Industries, providing a source of revenue generation.

The IP network shall consist of highly reliable and fault tolerant Layer-2, Layer-3 and Access switches configured with due redundancy both at Back bone and Access levels for the MAN/LAN. The switches shall have IP interface cards of 10 GBPS for backbone, 1 GBPS for interface with all telecommunication and non-telecommunication sub-system and 2 MBPS and higher levels for access level. All interfaces with other sub system shall be IP based with minimum 2 MBPS capacity.

➤ **Telephone Exchange**

A cost effective solution of an IP PBX having at least 50 IP extensions will be provided at each station and 500 IP extensions PBX will be provided at the central, intermediate location on corridor and depot. The Exchanges will serve the subscribers at all the stations, OCC and depot. It shall also caters 02 emergency telephones on each platform for the use of passengers to contact SCR/OCC in case of emergency. Capacity of Exchanges can be suitably augmented, if required , depending on available subscribers. The exchanges will be interconnected at multiple IP interfaces (2 MBPS) through redundant optical fiber cable paths.

➤ **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 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 as shown in **Figure 9.1**

The frequency band for operation of the system i.e 410-430 or 380-400 MHz may be taken as per availability. The system shall provide 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.

FIGURE 9.1: TRAIN CAB RADIO AND COMM. FACILITY FOR MAINTENANCE



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. In addition to the TETRA Radio Coverage for the internal use of the Metro, the city is also having Mobile Coverage from Private Operators.

➤ **Public Address System**

The public Address System shall be capable of digitized voice announcements and long range PA functionality suitable for evacuation situations in emergency. The public address is to for stations will generally operate in automatic mode providing information for the time and destination of the next schedule train, special upcoming event, safety and security announcement at pre determined intervals and general information to enhance the travel experience for all users but more specially the visually impaired.

➤ **Centralized Clock System**

The Clock System shall provide synchronized time for the whole Rail system. The time source shall be obtained from the Cesium Master Clock and Global Positioning System (GPS). The synchronized time information shall be displayed on slave clock units and provided to all other sub system including Rolling Stock & signaling via the Digital Transmission System and Track-Train Communication system as shown in **Figure 9.2**.

FIGURE 9.2: MASTER CLOCK



➤ **Passenger Information Display System**

At all stations, suitable Electronic Passenger Information Display Boards preferably LCD/LED (Flat Panel) will be provided as shown in **Figure 9.3**. The PIDS shall be train actuated (controlled by signaling system) along with facility for manual inputs from the local station as well as the central location (OCC).

FIGURE 9.3: PASSENGER INFORMATION DISPLAY SYSTEM



Passenger Information display boards will be provided at convenient locations at all stations to provide trilingual i.e Marathi, Hindi & English visual indication of the status of the running trains and will typically indicate information such as destination, platform numbers, arrival/departure time, and also special messages in emergencies. The boards will be provided at all platforms and concourses of terminal & junction stations as shown in **Figure 9.4**.

FIGURE 9.4: PIDS AT PLATFORM AND CONCOURSE



It is envisaged that 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.

➤ **Close Circuit Television**

CCTV system should ensure real time full coverage, high quality surveillance of all public and selected areas such as tunnel cross passages, ancillary buildings, on board conditions for secure passenger management, crowd control and other

emergency situations. Event reloading shall be possible for post video analysis. CCTV cameras shall also be provided in Operational rooms like OCC, SCR etc. A proper IP based recording and storing facility to record and store events for minimum of one month shall be ensured.

➤ **Central Voice Recording System (CVRS)**

A centralized digital voice recording system will be provided at OCC to record all Two-way Telephone conversation, PA calls from station and OCC, Two Way Radio Conversation of all controllers , TOs , SCRs and other users in OCC and Depot. In addition all conversation of the Radio System including private calls of all subscribers including Controllers, TOs shall also be recorded. Arrangement of free space audio recording in OCC, SCRs and Driver Cab shall also be made available.

➤ **Central Fault Reporting System (CFRS)**

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a CFRS / SCADA system which will help in reporting and diagnosing the 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.

➤ **Access Control and Intrusion Detection System (ACIDS)**

An Access Control and Intrusion Detection System (ACIDS) shall be provided for access management, alarm management and intrusion detection. The system shall include but not limited to the detection sensors/equipments, control switch, card readers, interface controllers, local and central ACS servers, display HMI, alarm printers, etc.

In addition to Access Control System there shall be a provision of attendance system using bio-metric (thumb or facial) access point reader at all stations, depot, OCC/BCC and RSS.

➤ **Office Automation & Information Technology Network (OA&IT)**

The Office Automation (OA) and Information Technology (IT) network shall provide the network infrastructure for the operators and other administration/maintenance staff to handle office administrative works at all the stations, depots, OCC/BCC and RSS. All the administrative works shall be carried out on this network. This network shall be distinct from the communication network provided for the train operations.

➤ **Uninterrupted Power Supply**

The uninterrupted power supply (UPS) of 60 KVA, 415 V $\pm$ 1%, 3 phase with Battery bank of 800AH capacity at each interlock station and 30 KVA with Battery bank of 300AH capacity at each non-interlock station will be provided for 2 hour back up.

The standards that will be adopted with regard to the Telecommunication system is shown in **Table 9.3**. These will conform to appropriate IRS/International standards.

TABLE 9.3: STANDARDS TO BE ADOPTED FOR TELECOMMUNICATIONS SYSTEM

Description	Standards
Transmission System	IP, GE (Giga Ethernet) based system for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall arranged in two different cables for path diversity.
Optical Fiber cable	OFC for underground environment shall be steel armoured and manufactured from Fire Retardant/resistance, Low Smoke and zero halogen materials. For elevated portion of corridor, it shall be steel armored and conforming to IRS specifications.
Public Address System	Passenger Announcement System shall be interfaced with signaling system for online update of train information. IEC 60268 as applicable or any equivalent international/National standard. Fire resistant Low Smoke Zero Halogen cable shall be used to maintain the circuit integrity in case of fire.
Telephone Exchange	IP based Electronic Exchange (IP PBX)
Passenger Display Information System	It shall be interfaced with signaling system for online update of train information. IEC as applicable or any equivalent international/National standard.
Synchronized Clock system	GPS based, master – slave system IEC 61588 or equivalent standard
CCTV/ Camera	CCTV network shall be as per IEEE standards.
Redundancy (Major System)	Redundancy on Radio base station equipment including server level for all communication sub-system.
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 coordination. Card/module level replacement will be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

9.3 PLATFORM SCREEN DOORS

Platform Screen Doors (PSD) are mainly provided at the metro stations to ensure safety and comfort of passengers. The principle advantages of Platform Screen Doors are:

- i) It prevents accidental falls off the platform onto the lower track area, suicide attempts and homicides by pushing.
- ii) It prevents or reduce wind felt by the passengers caused by the piston effect which could in some circumstances make people fall over.
- iii) It reduces the risk of accidents, especially from service trains passing through the station at high speeds.
- iv) It improves climate control within the station especially underground stations (heating, ventilation, and air conditioning are more effective when the station is physically isolated from the tunnel).
- v) It improves security - access to the tracks and tunnels is restricted.
- vi) It lowers operating costs- eliminate the need for motormen or conductors when used in conjunction with Unattended Train Operation (UTO).
- vii) It prevents litter build up on the track, which can be a fire risk.
- viii) It improves the sound quality of platform announcements, as background noise from the tunnels and trains that are entering or exiting is reduced.

There are some disadvantages of Platform Screen Doors, which are indicated below:

- i) Primary disadvantage is their cost; installing a system typically costs approx. INR 3Crores per platform.
- ii) When used to retrofit older systems, they limit the kind of rolling stock that may be used on a line, as train doors must have exactly the same spacing as the platform doors;
- iii) Maintenance facilities in the depot are required to be augmented for maintenance of platform screen doors also.

Since the advantages far outweigh the disadvantages, Platform Screen Doors (PSD) are proposed to be provided at all the stations of Thane Metro to ensure safety & comfort of commuters. The broad outline/details of Platform Screen Doors (PSD) is described hereunder:

9.3.1 System Configuration

The PSD's comprise Platform Screen Doors (PSD), Manual Secondary Doors (MSD), Emergency Escape Doors (EED) and Fixed Screens (FS) to form a glazed barrier along the edge of the platform for the passenger area. The configuration and location of the EED's and FS will be such that the PSD's will correspond to the location of the train doors when the train has berthed in the Correct Stopping Position (CSP) at the platform.

(i) Platform Screen Door (PSD)

These powered glass doors are located along the platform at the platform edge throughout the passenger area and door locations are corresponding to the train car passenger door locations. Opening/closing of the PSD will be after receipt of the doors open/doors close command signals from the Signaling Link. Signaling link enables automatic operation of PSD only when the train stops within ± 300 mm limits. The platform screen door is shown in **Figure 9.5**.

FIGURE 9.5: PLATFORM SCREEN DOOR



(ii) Manual Secondary Door (MSD)

These are manual glass doors located at one end of platform providing access from the platform onto the trackside. In case of emergency evacuation from tunnel/trackside the MSD can be opened from the trackside by using a push bar. The door will be designed to swing open and be held at an open position of 90° . The door will be self closing to the closed and locked position safely upon the opening position less than 90° , without need for staff intervention. Operation of the MSD is the same as for the EED. The manual screen door is shown in **Figure 9.6**.

FIGURE 9.6: MANUAL SCREEN DOOR



(iii) Emergency Escape Door (EED)

EEDs are located around PSDs of leading and trailing passenger cars. If the train does not stop at the correct position and opened train doors are not in front of PSD doors, the train passengers can go to the platform after opening the EED by pressing the emergency push bar located on the track side of the EED. Operation of the EED is the same as for the MSD. The arrangement is shown in **Figure 9.7**.

FIGURE 9.7: EMERGENCY ESCAPE DOORS & FIXED SCREENS/PANELS



(iv) Fixed Screens/Panels (FP)

Platform length sections not provided with any of PSD/EED/MSD i.e. fixed panels are provided with fixed glass screens called "Fixed Panel" (FP). Apart from acting as a safety feature for the passengers from falling off on the tracks, PSDs also help in reducing the power consumption for the station HVAC and reduce the track-side noise on the platform.

Options & Recommendations

There are mainly two options for providing Platform Screen Doors viz Full height PSD or Half height PSD. The advantages & limitations of PSD have been brought out above. The half height and full height PSD are shown in **Figure 9.8** and **Figure 9.9** respectively. To ensure the safety of the passengers, Half Height Platform Screen Doors is proposed to be provided at all the elevated stations and Full Height Platform Screen Doors at all the U/G stations of Thane Metro to reduce the energy consumption at underground stations.

FIGURE 9.8: HALF HEIGHT PSD



FIGURE 9.9: FULL HEIGHT PSD



Chapter – 10

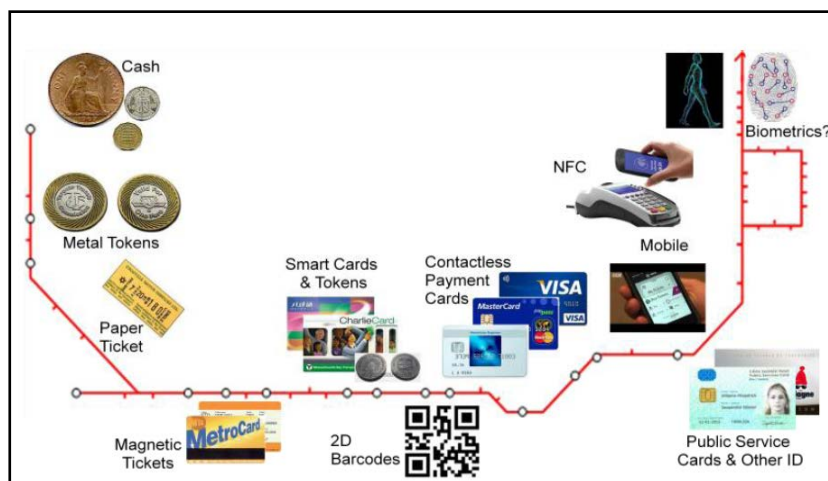
FARE COLLECTION SYSTEM

10. FARE COLLECTION SYSTEM

10.1. TICKETING & ACCESS CONTROL

Mass Rapid Transit System handles large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare collection system meets these requirements. Fare collection technology development is as shown in **Figure 10.1**.

FIGURE 10.1:FARE COLLECTION TECHNOLOGY DEVELOPMENT



Keeping in view of Metro Railways Automatic Fare Collection System, it is proposed to provide computer based automatic fare collection system with EMV based NCMC card, QR, RFID Paper Ticket & NFC for the Thane MRTS.

The equipments for the same may be provided at each station viz. Automatic Fare Gates, Ticket Office Machines, Ticket Readers, Hand held device, Central and Station Computers, Passenger Operated Machines/Ticket Vending Machines (POMs/TVMs) and UPS.

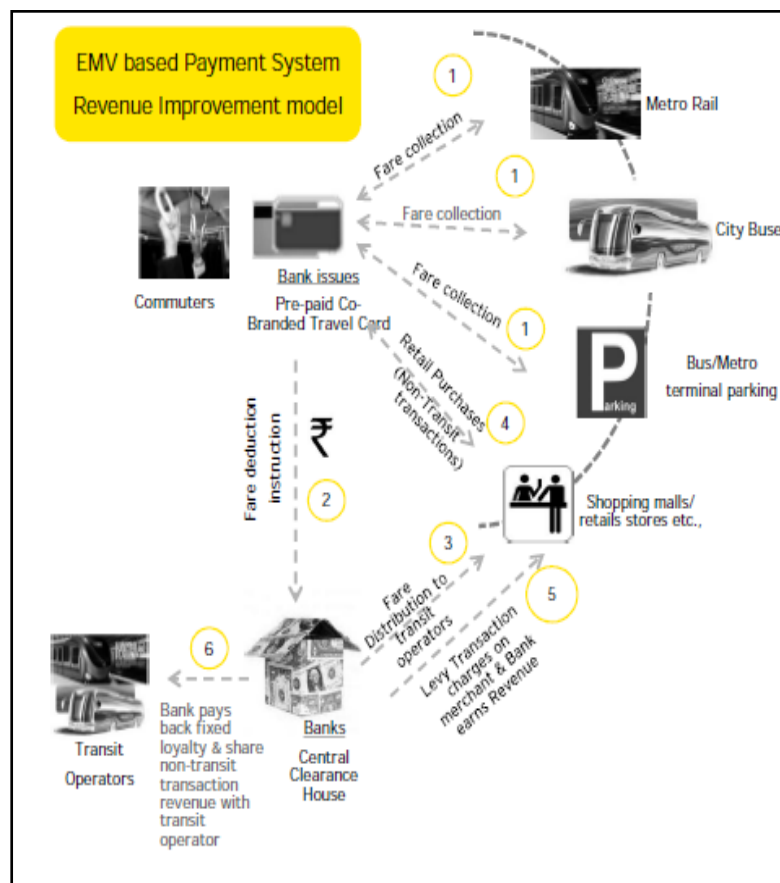
The AFC System Central Computer (CC) has a capacity to cater for upto 256 stations. The AFC system shall also have functionality of interface to CCHS (Central Clearing House System) which is capable of handling upto 32 operators and 10 million transactions with provision of integration with other transit (metro, bus etc) and non-transit (parking, toll etc) which may be planned in future in line with the state / national policy.

10.2. EMV BASED OPEN LOOP AUTOMATIC FARE COLLECTION SYSTEM

An EMV (Europay, MasterCard and Visa) a global standard is a credit or debit card with an embedded microchip designed to enable secure payment at compatible point of sale (POS) terminals. EMV cards can also support contactless payment through near-field communication (NFC) wireless connectivity. Transit Operator hires one or multiple financial institutions to issue a prepaid EMV enabled travel card to its commuters. The EMV based smart cards can be accepted within network of transit operator's terminals.

The transit operators fare acceptance terminals would need EMV enabled card readers. The same card can be used on network of other payment methods at any merchant outlet. Model is convenient for a commuter as Transit Card and acts as an eWallet that can be used for all payment needs as single media. The EMV model also aids commuters to gain loyalty points for usage of cards on transit or non-transit network. The EMV based system is shown in **Figure 10.2**

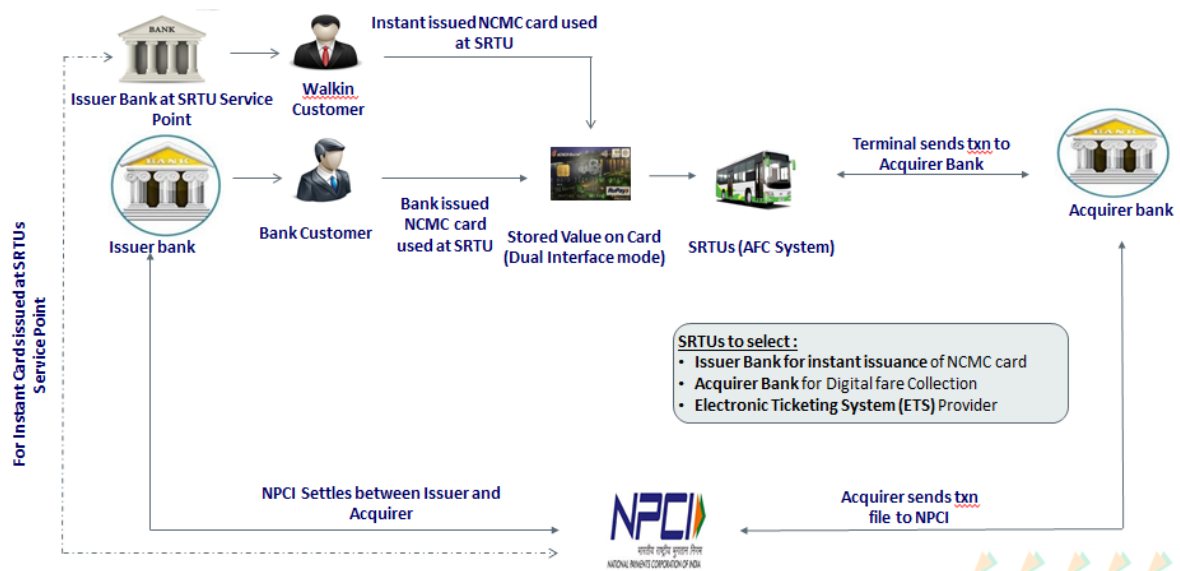
FIGURE 10.2: EMV BASED PAYMENT SYSTEM



10.3. INTRODUCTION TO NATIONAL COMMON MOBILITY CARD

Common Mobility Card (CMC) Smart Card will provide Common Fare Collection System across different operators (both Government and Private) and different modes of public transport and also enables account based retail applications. Accordingly, this card does away with the need of carrying separate cards for banking and transit requirements. Tipped as a nationwide interoperable transport card, the card aims to be a single point of transaction, applicable in state buses, Metro and even parking. The whole system overview is presented in **Figure 10.3.**

FIGURE 10.3: COMMON MOBILITY CARD IMPLEMENTATION



10.4. AFC EQUIPMENT STANDARDS

The standard equipment proposed for AFC system are given in the **Table 10.1.**

Table 10.1: Standards proposed for AFC System

Equipment	Description
Fare media	Fare Media shall be EMV based NCMC card, QR, RFID paper tickets and NFC.

Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: Entry Exit Reversible – can be set to entry or exit Differently abled – Wide reversible gate for differently abled people.
Station computer, Central computer and AFC Net work	All the fare collection equipments will be connected in a local area network with a station server controlling the activities of all the machines. These station servers will be linked to the central computer situated in the operational control centre 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 Ticket office machine may be installed in the stations for issuing EMV CSC, QR based paper tickets, recharge to EMV CSC and validation.
Ticket reader	Ticket readers are standalone devices for checking the fare media details.
Hand held device	Hand held devices are electronic ticketing machines and shall be deployed for checking, validating and issuing the fare media to the commuters.
Ticket Vending Machine (TVM)	Ticket Vending Machines (TVMs) shall be a kiosk where a commuter can purchase QR based paper tickets and Add value/products to EMV CSC. These are located in the unpaid area of the stations.
Mobile Application feature	The AFC Provider shall be responsible for developing a mobile application that shall be integrated with AFC system for the purpose of ticketing. Mobile Application that shall be developed by AFC Provider on to offer mobile ticketing services. As part of mobile platform, it should offer various value added services to its commuters like e- Commerce tie-ups, taxi sharing etc.
UPS (uninterrupted power at stations as well as for OCC).	Common UPS of S&T system will be utilized.

Chapter – 11

ROLLING STOCK

11. ROLLING STOCK

11.1 SELECTION OF TECHNOLOGY

The transport demand forecast for the corridor is the governing factor for the choice of physical parameters of the Rolling Stock viz. capacity, dimensions etc. Keeping in view, the traffic demand of the city, 2.9m wide coaches have been selected for adoption in Thane Metro corridor. State of the art proven technology has been proposed for rolling stock of Thane Metro corridor.

Following important criteria is proposed for selection of rolling stock:

- Passenger comfort & safety
- Proven equipment with high reliability
- Energy efficiency
- Light weight equipment and coach body
- High rate of acceleration and deceleration
- Optimized scheduled speed
- Flexibility to meet increase in traffic demand
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost

The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems.

11.1.1 The selection of following technologies is proposed to ensure low life cycle cost.

(i) Car body

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



(ii) Bogies

Bolster less light weight bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000 km. The use of air spring at secondary stage may be considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. A smooth curving performance with better ride index will be ensured by provision of above type of bogies.

(iii) Braking System

The brake system shall consist of –

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

(iv) Propulsion System Technology

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

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

For Thane Mass Rapid Transit System, three phase AC traction drive with VVVF control is recommended for adoption.

(v) Interior and gang ways

The 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 equipment 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.



(vi) Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach may be considered. These doors shall be of such dimensions and location that all the passengers inside the train are able to evacuate within least possible time without conflicting movement. Automatic door closing mechanism is envisaged from consideration of passenger safety.



(vii) Air conditioning

With passenger loading of 6 persons/ m² for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, the air conditioning of coaches is considered essential. Each coach shall be provided with two air conditioning units capable of automatically controlling interior temperature throughout the passenger area at all times under varying ambient condition up to full load. For emergency situations such as power failure or both AC failures etc ventilation provision supplied from battery may be made.

(viii) Cab Layout

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

11.1.2 Broad Features of Rolling Stock

- a) Rolling Stock proposed for the Thane MRTS corridor will be similar to Delhi Metro. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed are indicated in **Table 11.1**.

TABLE 11.1: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC 1 TC 6 Car basic unit 2 DMC, 2 MC and 2 TC Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3 Car : DMC+TC+DMC 6 Car: DMC+TC+MC+MC+TC+DMC
3	Coach construction	Light weight stainless steel/ Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	25KV AC OHE System

b) Coach Dimensions

The following broad parameters for coach dimensions are proposed to be chosen for Thane MRTS corridor as mentioned in **Table 11.2**.

TABLE 11.2: COACH DIMENSIONS

Type of coach	Length*	Width	Height
Driving Motor Car (DMC)	21.64 m	2.9 m	3.9 m
Trailer car (TC)/ Motor Car(MC)	21.34 m	2.9 m	3.9 m

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

c) 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, 6 persons in crush state of peak hour and 8 persons in dense crush state of peak hour.

The train composition is proposed as 3-Car & 6 - Car Train. The carrying capacity of Metro Rail Vehicle is indicated in **Table 11.3**.

TABLE 11.3: CARRYING CAPACITY OF METRO RAIL

Description	Driving Motor Car (DMC)			Trailer Car (TC)/ Motor Car (MC)			3 Car Train			6 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136	286	286	286
Standing	102	204	272	110	220	293	314	628	837	644	1288	1716
Total	145	247	315	160	270	343	450	764	973	930	1574	2002

Normal - 3 Per/ Sqm of standee area, **Crush**- 6 Per/ Sqm of standee area, **Dense Crush** – 8 Per/ Sqm of standee area.

d) Weight

The weights of motor cars and trailers are estimated in **Table 11.4**, considering the average passenger weight as 65 kg.

TABLE 11.4: WEIGHT OF MASS RAIL VEHICLES (TONS)

Description	DMC	TC/MC	3 Car	6 Car
Tare Weight (Max.)	40	40	120	240
Passenger				
(Normal @ 3p/ m ²)	9.425	10.4	29.25	60.45
(Crush @ 6p/ m ²)	16.055	17.55	49.66	102.31
(Dense Crush @ 8p/ m ²)	20.475	22.295	63.25	130.13
Gross				
(Normal @ 3p/ m ²)	49.425	50.4	149.25	300.45
(Crush @ 6p/ m ²)	56.055	57.55	169.66	342.31
(Dense Crush @ 8p/ m ²)	60.475	62.295	183.25	370.13

Description	DMC	TC/MC	3 Car	6 Car
Axle Load @ 6p/ m ²	14.01	14.39	42.42	85.58
Axle Load @ 8p/ m ²	15.12	15.57	45.81	92.53

The axle load @6 persons/ m² of standees works out in the range of 14.01T to 14.39T per coach. Heavy rush of passengers with loading @8 standees per sq. meter can be experienced occasionally during peak hours. It is recommended to design the coaches 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 16 T axle load.

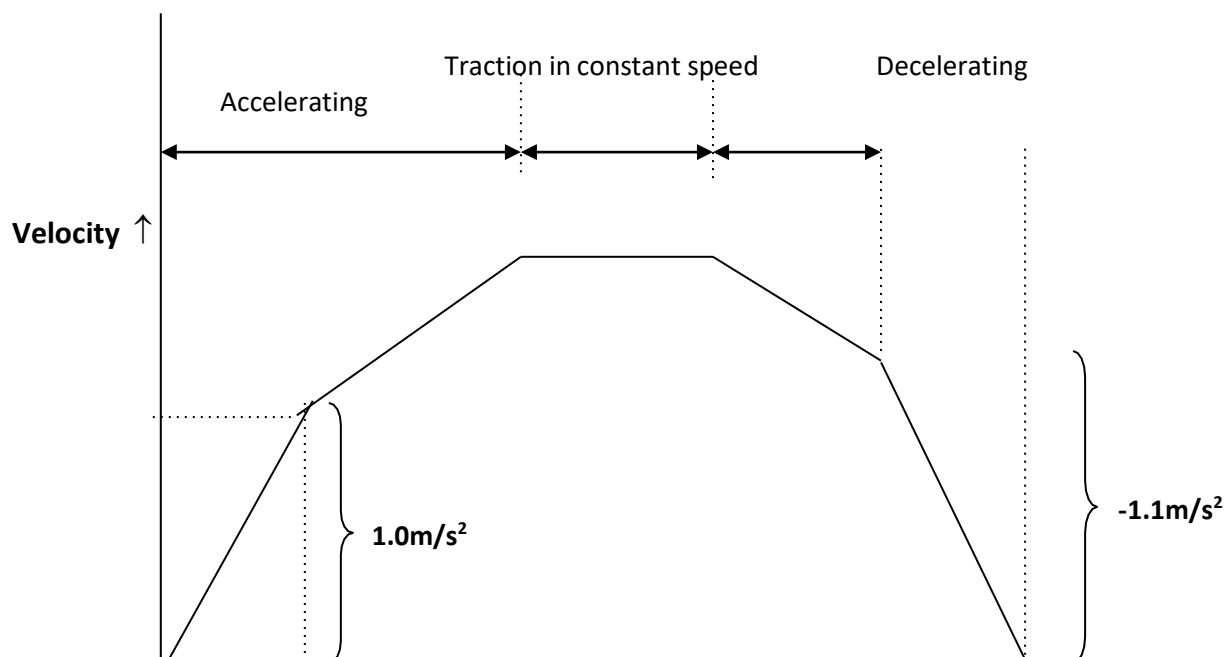
e) Performance Parameters

To achieve the desired schedule speed and running time between stations, the following values of acceleration and deceleration are recommended in consideration of riding comfort, adhesion and requirement of makeup time.

- Max. operating speed :**90 KMPH**
- Max. Acceleration :**1.0 m/s²**
- Max. Deceleration :**1.1 m/s² (Normal brake)**
- More than **1.3 m/s²(Emergency brake)**

The velocity time operation curve is shown in **Figure 11.1**.

FIGURE 11.1: SIMPLIFIED VELOCITY – TIME OPERATION CURVE



11.2 ROLLING STOCK REQUIREMENT

Rolling Stock requirement for different horizon years has been calculated based on the train operation plan. The calculation for the rake requirement of the corridor for different horizon years has been given in Train Operation Plan. The coach requirement for the corridor of Thane Metro is given in **Table 11.5**:

TABLE 11.5: COACH REQUIREMENT FOR THANE METRO CORRIDOR

Corridor	2029	2035	2045	2051
New Thane to New Thane (Ring Corridor)	150	180	219	246

Chapter – 12

POWER SUPPLY SYSTEM

12. POWER SUPPLY SYSTEM

12.1 CHOICE OF ELECTRIC TRACTION SYSTEM

Traditionally, electric traction has been used to meet the requirement of high acceleration, pollution free services and to achieve the optimum performance in urban, Sub-urban and main line rail transport system. Selection of an appropriate technology for traction system may be based on following factors:

- Cost of the technology
- Previous experience & proven-ness
- Maintenance requirements
- Energy Efficiency
- Aesthetics, Economic viability & Sustainability

The Cost of traction power system depends upon the following factors:

- Maximum power demand of load
- Level of redundancy & reliability
- Land Cost particularly for Traction Sub-station and Sectioning Posts
- Availability of technology and equipment at Competitive price

There are three standard and proven systems of electric traction for use in suburban and metro lines:

- 25 KV AC system
- 1500 V DC Third Rail/ Overhead Catenary System
- 750 V DC Third Rail System

The merits and demerits of these systems are discussed below:

12.1.1 25 KV AC System

25 KV AC traction system has been adopted by Delhi, Jaipur, Chennai and Hyderabad metro rail corporations as well as Indian Railways. The system has the potential to carry large traffic (60,000-100,000) PHPDT and possibility of linking to mainline railways, if required.



In comparison to DC systems, the regeneration capacity for 25 KV AC system is more and the line losses are less. In case of 25KV AC traction, 100% recovery of regenerated energy is possible compared to 60% in case of 750 V DC if no special measures are taken to recover the regenerated energy. Energy saving on account of regenerative braking is about 25-35% of traction energy in case of 25kV ac traction as compared to about 20% in case of 750V dc traction.

Suitable measures are required for mitigation of electro-magnetic interference (EMI) caused by single-phase 25kV AC traction currents. 25kV AC train will require the heavy transformers to be carried in the motor coach which will increase the weight and hence there will be an increase in the energy consumption.

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 costs. Overall cost of land and equipment's for 25kV ac traction system is significantly lower compared to that for 1500V dc or 750V dc traction system. In addition, it is widely used traction system on Indian Railways with availability of proven indigenous technology for all the components of 25 kV ac systems.

12.1.2 1500 V DC Third Rail/ Overhead Catenary System

1500V DC Third Rail/ Overhead Catenary System have been adopted by few metros to overcome the limitation imposed by 750V DC system for catering to traffic of 60,000-80,000 PHPDT.

The 1500V DC third rail system has been adopted in Chinese Metros by Guangzhou Metro and Shenzhen Metro during last decade from aesthetics and reliability considerations. It can meet higher traffic needs with 5.4m tunnel diameter. There is not much experience over use of 1500V DC third rail system and also it has major constraints on requirement of power block for any kind of attention to track, signaling, other equipment and side evacuation.

The 1500V DC Overhead Catenary System requires use of catenary masts on elevated viaducts thereby affecting aesthetics of the city. Overhead catenary may be prone to lightning and thunderstorm. In addition, suitable measures are required to manage the stray currents which may cause corrosion of metallic structures. Mumbai suburban section of Western Railway and Central Railway which was provided with 1500 V DC catenary, has been converted to 25 kV AC system due to limitation of this system to handle increase in the traffic demand.

12.1.3 750 V DC Third Rail System

750 V DC third rail system which has been extensively used in metros and more than 60% of existing metro systems in the world utilize 600-750V DC third rail system. However, the traffic handling capacity of this system is limited to 60,000 PHPDT.



In India Kolkata, Kochi and Bangalore Metro have 750V DC traction system introduced in 1984 and 2011 respectively. Kolkata Metro was built with the primitive technologies i.e. use of Steel third rail with top contact, non-air conditioned rakes with tunnel air conditioning and non-regeneration. Bangalore Metro is using the advanced technology with Al composite third rail, air conditioned coaches and VVVF control of traction motor with regenerative braking.

750 V DC third rail system offers the best aesthetic solution because of the absence of any overhead conductors and supporting structures. The 750V DC third rail needs very little maintenance since by virtue of its solid rigid design it is able to withstand passing of current collector devices of the train without any significant wear & tear. However, maintenance of substation costs more as they are more in numbers.

Because of lower voltage, the 750V DC traction power system handles much higher operating current resulting into higher voltage drop and line losses along the third rail distribution system. This necessitates closer spacing of sub-stations, leading to higher cost of construction. The presence of live third rail at ground may be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.

In a third rail system, where the running rails are used as a return path, a part of the stray current leaks into the track structure. This current is called Stray current. The stray current corrosion is often encountered in dc-electrified systems and therefore, suitable measures are required for protection against corrosion of metallic components in the track-structures as well as metallic reinforcement and metal pipes etc in the vicinity of metro alignment. The civil structure should be compatible with 750V DC third rail system in view of mitigation of stray current.

12.1.4 Selection of appropriate Traction system for Thane Metro

The selection of proper traction system has a significant impact on capital cost, operational cost, traffic growth, operational flexibility and expandability of the

system in future. It is also linked to the ultimate capacity being planned. Appropriate selection of traction system at design stage is essential to achieve optimum performance of a MRTS system.

25 KV AC is most economical followed by 1500 V DC and 750 V DC traction systems both from initial cost point of view as well as energy efficiency. But from the aesthetic point of view, 750 V DC Third rail system is better. 25 KV AC system has an ability to carry a high traffic at a reduced cost with higher efficiency of operation. Considering the ultimate traffic demand and the techno economic advantages offered by 25 kV AC system, it is proposed to adopt 25 kV AC system for Thane MRTS.

The elevated and at grade sections of the corridor will be provided with flexible OHE (Overhead Equipment) whereas the underground sections will be provided with the rigid overhead catenary system.

12.2 PROJECTED POWER DEMAND

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications.

The power supply system is proposed to be designed for 28000 PHPDT (peak hour peak direction trips) for New Thane to Thane Junction (Ring Corridor).

The Power supply system design has been conceptualized considering 6 car rake composition and train operation at 200 seconds headway. The designed system shall ensure high reliability and adequacy of the system to meet unforeseen growth in traffic demand.

The ultimate (design) power requirement for this corridor will be conceptualized considering following norms, directives/ guidelines:

- Train operation with 6 car rakes with carrying capacity of 1574 passengers (standing @ 6 passengers/ m²).
- Peak period headway of 200 seconds.
- Specific energy consumption of rolling stock – 75 KWh/ 1000 GTKM
- Regeneration @ 30%
- At grade/ Elev. station load – initially 200 kW, ultimate design 300 kW
- Underground station load – initially 2000 kW, ultimate design 2500 kW

- Depot auxiliary load – initially 1500 kW, ultimate design 2000 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, power demand estimation for the proposed corridor of Thane Metro is given in Table 12.1.

TABLE 12.1 : POWER DEMAND ESTIMATION (MVA)

Load	Year			
	2029	2035	2045	2051
Traction	14.95	18.32	22.50	24.66
Auxiliary	11.08	11.08	12.10	13.13
Total	26.03	29.40	34.60	37.78

The calculations for the traction and auxiliary power demand estimation are shown in **Annexure 12.1**. However, this requirement has been worked out based on the conceptual design and therefore, needs to be reaffirmed and fine-tuned by conducting necessary simulation study during detailed design stage of project implementation.

12.3 SOURCES OF POWER SUPPLY

Need For High Reliability of Power Supply

New Thane to New Thane(Ring corridor) are being designed to cater to about 28000 passengers per direction during peak hours (PHPDT) when trains are expected to run at high frequency of 200 seconds. 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 already 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.

In order to ensure high reliability of power supply, feed from more than one RSS have been planned for the proposed corridor. Under normal circumstances, each RSS will feed specific sections of the corridor. In case of emergency condition i.e. when one RSS fails, the other RSS will feed the section of the RSS under outage. Therefore, it is essential that all the sources of supply and connected transmission

& distribution networks are reliable and have adequate built in redundancies.

Sources Of Power Supply

Thane City has 220kV, 132kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridor. Keeping in view of the reliability requirements and considering the complete length of corridor, two Receiving Sub-stations are proposed to avail power supply for traction as well as auxiliary services from the Maharashtra Power Transmission Company Limited (MSETCL) grid sub-stations at 220 kV voltage through cable feeders. The details are presented in **Table 12.2**.

Table 12.2: Sources of Power Supply (Proposed)

GRID SUB-STATION	RSS OF METRO AUTHORITY PROPOSED	APPROX. DIST. GSS TO RSS
400KV MSETCL SUBSTATION, KALWA	SHIVAJI CHOWK RSS (220/33 KV)	5 KM
MSED 220KV SUB-STATION, THANE	GANDHI NAGAR RSS (220/33 KV)	6 KM

The HT power supply from grid substations at 220kV will be stepped down to 25kV single phase supply for traction purpose and 33kV supply for auxiliary power supply at the Receiving cum Traction Substations (RSS/ TSSs) of MRTS authority. The traction power will be fed to 25kV OHE system through cable feeders and the auxiliary power will be distributed along the alignment through 33kV Ring main cable network for feeding auxiliary loads. These cables will be laid in dedicated ducts/ cable brackets along the viaduct/ tunnel.

The entire power supply system & auxiliary power supply system will be monitored and controlled from a centralized Operation Control Center (OCC) using a SCADA system.

The summary of expected power demand at various sources is given below in **Table 12.3**.

In normal conditions, RSS 1 will feed the section from New Thane to Waghbil and RSS 2 will feed from Waghbil to Thane Junction including Depot. In case RSS 1 fails, the feed can be extended from RSS 2 and vice-versa. Thus in case of failure of one RSS, single RSS will feed the complete length of the corridor.

Table 12.3 : Power Demand Projection for various sources

Name of RSS	Peak Demand – Normal(MVA)				Peak Demand – Emergency (MVA)			
	2029	2035	2045	2051	2029	2035	2045	2051
RSS 1 (New Thane to Waghbil)								
Traction	8.15	9.48	11.64	12.75	13.83	18.32	22.50	24.66
Auxiliary	4.90	4.90	5.37	5.83	11.08	11.08	12.10	13.13
Total	12.05	14.38	17.00	18.59	24.91	29.40	34.60	37.78
RSS 2 (Waghbil to Thane Junction)								
Traction	6.80	8.84	10.86	11.90	13.83	18.32	22.50	24.66
Auxiliary	6.18	6.18	6.74	7.29	11.08	11.08	12.10	13.13
Total	12.86	15.03	17.60	19.20	24.91	29.40	34.60	37.78

The equipment rating of the RSS cum TSS will be determined considering the normal as well as emergency situation. When one RSS fails, the traction & auxiliary supply will be maintained by extending feed from adjoining RSS. However, in case of total grid failure, all trains may come to a halt but emergency lighting, fire, hydraulics and other essential services can be catered to by stand-by UPS/ DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

Based on emergency demand expected at each RSS, 2 traction transformers of 220/25kV, 25MVA (ONAN) capacity each are proposed. Similarly, 2 nos. Auxiliary transformers (220/33 kV) of 15 MVA(ONAN) capacity each are proposed to be provided at all the RSSs. Indoor type Gas Insulated Substation (GIS), which offers the advantage of considerable saving in space requirement shall be proposed in case of constraint in land availability.

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV XLPE insulated FRLS cable ring network is proposed for Auxiliary ring main network, which shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations. Adequate no. of cables is also required for transfer of traction power from Metro's RSS to nearest feeding point of 25kV OCS.

The rating of major equipments have been worked out based on the conceptual design and therefore, these capacities needs to be reaffirmed and fine tuned by conducting necessary simulation study during detailed design stage of project implementation.

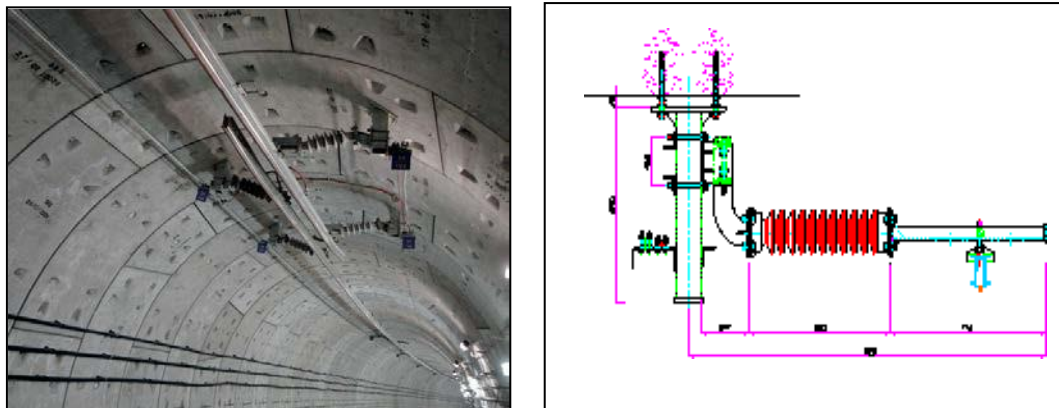
12.4 TRACTION POWER SUPPLY

12.4.1 25 KV Rigid OHE System (for Underground section)

The proposed 25kV Rigid OHE system in underground section is similar to the one installed in underground sections of Delhi Metro. 25kV Rigid OHE system (Figure 12.1) comprises a hollow Aluminum Conductor Rail of adequate cross section with 150 sq.mm copper contact wire held with elastic pinch. The Al conductor rail is supported by an insulator and cantilever arrangement attached to drop-down supports fixed to tunnel roof. The supports are located at every 10 metre and there is no tension in the conductors and hence, no tensioning equipment is required in tunnel. The design of 25kv rigid OHE system shall be in accordance to electrical clearances and contact wire height as per IEC 60913 and EN50122, which is summarized below:

- Contact wire height = 4324mm (with Panto locked down height of 4048mm)
- Structure to Live parts clearances = 270/170/150mm (Static/Dynamic/Abs. min dynamic)
- Vehicle to Live parts clearances = 290/190/150mm (Static/Dynamic/Absolute/ min dynamic)

Figure 12.1: 25KV RIGID OHE ARRANGEMENT



12.4.2 25 KV flexible Overhead Equipment System (For Elevated section & Depot)

25 kV ac Flexible Overhead equipment system shall comprise 150 sq mm HD-copper contact wire and 65sqmm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq mm cross section. From safety considerations, Hydraulic type Auto-Tensioning Device (ATDs) are proposed on mainlines which does not require use of balance weight for tensioning of OHE conductors. Proven catenary fittings are proposed similar to DMRC system.

12.5 AUXILIARY POWER SUPPLY

12.5.1 The auxiliary power will be required for:

- Lights & fans for station
- Service buildings
- Foot over bridges/ Subways
- Maintenance depots
- Air-conditioning
- Lifts
- Escalators
- Water Supply Pumping stations – for washing, toilets as well as fire protection measures.
- Equipment – Signaling, Telecom, Platform Screen Doors and Automatic Fare Collection etc.

Auxiliary sub-stations (ASS) (**Figure 12.2**) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 200 kW in the initial years and is likely to reach 300 kW in the horizon year. Similarly, for the underground stations, the auxiliary load requirements have been assessed at 2000 kW for underground station which is likely to increase to 2500 kW in the horizon year. The average load considered for elevated station and underground station will have to be fine tuned to suit station requirement during detailed design stage.

Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 500 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. Two transformers (33kV/415V, 3-phase) of 2500 kVA at each underground ASS for the underground stations are proposed to be installed (one transformer as standby). Apart from stations, separate ASS is required at each depot with 2x2000 kVA auxiliary transformers to cater to depot cum workshop load.

12.5.2 E&M Systems

a) LT Power Distribution

33 kV ring main cables running all along the route shall feed each ASS by loop in loop out arrangement. The 33 kV power supply is stepped down to 415 V, 3 phase for distribution to the consumption points (service utilities) viz. Elevators, Escalators, Light & power sockets, Fire system, HVAC system and Signal & Telecom

system etc.

Figure 12.2: TYPICAL INDOOR AUXILIARY SUB-STATION



The power distribution system shall be designed by using low voltage power cable run on the cable tray, raceway and conduit as suitable to supply power to various loads within station and buildings. The low voltage power distribution cables shall comply with IEC 60502 or other applicable international standard. Fire resistant cables shall be used for safety purpose and comply with the performance requirements of IEC 60331 and BS 6387.

b) Illumination System

For Illumination generally, all lighting fixtures shall be applied with 240V, single phase 50Hz power supply. The type and quality of fittings and their luminous intensity shall relate to the space being illuminated and will take into account the effect of architectural space concept and colour scheme as per IS 3646.

The LED lights offer advantages over conventional fluorescent lighting on account of Energy savings, lower life cycle cost, longer life span, rugged nature etc. Considering the benefits of LED light fixtures over the conventional/ fluorescent fixtures, the use of LED light fixtures is recommended at elevated and underground stations of the corridor and the office buildings of the depot. However, the conventional fluorescent light fittings may be adopted at selected locations wherever payback period for additional cost of LED light is much higher or non-availability of efficient and proven LED light fixtures such as Medium/ High Bay lighting of high wattage (250W – 400W) in depot.

c) Lifts and Escalators

Lifts and escalators shall be provided at each station for the convenience of the passengers. The power supply for the operation of lifts and escalators is fed from the Auxiliary substation at each station. The number of lifts and escalators

proposed to be provided for the passengers at each station of Thane Metro corridor is given in **Table 12.4**. It is proposed to be implemented under PPP model.

TABLE 12.4 : REQUIREMENT OF LIFTS & ESCALATORS (AT EACH STN.)

Stations	Lift	Escalator
Elevated Stations-20 NOS.	4	10
Ug Stations-02 NOS.	3	6

d) Fire Detection and Alarm System

The Fire Detection & Alarm System shall be in conformance to the applicable NFPA standard or Other International Standards & also comply with the codes of practice, standards, regulations and requirements of the Statutory Authorities. The coordination of Fire Detection & Alarm System with the following services should be verified, tested, and validated as a complete system before implementation-

- i. Fire Detection & Alarm System,
- ii. Public Address & Voice Alarm System,
- iii. Emergency Lighting System,
- iv. Conveying Systems (Lifts & Escalators),
- v. HVAC systems (AHUs / fire dampers / staircase pressurization fans / chillers, motorized dampers / exhaust fans etc),
- vi. Fire Fighting Systems (Fire Pumps / Sprinkler Valves),
- vii. Automatic Doors,
- viii. Traction SCADA,
- ix. E&M SCADA,
- x. Rolling Shutters,
- xi. Networking of main fire alarm system, at station to the station control room, and backnet Interface on TCP/IP for third party systems.
- xii. Systems not listed above but that requires interfacing with the Main Fire Alarm System.

e) Fire suppression

Portable Fire Extinguishers

The portable fire extinguishers shall be installed at all the stations in compliance

with relevant BS EN Codes and codes of practice, standards, regulations & requirements of the Statutory Authorities. All the covered areas should be provided with suitable type of fire extinguishers. In the Concourse and Platform areas, Fire Extinguishers shall be provided in a central location inside a suitably sized cabinet of approved construction. The location and design of the extinguisher cabinets provided shall comply fully to the local fire authority requirements.

Extinguishers shall be conspicuously located in positions where they will be readily accessible and immediately available in the event of fire. They shall be located near to room exits, corridor, stairways, lobbies and landings. Extinguishers shall be installed at a height of 1 metre above the floor level and shall be placed in a manner such that the extinguisher operating instructions face outward.

Wet Mains System

The Fire Fighting wet mains system shall be based on BS- 9990: 2006, BS-9999: 2008 & National Building Code. The system shall comprise pipe work, breeching inlets, landing valves, automatic air release valves, fire hose cabinets and fire hose reels etc. The wet mains system is charged by the Fire pumps set. The fire pump set shall have dual power supply and the system shall be designed to achieve a pressure of 3.5 Bar at the remote fire hydrant point. The system will draw water from the fire water storage tank provided near station building based on the NBC requirements.

Fire Hose Cabinets

The Fire Hose Cabinets shall be provided as per NBC and fire authority regulations in internal and external public areas of the station.

Fire Hose Reels

The hose reels shall meet the requirements of BS 5306.1: 2006 & BS EN 671 – 3:2004. Hose-reel shall be provided in such a way that it covers the entire Concourse / Platform areas with suitable number of fire hose cabinets. The hose reels system will be based on direct feed from the Fire Water Wet mains. Hose-reels shall be of the swing-recessed type. Each hose-reel shall be an integral unit consisting of a stop valve, reel, hose, and shut-off assembly. It shall be designed so as to facilitate the swift withdrawal of the hose in any direction with the reel axis horizontal.

Gas Flooding System

Gas Flooding System is proposed to be provided for protection of the equipments in electrical Auxiliary sub-stations and S&T Equipments in Depot Control Centre/ Operational Control Centre. The design of the system shall be in conformance to

NFPA standards.

12.5.3 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the RSSs or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 180 kVA at all elevated stations and 2 x 1000 kVA capacity at underground stations to cater to the following essential services:

- Lift operation
- Essential lighting
- Signalling & telecommunications
- Firefighting system
- Fare Collection system

Silent type of DG sets, which have low noise levels and do not require separate room for installation, are proposed. In addition, UPS with adequate power backup may be installed for the very essential lighting load.

12.6 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 fibre cables provided for telecommunications will be used as communication carrier for SCADA system. The SCADA system is presented in **Figure 12.3**.

Figure 12.3: SCADA SYSTEM



12.7 ELECTROMAGNETIC INTERFERENCE (EMI) & ELECTROMAGNETIC COMPATIBILITY (EMC)

25kV ac traction currents produce alternating magnetic fields that cause induced voltages in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) system is proposed for EMI mitigation.

Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc. Two earth conductors – Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with track. All the concrete and metallic structures, structural reinforcement, running rails etc. will be connected to these conductors to form an equipotential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE on the section. Similar arrangements have been adopted on Delhi Metro as well.

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, signalling & 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 and Earthing & Bonding plan require to be developed during design stage.

12.8 SOLAR ENERGY HARNESSING SYSTEM

12.8.1 Introduction

The solar mission, which is part of the National Action Plan on Climate Change has been set up by Govt. of India to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options.

Considering the futuristic technology and potential for solar power generation, Delhi Metro has recently implemented roof top grid connected solar power systems at selected locations of elevated stations and maintenance depot. Metro Railways under implementation in different cities of the country viz. Jaipur, Lucknow, Nagpur etc. are also exploring the possibilities of harnessing solar photovoltaic energy.

With the downward trend in the cost of harnessing solar energy and appreciation for the need for development of solar power, provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations/ sheds

and buildings is proposed for Thane MRTS.

12.8.2 Solar PV Power Generation Potential

The roof top on the elevated stations of Thane Metro corridor and the different sheds and buildings of the depot viz. Stabling, Inspection and Heavy Repair Shed, Administrative Building, Training Centre, DCC/OCC Building etc is proposed to be used for SPV installation at suitable orientation and inclination to optimize the solar energy potential. The roof of the sheds should be south facing to maximize the Solar power generation in depot. The solar power would be used locally to the extent of load in the building and the generation over and above the requirement of the building would be fed into the grid.

The average raw sunshine available which can be harnessed for the power generation depends on the geometrical coordinates of the place. The intensity of solar radiation varies with time of the day. The combined effect of these factors and the additional complication of the wobble of the seasons is that the average raw power of sunshine per square meter of south-facing roof in India is roughly 100 to 120W/m².

The mean global solar radiant exposure at Thane varies from 3.7 kWh/ m²/ day in the month of December to 6.6 kWh/ m²/ day in the month of May.

Based on the solar radiation intensity in the city of Thane, the peak solar power generation of Thane Metro corridor is expected to be about 50 kWp for the elevated stations and about 2000 kWp for maintenance depot.

The power generation depends upon various factors such as the intensity of the solar radiation, the net useable area available on the roof top, the obstructions due to shadow or the shading factor, the orientation of the solar panels, efficiency of the solar cells etc. The solar power generation potential in Thane metro corridor is required to be reviewed and finalized during detail design stage.

12.9 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 includes the following energy saving features:

- 1) Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.
- 2) Rolling stock has regeneration features and it is expected that 20% of total traction energy will be regenerated and fed back to 750 V dc third rail to be consumed by nearby trains.
- 3) 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 (operation or maintenance hours etc).
- 4) Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.
- 5) 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.
- 6) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) has been incorporated in the system design.
- 7) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

Annexure 12.1

**Traction and Auxiliary Power Requirement for
New Thane to Thane Junction Corridor**

(A)	TRACTION LOAD					
			2029	2035	2045	2051
1	Average speed (KMPH)	S	34	34	34	34
2	Frequency of service (Sec.)	F	225.0	225.0	200.0	200.0
3	Headways (Km.)	H	2.1	2.1	1.9	1.9
4	Nos of trains per hour	N	17(12,5)	16 (5,11)	18(3,15)	18
5	Specific energy consumption (KWh/Thou GTKM)	SEC	75	75	75	75
6	Gross tonnage of 3 & 6 car rake	T	222	300.75	327	357
7	Corridor length (Km)	D	29.1	29.1	29.1	29.1
8	Power factor of load	PF	0.9	0.9	0.9	0.9
9	Max. demand on TSS (KW)		15505	21005	25693	28050
10	Energy Saving on the account of Regeneration @30%		4652	6302	7708	8415
11	Net Demand		10854	14704	17985	19635
12	Depot Traction Load		1000	1000	1300	1500
	Total Traction load of the corridor		11854	15704	19285	21135
	Max. demand on TSS in KVA		13171	17448	21428	23484
	considering 5 % loss (MVA)		13.83	18.32	22.50	24.66
(B)	AUXILIARY LOAD					
1	Load of each elevated stations (KW)		200	200	225	250
2	Nos of at grade/elevated station		20	20	20	20
3	Load of each U/G stations (KW)		2000	2000	2125	2250
4	Nos of U/G stations		2	2	2	2
5	Load of shed (KW)		1500	1500	1625	1750
6	Total load of the stations & 1 Depot (KW)		9500	9500	10375	11250
7	Power factor of the load		0.9	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)		10556	10556	11528	12500
	considering 5 % loss (MVA)		11.08	11.08	12.10	13.13
	Total Max. power Demand Traction + Aux. (MVA)		23.73	28.00	32.96	35.98
	Net demand (MVA) considering 5% distribution loss		24.91	29.40	34.60	37.78

Chapter – 13

VENTILATION AND AIR CONDITIONING SYSTEM

13. VENTILATION AND AIR CONDITIONING SYSTEM

13.1 NEED FOR VENTILATION AND AIR CONDITIONING

The alignment of Thane Metro corridor is the combination of underground and elevated section. The elevated section of the corridor generally has less requirement for air conditioning and ventilation system. The air conditioning is required for a few equipment rooms within the station premises. However, in the underground section, air conditioning and ventilation is very important for proper functioning of the system. The Ventilation and Air-conditioning (VAC) system requirements for the underground sections include the following:

- Station Air-conditioning System
- Ventilation System for station plant rooms (ancillary spaces)
- Station Smoke Management System
- Tunnel Ventilation System

The underground stations of the Corridor are generally built in a confined space. A large number of passengers occupy concourse halls and the platforms, especially at the peak hours. The platform and concourse areas have a limited access from outside and do not have natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the authority's staff;
- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing;
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way;
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates, etc. working in the stations;
- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

This large quantity of heat generated in underground stations cannot be extracted by simple ventilation, especially when the outdoor air temperature and humidity is high. It is, therefore, essential to provide mechanical cooling in order to remove the heat to the maximum possible extent. As the passengers stay in the stations only for short periods, a fair degree of comfort conditions, just short of discomfort are considered appropriate.

13.2 INTERNAL DESIGN CONDITIONS IN UNDERGROUND STATIONS

It is essential to maintain appropriate conditions in the underground stations in order to provide a comfortable and pollution-free environment. The plant capacity and design of VAC system needs to be optimized for the designed inside conditions.

The Indian Standards & Codes, which pertain to office-buildings, commercial centres and other public utility buildings, have no guidelines on temperature standards to be maintained for the underground mass rapid transit system as yet. The standards used for buildings cannot be applied straightaway for the underground spaces, because the patrons will stay for much shorter durations in these underground stations.

The comfort of a person depends on rapidity of dissipation of his body heat, which in turn depends on temperature, humidity and motion of air in contact with the body. Body heat gets dissipated by the process of evaporation, convection and conduction. Evaporation prevails at high temperature. Greater proportion of heat is dissipated by evaporation from the skin, which gets promoted by low humidity of air. The movement of air determines the rate of dissipation of body heat in the form of sensible and latent heat.

There are different comfort indices recognized for this purpose. The 'Effective Temperature' criterion was used in selecting the comfort conditions in the metro system. In this criterion, comfort is defined as the function of temperature and the air velocity experienced by a person. More recently a new index named RWI (Relative Warmth Index) has been adopted for metro designs worldwide. This index depends upon the transient conditions of the metabolic rate and is evaluated based on the changes to the surrounding ambience of a person in a short period of about 6 to 8 minutes. It is assumed that during this period human body adjusts its metabolic activities. Therefore, in a subway system where the train headway is expected to be six minutes or less, RWI is the preferred criterion.

Sub Soil Temperature

The temperature conditions of sub-soil play a vital role in the system design of the underground stations. It is also expected that water table surrounding the underground alignment is not very much below the surface level, thereby facilitating adequate heat exchange between the tunnel structures and soil.

13.3 DESIGN PARAMETERS AND DESIGN CONCEPTS FOR VAC SYSTEM

Thane has a tropical monsoon climate that borders on a tropical wet and dry climate. Overall climate is equable with high rainfall days and very few days of extreme temperatures.

Based on prevalent practices and ambient conditions of Thane, the following VAC system design parameters are assumed to be provided for underground sections of the proposed corridor of Thane Metro

- (i) Outside ambient conditions:
 - Summer: - 38°C (DB), 27.8°C (WB)
 - Monsoon: - 30°C (DB), 28.5°C (WB)
- (ii) Inside design conditions:
 - Platform areas - 27°C at 55 % RH
 - Concourse - 28°C at 60 % RH
- (iii) Tunnel design conditions:
 - Normal conditions - Max. DB 40°C
 - Congested conditions - Max. DB 45°C
- (iv) Minimum fresh air - 10 % or 18 cmh/ person
(in station public area)

There are various VAC design concepts technically feasible in a subway system that can provide and maintain acceptable subway environment conditions under different requirement and constraints. These are: Open type; Closed type; Mid - Tunnel Cooling; Semi Transverse Ventilation; Use of jet fans; use of mid-shafts; platform screen doors etc. The experience available from the design of VAC system for Delhi Metro also provides key guidelines.

From the experience of DMRC, for such conditions it can be concluded that with open shaft system the piston effects can be sufficient to maintain acceptable conditions inside the tunnel, as long as the ambient DB temperature is below 33⁰C. When the outside temperature is higher than 33⁰C, the tunnel shafts should be closed to prevent any further exchange of air with atmosphere. The station premises (public areas) can be equipped with separate air-conditioning system during the summer and monsoon months to provide acceptable environment for patrons.

There shall be provision of Trackway Exhaust System (TES) by which platform air can be re-circulated. The train cars reject substantial heat inside subway. When the trains dwell at the stations, TES would capture a large portion of heat released by the train air-conditioners mounted on the roof tops and under gear heat because of braking, before it is mixed with the platform environment. The TES includes both an under platform exhaust (UPE) duct and an Over-trackway (OTE) exhaust duct. The TES uses ducts formed in the under platform void and over the trackway. Exhaust intakes are located to coincide with the train-borne heat sources.

The train heat generated inside the tunnel sections would be removed by the train piston action. It is envisaged that for the design outside conditions, it may not be necessary to provide forced ventilation using Tunnel Ventilations Fans for normal operating conditions. The number of shafts required would be two or three depending on the inter-station distances. The two shafts would be at the end of the stations and the third shaft, if required, can be built at the mid-tunnel section. These end-shafts at the stations also serve as Blast Relief Shafts, i.e. the piston pressure is relieved to the atmosphere before the air-blast reaches the station. All these shafts are connected to the tunnels through dampers. The dampers are kept open when the exchange of air with the atmosphere is permitted (Open system). For the closed system, the shaft dampers can be in closed mode and the displaced air is dumped in the adjacent tunnel.

Generally, each tunnel ventilation shaft has a fan room in which there are two fully reversible tunnel ventilation fans (TVF) are installed with isolation dampers. These dampers are closed when the fan is not in operation. There is a bypass duct around the fan room, which acts as a pressure relief shaft when open during normal conditions, and enables the flow of air to bypass the TV fans, allowing air exchange between tunnels with flows generated by train movements.

Dampers are also used to close the connections to tunnels and nozzles when under different operating conditions. The details for the shaft sizes, airflow exchange with the atmosphere, fan capacities can be estimated in more accurate manner with the help of Computer Simulations during the detailed design stage.

13.4 STATION VENTILATION AND AIR CONDITIONING OF ANCILLARY SPACES

Ancillary spaces such as staff room, equipment plant room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/ humidity.

All ancillary areas that require 24-hour air conditioning will be provided with fan-coil units (FCU) and standby AC units. During the revenue hours when the main chilled water system is running the FCU will be used for air-conditioning and in non-revenue hours standby AC units will be operated. Return air grilles will be fitted with washable air filters for the re-circulation of the air.

Where fresh air is required it will be supplied to the indoor unit via a fresh air supply system, complete with filter, common to a group of ancillary areas. The fresh air unit will be located in the VAC plant room and will be time switch controlled with local override. Temperature control will include an alarm setting, which is activated on attaining high temperature.

➤ **Station Air Conditioning**

The platform and concourse areas will be air-conditioned using supply 'air handling units' located in air-handling plant rooms throughout the station as shown in **Figure 13.1**. Each platform will be served by at least two separate air handling units (AHU's) with the distribution system combined along each platform to ensure coverage of all areas in the event of single equipment failure. Based on the initial estimation about 6 units (2 for the concourse each with 18 cum/s and 4 for the platform each having 24 cum/s air-flow) would be needed for the full system capacity.

These air conditioning system mix return air with a desired quantity of outside air. The outside air requirement is based on occupancy, with a minimum of 5 litres per second per person or 10% of circulated air volume, whichever is the greater. The provision of free cooling by a simple two-position economizer control system will be included, with the use of enthalpy sensors to determine the benefits of using return air or outside air. This will signal the control system to operate dampers between minimum and full fresh air, so as to minimize the enthalpy reduction needed to be achieved by the cooling coil. This mixture of outside and return air is then filtered by means of suitable filters and then cooled by a cooling coil before being distributed as supply air via high level insulated ductwork to diffusers, discharging the air into the serviced space in a controlled way to minimize draughts. Return air to the platform areas is extracted via the track-way exhaust system and either returned to the AHU's or exhausted as required.

FIGURE 13.1: CONCOURSE AIR HANDLING UNIT



The station air conditioning closed system scheme and section view are shown in **Figure 13.2** and **Figure 13.3**.

FIGURE 13.2: STATION AIR CONDITIONING CLOSED SYSTEM SCHEME

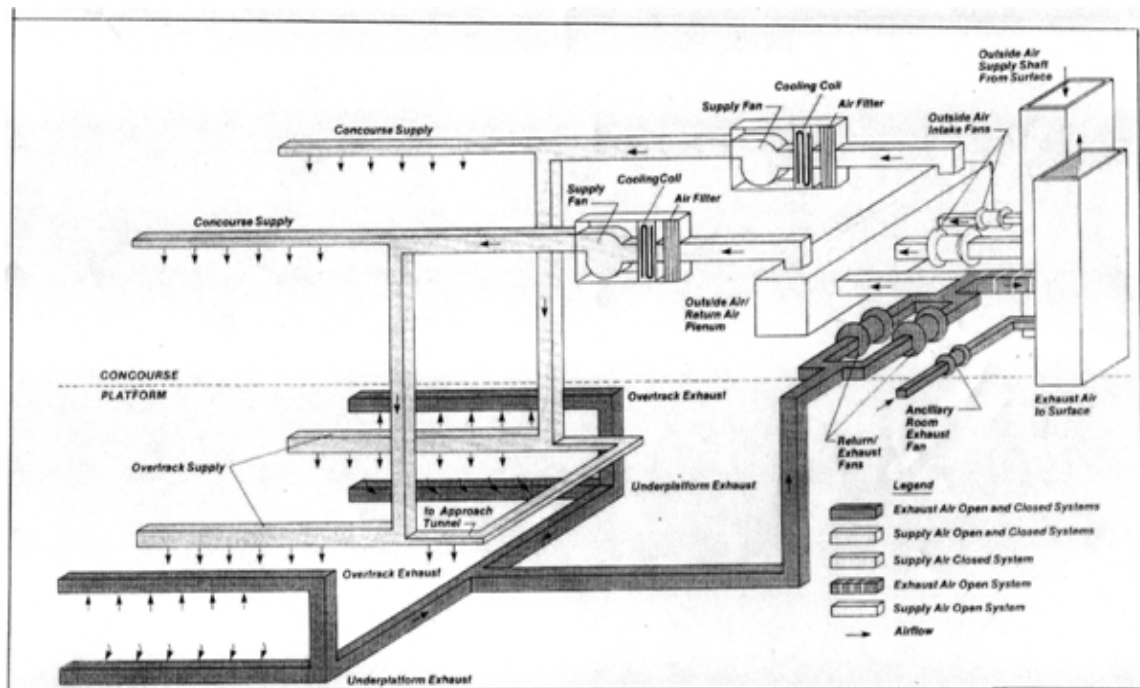
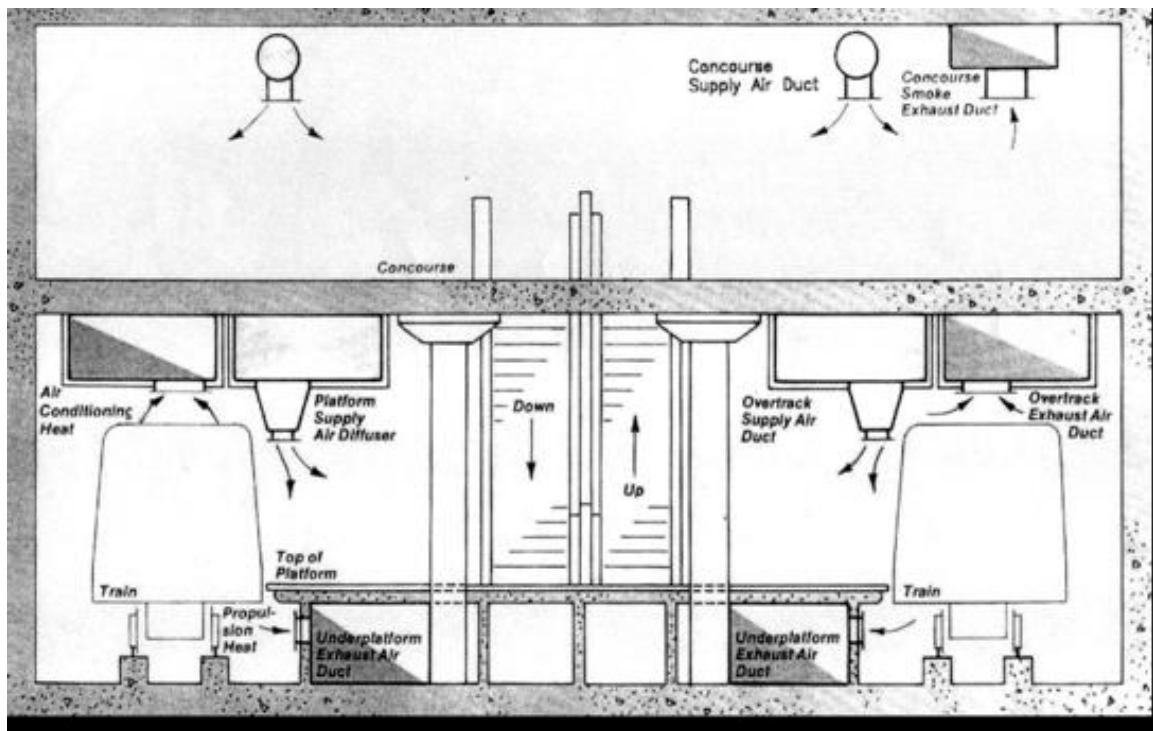


FIGURE 13.3: STATION AIR CONDITIONING SECTION VIEW



Water-cooled chiller units with screw compressors are recommended to be provided at each station, which are energy efficient. These units can be installed in a chiller plant room at surface level or in the underground premises. Based on the initial concept design, the estimated capacity for a typical station would be around 400 TR, hence three units of 200 TR (including one stand-by) may be required for full system capacity (i.e. design PHPDT traffic requirement). This capacity needs to be reaffirmed during the detail design stage for individual station depending on the heat loads. It is recommended that initially two units of 200 TR may be installed with the provision in terms of space be kept for the future addition.

In view of the temperate outdoor conditions, alternatively, it is possible to utilize air-cooled chiller units, which can save large amount of water requirement. The air-cooled chillers should be equipped with screw compressors so that they can be operated at a very less load with high efficiency. These units also eliminate requirement of condenser water circuits including pumps, cooling towers and make up water plants, but are less efficient as compared to the water-cooled- units.

13.5 Tunnel Ventilation System (TVS)

The TVS is provided in a Subway system essentially to carry out the following functions:

- a) Train Pressure relief during normal operation
- b) Ventilation during maintenance periods, if required
- c) Removal of smoke during emergency conditions
- d) Maintenance of smoke free

evacuation route and provision of adequate fresh air during fire related emergencies.



There are various operating modes (scenarios) for the Tunnel Ventilation system. These are described as under:

➤ **Normal Conditions**

Normal condition is when the trains are operating to timetable throughout the system, at prescribed headways and dwell times, within given tolerances. The primary source of ventilation during normal conditions is generated by the movement of trains operating within the system and, in some cases, the trackway exhaust system.

During summer and the monsoon seasons, the system will be functioning essentially with the station air conditioning operating. The vent shafts to the surface will enable the tunnel heat to be removed due to train movements. The platform air captured by the trackway exhaust system shall be cooled and recirculated in the station. For less severe (i.e. cool) environmental conditions (or in the event of an AC system failure), station air conditioning will not be used and ventilation shafts will be open to atmosphere (open system) with the trackway exhaust system operating. For cold conditions, the closed system or open system mode may be used without any station air conditioning. System heating is achieved by the train heat released into the premises.

➤ **Congested Conditions**

Congested conditions occur when delays cause disruption to the movement of trains. It is possible that the delays may result in the idling of a train in a tunnel section. Without forced ventilation, excessive tunnel temperatures may result reduced performance of coach air conditioners that may lead to passenger discomfort. During congested operations, the tunnel ventilation system is operated to maintain a specific temperature in the vicinity of the car air conditioner condenser coils (i.e. allowing for thermal stratification). The open

system congested ventilation shall be via a 'push-pull' effect where tunnel vent fans behind the train are operated in supply and tunnel vent fans ahead of the trains are operated in exhaust mode. Nozzles or booster (jet) fans will be used to direct air into the desired tunnel, if required.

➤ **Emergency Conditions**

Emergency conditions are when smoke is generated in the tunnel or station trackway. In emergency conditions, the tunnel ventilation system would be set to operate to control the movement of smoke and provide a smoke-free path for evacuation of the passengers and for the fire fighting purposes. The ventilation system is operated in a 'push-pull' supply and exhaust mode with jet fans or nozzles driving tunnel flows such that the smoke is forced to move in one direction, enabling evacuation to take place in the opposite direction depending upon the location of fire on the train.

➤ **Pressure Transients**

The movement of trains within the underground system induces unsteady air motion in the tunnels and stations. Together with changes in cross section, this motion of air results in changes in air pressure within trains and for wayside locations. These changes in pressure or 'pressure transients' can be a source of passenger discomfort and can also be harmful to the wayside equipment and structures. Two types of transient phenomenon are generally to be examined:

- a) Portal Entry and Exit Pressure Transients – As a train enters a portal, passengers will experience a rise in pressure from when the nose enters until the tail enters. After the tail enters the pressure drops. Similarly, as the nose exits a portal, pressure changes are experienced in the train.
- b) Wayside Pressure Transients – As trains travel through the system they will pass structures, equipment and patrons on platforms. Equipment would include cross passage doors, lights, dampers, walkways etc. Pressures are positive for the approaching train and negative for retreating trains.

Most rapid changes occur with the passage of the train nose and tail. The repetitive nature of these pressures may need to be considered when considering fatigue in the design of equipment.

The detailed analysis to assess the effect of pressure transients will be done during the design stage. For the portal entry/exits the effect of higher train speed may pose discomfort to the passengers. The estimation of Way-side transients during

design stage would be necessary to select design mechanical strength of the trackside fixtures, e.g. false ceilings, light fittings etc at the platform levels.

➤ Tunnel Ventilation Fans

As described earlier tunnel ventilation fans will be installed in each of the fan rooms near vent shafts. There shall be two fans in a fan room at each end of the station. The fan capacity depends on the inter-station distances and may vary from 60 cum/s to 100 cum/s. The exact capacity will be obtained through the simulation during detailed design stage. If necessary, nozzle type structures made up of concrete or steel may also be constructed to achieve desired airflow and air velocity in the tunnel sections. Alternatively, booster fans (jet fans) may be installed to direct the flow in the desired direction. These fans may also be used for emergency ventilation at crossover locations.

The track-way exhaust system will have two fans of each 30 cum/sec. for each platform. The connections to tunnels and shafts will be through damper units that may be either electrically or pneumatic actuated.

13.6 CONTROL AND MONITORING FACILITIES

For the underground stations the control and monitoring of station services and system such as station air-conditioning, ventilation to plant rooms, lighting, pumping system, lifts & Escalators, etc shall be performed at Station Control Room (SCR). However, the operation and control of Tunnel Ventilation as well as Smoke Management system will normally be done through OCC. All these system shall be equipped with automatic, manual, local and remote operation modes. The alarms and signals from the equipment at stations shall be transmitted to the OCC via communication network.

13.7 CODES AND STANDARDS

The concept VAC design is guided by the following codes and standards:

- SEDH – Subway Environment Design Handbook
- ASHRAE – Handbook, current series.
- CIBSE – Relevant document.
- NFPA – 130, 2003 edition.
- ECBC – Energy Conservation Building Code

Chapter – 14

DEPOTS

14. DEPOT

14.1 DEPOT LOCATION AND APPROACH TO MAINTENANCE

The Maintenance facilities for New Thane to New Thane (Ring Corridor) via Dongripada & Thane Junction of Thane MRTS is proposed to be provided at land near Kasarvadavali for about 41 rakes of 6 cars. The depot will have infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signaling & Telecommunication; Automatic Fare Collection etc.

In broad terms, based on the planned rolling stock requirements, this chapter covers the conceptual design of the following aspects of the Depot.

- Conceptual design and layout of Servicing Shed and Workshop to provide maintenance facilities and stabling facilities for 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.

The details of the two depot are provided on conceptual design basis and will work as a guideline for detailed design later.

14.1.1 Maintenance Philosophy

The outline of the maintenance philosophy followed would be as below:

- Typical Maintenance schedules being followed by Delhi Metro have been considered for determining the requirement of lines in depot.
- Unit replacement and to get essential repairs to major equipments done by the OEMs.
- Automation with state-of-the-art machinery to ensure quality and reliability. Labour intensive procedures will be kept to the minimum.

- Maintenance staff shall be given special training to develop high-level skills in their trade to ensure quality and productivity in their performance.
- Adequate facilities for the stabling have been provided at the depot.
- To maintain high degree of cleanliness, Automatic washing plant has been proposed for cleaning of rakes.

14.1.2 Planning of Maintenance Facilities Setup

The Rolling Stock requirements in different horizon years for the proposed corridors are indicated in **Table 14.1**:

Table 14.1 : RAKE REQUIREMENT FOR DIFFERENT HORIZON YEARS

Year	2029	2035	2045	2051
Headway (seconds)	225	225	200	200
No. of Cars/Train	3/6	3/6	3/6	6
Rakes Required	50	60	73	41
Cars Required	150	180	219	246

All the system and infrastructure on the proposed corridor has been conceptualized considering 6 car trains operating at 200 seconds headway.

14.1.3 Rolling Stock Maintenance Needs

➤ Maintenance Schedule

Servicing requirements shall be determined from the Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;
- Wheels (Re-discing / re-axling is planned at workshop only);
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;
- Batteries;
- Rolling stock air conditioning;
- Brake modules;

- Vehicle doors, windows and internal fittings.

The modern, fully equipped facilities are to be provided that meet these requirements efficiently and in full. In meeting these requirements, it shall be assumed that the average daily distance travelled by each rolling stock unit is approximately 300 km. The following maintenance schedule has been followed for the conceptual design:

Table 14.2 : PROPOSED MAINTENANCE SCHEDULE

Type of Schedule	Interval	Work content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Internal 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 (approx. 3.5 years)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km (approx. 7 years)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

➤ Washing Needs of Rolling Stock

The Metro trains are maintained to a high degree of cleanliness and therefore needs the maintenance schedule as mentioned in **Table 14.3**

Table 14.3 : SCHEDULE OF CLEANING

S.N.	Kind of Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside Cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Automatic washing plant of Depot Single Pass
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area, Floor, walls inside/outside and roof. Manually)	30 days	3 hrs.	Automatic washing Plant & washing line

14.2 DESIGN OF DEPOT FACILITIES AND DEPOT LAYOUT PLANS

14.2.1 Depot Layout Plans

The layout plan of proposed Depot cum workshop of Kasarvadavali depot for corridor is shown in Annexure-14.1. The conceptual layout for Kasarvadavali Depot has been evolved for maintenance & POH of 41 rakes of 6 car length.

The rake induction and withdrawal from depot to the open line will have to be so planned that the headway of open line is not affected. For the purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line should be created. The stabling area should be interlocked with the open line so that the induction of train from the stabling can be done without loss of time. The rake washing can be done at automatic coach washing plant provided at the entry of depot i.e before rake is placed on stabling lines.

The other movements in the depot, viz from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. One emergency re-railing line have been provided from which emergency rescue vehicles can be dispatched to open line in the event of any emergency. To cater to the peak requirements, all trains would be in the service, only trains under maintenance would be in the shed. However during the off-peak hour in daytime, approximately half of the trains will be withdrawn from the service. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night.

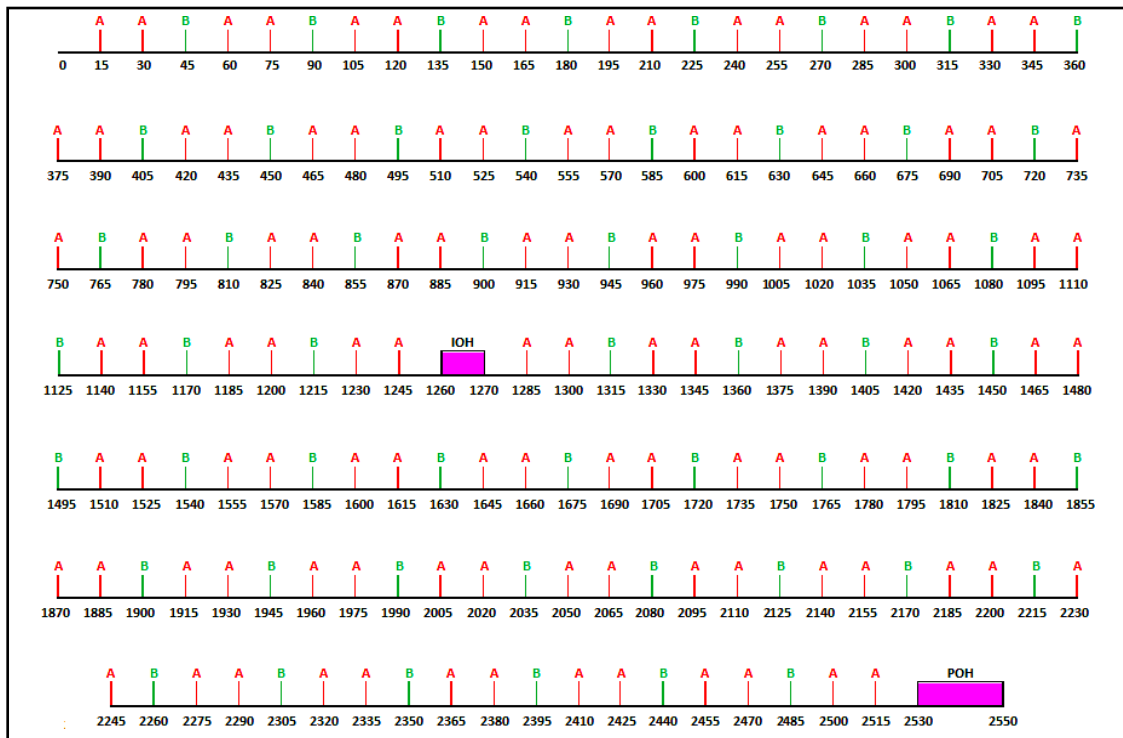
The stabling and the yard layout would be at grade level for least power requirements in shunting movements and to avoid accidental rolling of Rolling Stock resulting into accidents and damages to the property.

14.2.2 Infrastructure Facilities Planned At Depot

A. Inspection Lines and Workshop Lines in Depot

As per the frequency of inspections indicated in **Table 14.2**, the visits of rakes to Depot are as given below in **Figure 14.1**:

FIGURE 14.1: RAKE VISITS TO DEPOT AND WORKSHOP



To assess the number of lines required to maintain the rakes, following assumptions are made:

- For Washing of rakes, an automatic washing plant is proposed. Hence, no separate washing line is needed exclusively for washing. However, one line is provided for heavy cleaning (Manual cleaning of Floor, walls inside/outside and roof).
- In a day, two rakes are taken for 'A check' on a pit line.
- In a day, one rake is taken for 'B checks' on a pit line.
- Based on the number of holidays as given below, total numbers of working days are taken as 300 for calculating the requirement of lines.

- No. of days of Public holidays in a year : 13
- No. of Sundays in a year : 52
- No. of available working days in a year : 365 - 65 = 300 days.

As against above requirement, the infrastructure provided for Schedule inspection is indicated in **Table 14.4**.

Table 14.4 : REQUIREMENT OF INSPECTION AND WORKSHOP LINES PROVIDED FOR CORRIDOR

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising (for 41 rakes)	Line Occupancy	Lines Required (6 car length)	Lines Provided (6 car length)
Inspection Shed						
A Service Check	112	16	656	2 rake/ day	1.09	1
B Service Check	54	7.71	316	1 rake/ day	1.05	1
Adjustment line for minor repair/testing after POH						2
Inspection Lines Provided						4
Workshop Shed						
IOH	1	0.14	5.74	1 rake 10 days	0.19	1
POH	1	0.14	5.74	1 rake 20 days	0.38	1
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						1
Workshop Lines Provided						3

Kasarvadavali Depot will have the infra-structure for inspection and overhaul of 41 Rakes of 6 Car . Accordingly, 4 lines have been provided for the schedule inspections & 3 lines for periodical overhaul/major unscheduled repairs etc.

B. Stabling Lines in Depot

The rake requirement for Thane metro corridor is 41 rakes of 6 car for ultimate design year. Kasarvadavali Depot on the corridor is planned with 41 lines of 6 car length each. At a given time, some rakes would remain under inspection and the remaining rakes will be stabled at terminal/ enroute stations for the start of early morning services.

Hence, the depot layout for the proposed corridor is sufficient to cater to the maintenance requirements of the rolling stock operational on the corridor for the design/ultimate year.

14.2.3 Depot Cum Workshop Planning

As per the dimensions of the Rolling Stock, the approximate length of 3-car and 6 - car trains would be 67.8m and 135.6m respectively. However in the design of the Inspection shed, workshop lines and stabling lines at depot, length of 6-car train is taken in consideration.

i) Stabling Lines in Depot

For the design of the stabling lines in the depot, following approximate lengths have been taken in consideration:

- a. Length of one 3-car rake= 67.5 m
- b. Gap between two 3 car trains= 15m
- c. Free length at outer end (front end) of the rake (for cross pathway, Signal and Friction buffers)= 15m
- d. Free length at outer end (rear end) of the rake (for cross pathway, Signal and Friction buffers on front side)= 20m
- e. Total length of Stabling line = (c)+(a)+(b)+(a)+(d)= 15m + 67.5m+ 15m + 67.5m + 20m = 185m

Looking to the car width of 2900 on Standard Gauge, 4.6m Track Centre is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include a pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection.

Stabling lines 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.

ii) Inspection Lines in Depot

For the design of the Inspection Bay Lines in the depot, following approximate lengths have been taken in consideration:

- (i) Length of one 6-car rake= 135.6 m
- (ii) Cross path at each end = 10 m
- (iii) Total length of Inspection line = (ii)+(i)+(ii)= 10+ 135.6+ 10= 155.6 m (say 160)

The inspection bay in Kasarvadavali Depot shall be of 160 X 29.75m² size, inspection lines having sunken floor. The track spacing between the adjacent inspection Bay Lines shall be 6.25 m.

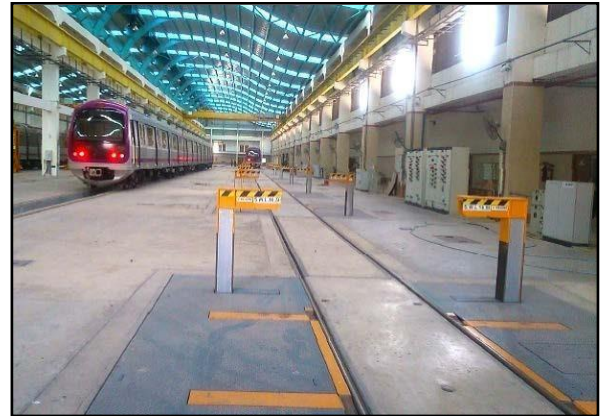
There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for

movement of material for the cars. Further, 10 m 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.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

iii) Workshop lines in Depot

The size of the workshop shed in Kasarvadavali depot shall be 160 x 39 m² and an additional covered space of 160 x 7.5 m² shall be provided in the depot to cater for offices cum maintenance sections, costly item store, locker room, toilet etc. Following equipment repair/overhaul facilities are planned in the workshop.



- Body furnishing.
- Bogie.
- Wheels.
- Traction Motor.
- Axle box and axle bearing.
- Power Collector.
- Electrical equipment like transformer, converter/inverter, circuit breaker, relays.
- Battery.
- Air compressor.
- Air conditioning equipments.
- Brake equipment.
- Door actuators.
- Control and measuring equipments.
- Pneumatic equipments
- Dampers and Springs
- Couplers/ Gangways

Cross track equipped with bogie turntables have been provided for movement between bays. A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

iv) Pit Wheel Lathe

A separate building is planned for housing pit wheel lathe (PWL) in the kasarvadavali Depot which is 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.



v) Auxillary shed Cum Emergency Re-railing Shed

Since the workshop cum depot is designed optimally, it would not be wise to waste its capacity in maintaining the other than passenger Rolling Stock vehicles. Carrying these vehicles to the inspection shed affects the Rolling Stock maintenance as shunting is also involved. Therefore, other vehicles like emergency re-railing, rail cum road vehicle, tower wagons, etc. may be housed and given required inspection attention in a separate shed called Auxiliary shed cum Emer. re-railing bldg, for which 1 line have been provided in the main depot. However for the heavy lifting needs, these vehicles may be taken to main workshop for required attention.



vi) Car Delivery Area

The newly procured coaches, which are transported by road, 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. 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.

vii) 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 six 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.

viii) Test Track

A test track of 1100m in Kasarvadavali Depot will be provided beside workshop. 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. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

ix) 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.

x) 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 cycle/scooter/car stand facility for convenience of the train operating staff.

xi) 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.

xii) Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

- (i) Close to the depot entry.
- (ii) Close to the stabling lines.
- (iii) Close to the Workshop/ IBL.

b) Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

xiii) Watch Towers

There shall be provision of adequate number of watch towers for the vigilance of depot boundary.

xiv) Power Supply

An auxiliary substation of 2500 KVA capacity has been planned for catering to the power supply requirement of the depot. Details of connected load, feeder may be worked out during detailed designing stage.

xv) Standby Power Supply

The standby power supply is proposed through silent DG set of 2X320 KVA capacity to supply all essential loads without over loading.

xvi) Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depot at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

xvii) 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 depot for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the underground reserves.

xviii) Plant And Machinery

Plant and machinery proposed for the maintenance facilities in depot have been listed in Annexure 14.2. Some of the major equipments used in the Maintenance Depot are given in figure below:

Synchronised Pit Jacks

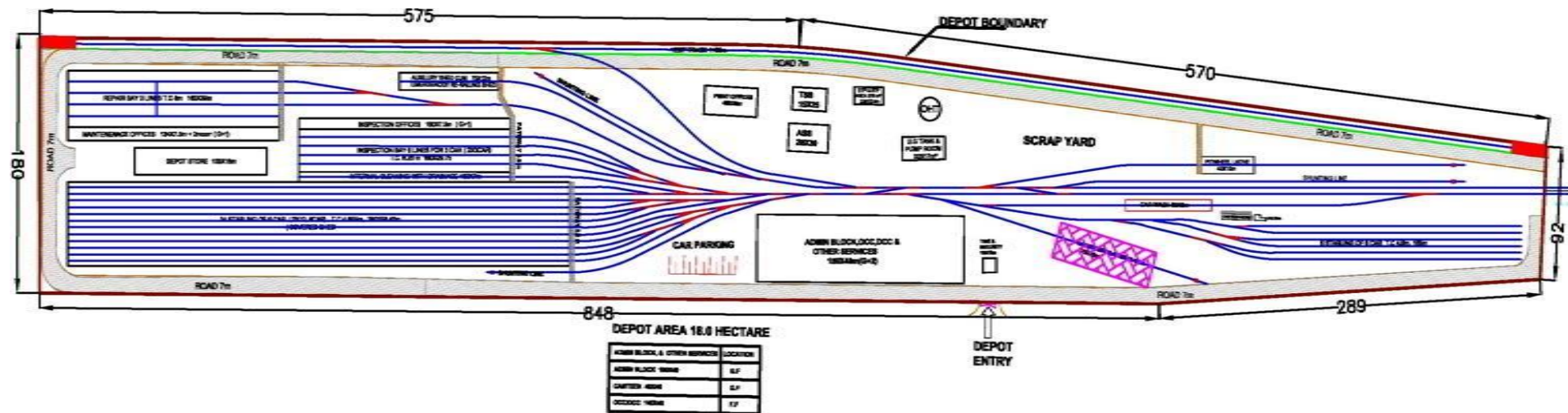


Synchronized Mobile Jacks



KASARVADAVALI DEPOT LAYOUT PLAN

Annexure 14.1



Annexure 14.2

LIST OF MAJOR PLANT & MACHINERY FOR KASARVADAVALI DEPOT

Sl no.	PLANT & MACHINERY	Depot
A.	MATERIAL HANDLING	
	Travelling over head EOT cranes for workshop 25/5T	2
	Travelling over head EOT cranes for inspection bay 1.5T	2
	Travelling over head EOT cranes for ETU shed 5T	1
	Jib crane for workshop 3 T	2
	Synchronized pit jacks system for car lifting	2
	Car body stands for keeping 6 car shells	24
	Dummy bogies	6
	Mobile lifting jacks-15T	1 set
	Mobile lifting jacks 10T	1 set
	Battery powered locomotive	1
	OHE Inspection car	1
	Road mobile Crane 5T cap	1
	Fork lift truck 3T cap	1
	Fork lift trucks 2T cap	1
	Pallet trucks	4
	TATA Truck	1
	Scissors type lifting trolley - 2T capacity	2
	Hydraulic trolleys - 2T capacity	2
B.	Wheel shop	
	500T wheel press	1
	Vertical boring m/c (Turret Lathe)	1
	Multipurpose Wheel Lathe	1
	Axle turning lathe	1
	Axle UST inspection machine	2
	Radial drill m/c	1
	Induction Heater	1
	Bearing Extractor	1
C.	Bogie shop	
	Bosch Tank : Bogie wash/cleaning plant	1
	Bogie static load testing m/c	1
	Shock absorber testing m/c	1
	Spring scragging & testing m/c	1
	Magnacheck crack detector	1
	Glowcheck crack detector	1
D.	Rotating m/cs	
	Baking Oven	1
	Dynamic balancing	1
	Traction motor test console	1
	Motor compressor test bench	1
	Tan Delta testing instrument	1
E.	Other m/cs	

	Under floor Pit wheel lathe	1
	Chip crusher and conveyor for pit wheel lathe	1
	Automatic Washing plant for Metro cars.	1
	High-pressure washing pump for front and rear end cleaning of cars.	1
	Turn table for one car	1
	Turntable for bogies	4
	Driving Cab Simulator	1
	Water de-mineralizing plant (Distillation plant)	2
	Painting booth for separate parts	1
	Floor cleaning machine	4
	Welding equipments	5
	Compressor 500Cfm	1
	DG set 320 KVA	3
	Battery charger	2
F.	Machine shop	
	Guillotine Shearing m/c	1
	Shearing, punching & cropping	1
	Universal tool cutter & grinder	1
	Vertical surface grinder	1
	Centre lathe 2m bed	1
	Centre lathe 1m bed	1
	Radial drill m/c	1
G.	Test Benches/Instruments	
	Brake test bench	2
	SPM test bench	2
	Door test bench	2
	Inverter test bench	1
	Other test benches (MCB, RMPU etc.)	1
	Oscilloscope	1
H.	Furniture/material storage/Small tools	
	Vertical storage system for DCOS store	1
	Computer MMIS with LAN connectivity	1
	Storage racks	LS
	Industrial furniture	LS
	Electric and pneumatic tools	LS
	Measuring and testing equipments	LS
	Tool kits	LS
	Mobile safety steps	10

Chapter – 15

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

15. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

15.1 EXISTING SCENARIO

The objective of Environmental Impact Assessment (EIA) is to ascertain the baseline environmental conditions, assess the impacts as a result of the proposed project during various phases of the project cycle and recommend measures to mitigate adverse impacts due to the project. Environment includes water, land, air, ecology, noise and socio – economic issues. The baseline data on above parameters has been collected from desk research, secondary sources and field studies. Primary monitoring of air, water, soil, noise and survey of flora was carried out in the Month of April 2018 and socioeconomic survey was carried out in the month of June 2018. A scoping matrix was formulated to identify the attributes likely to be affected due to the development of proposed project and is presented in **Table 15.1**.

Table 15.1: SCOPING MATRIX FOR THE PROJECT

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
A. Land Environment	
Construction Phase	Increased soil erosion
	Pollution by construction spoils
	Solid waste from worker colonies, construction sites
B. Water Resources & Water Quality	
Construction Phase	Water quality impacts due to disposal of wastewater from worker camps and construction sites, spoils.
	Depletion of groundwater resources
Operation Phase	Drainage, Water requirement, and Disposal of waste water
C. Air Pollution	
Construction Phase	Impacts due to emissions generated by construction machinery
	Fugitive emissions from construction machinery and trucks
D. Noise Pollution	
Construction Phase	Noise due to operation of construction equipment
	Noise due to vehicular movement
	Noise due to DG sets
Operation Phase	Noise from Metro operation
	Noise due to DG sets

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
E. Ecology	
Construction Phase	Removal of vegetation cover/loss of biomass
F. Socio-Economics	
Construction Phase	Improved employment potential
	Pressure on existing infrastructure facilities
Operation Phase	Increase in direct and indirect Employment Opportunities

Frequency of monitoring of environmental attributes for this EIA is presented in **Table 15.2**.

TABLE 15.2: ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

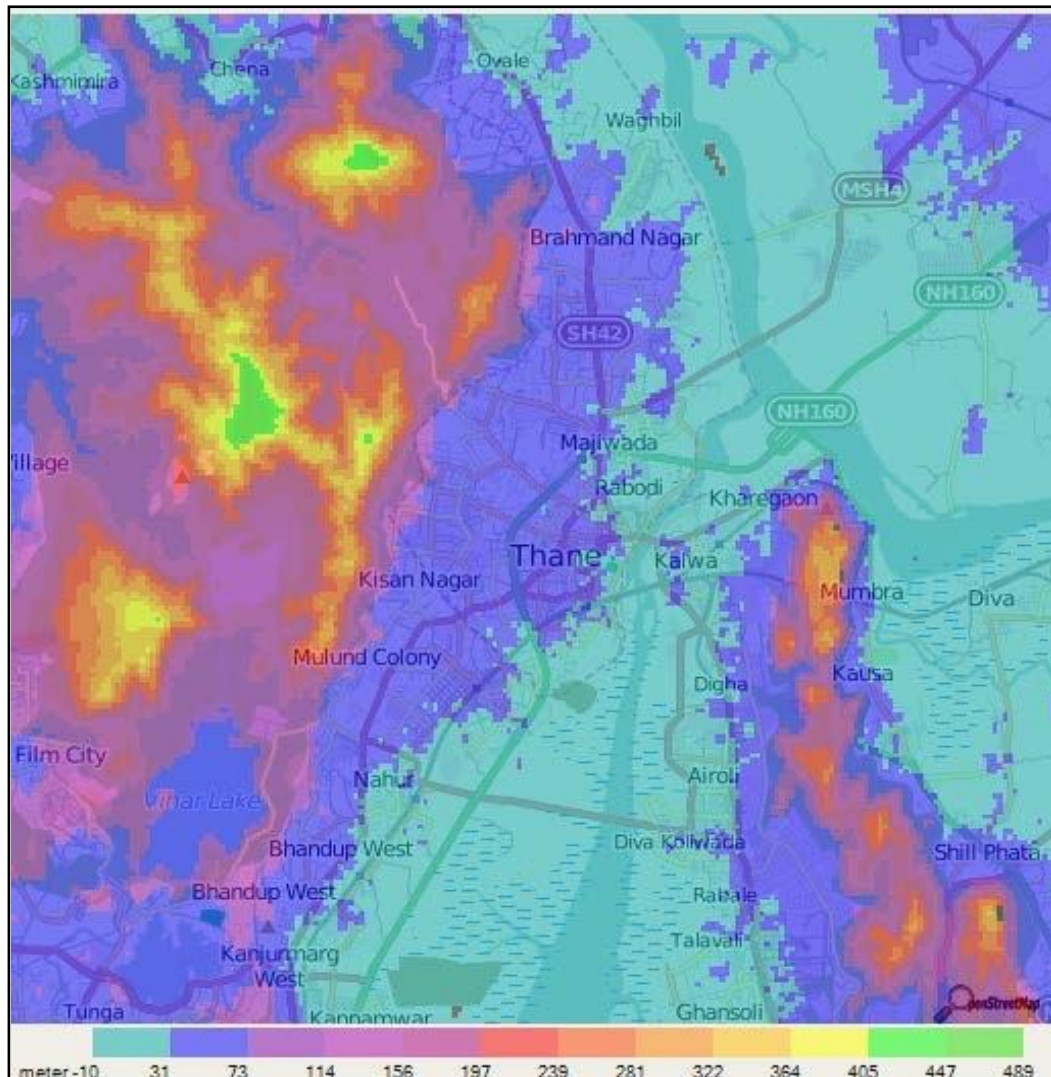
S. NO	ATTRIBUTE	PARAMETER	FREQUENCY	SOURCE
LAND ENVIRONMENT				
1	Soil	Soil Characteristics	Once	Field studies/literature review
2	Geology	Geological History	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
4	Water Quality	Physical, Chemical and Biological parameters	One Season	Field studies/literature review
AMBIENT ENVIRONMENT				
5	Ambient Air Quality	PM _{2.5} , PM ₁₀ , SO ₂ , NO ₂ , CO	24hr for two days in one Season	Field Studies
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Last five years/available	India Meteorological Department/literature review
7	Noise	Noise levels in dB (A)	24hr for two days in one Season	Field studies
SCIO-ECONOMIC				
9	Socio-economic aspects	Socio-economic characteristics	Once	Field Studies, Literature review.
ECOLOGY				
10	Ecology	Flora & Fauna	Once	Literature and Field observations

15.1.1 Land Environment

Physiography: Thane district extends between 18°42' and 20° 20' North latitude and between 72° 37' and 73° 45' East longitude. Nasik and Ahmednagar are located on East, union territory of Dadra to its North, Pune to the south east, Raigad to the south and

Mumbai metropolis to the south west of Thane district. The two main rivers flowing through the district are the Ulhas and the Vaitarana. The Topographic map of the Thane district is shown in **Figure 15.1**.

FIGURE 15.1: TOPOGRAPHICAL MAP OF THANE



Source: Thane, India elevation map

Geomorphology and Soils: Thane district forms part of western slope of Sahayadri hill range. The soil has been classified into three broad categories based on the characteristics and relationship with topographic set up.

(1) **Soil of Coastal Lands with Residual Hills** - These soils are slightly deep, poorly drained, fine soils on gentle sloping land and very fine soil on sloping land. These soils are calcareous and occur along the coast of Vasai, Palgarh and Dahanu.

(2) **Lighter Colored soils** - These soils are occurring on the undulating, elongated hills and 5 intervening valleys. These are medium to deep grayish in color, poor in fertility,

clayey to loamy in nature, shallow in depth and coarse in texture. These soils occur on the eastern part of the district.

(3) **Black Colored Soil**- These soils occur on plains in the middle and eastern part of the district along the valleys.

Soil sample was collected from five sampling locations listed in **Table 15.3** and shown on **Figure 15.5**. Soil analysis results are given in **Table 15.4**.

TABLE 15.3: SAMPLING LOCATIONS FOR SOIL

S. No.	Soil Sample Location	Coordinates
1.	Between Patlipada&Dongripada Metro Station	19°13'14.1816"N,72°57'18.6480"E
2.	Upvan Lake	19°11'21.8940"N, 72°57'21.8844"E
3.	Near Bakumnaka&Laxminagar Metro Station	19°12'48.4452"N, 72°54'39.5808"E
4.	Raila Devi Talab	19°14'53.5164"N, 72°58'34.6008"E
5.	Creek between Waghbil and Hiranandani road station	19°15'58.8960"N, 72°58'37.0236"E

TABLE 15.4: RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLE

Sr. No.	Parameters	Unit	SQ1	SQ2	SQ3	SQ4	SQ5
1	Particle size distribution						
	i. Sand	%	86.4	90.3	96.6	85.9	95.5
	ii. Slit	%	7.6	5.9	1.4	7.9	1.0
	iii. Clay	%	6.0	3.8	2.0	6.2	3.5
2	Texture	-	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand
3	pH (1:10 suspension)	-	6.8	7.2	7.4	6.6	7.3
4	Electrical Conductivity	mS/cm	250	650	17810	655	30970
5	Calcium	-	4240	6166	13929	5090	6917
6	Carbonates	mg/kg	BDL	BDL	BDL	BDL	BDL
7	Bicarbonate	mg/kg	158	105	158	158	263
8	Total Phosphate	mg/kg	28.5	9.4	8	16.7	9.3
9	Total Nitrogen	Kg/ha	579	947	127	231	181
10	Sodium	mg/kg	568	652	5732	806	8934
11	Potassium	Kg/ha	188	840	833	836	414
12	Phosphorus	Kg/ha	20.83	6.94	5.82	12.32	6.72

13	Lead (Pb)	mg/kg	24.3	31.4	24.2	31.5	11.6
14	Cadmium (Cd)	mg/kg	589.8	628.0	8.0	907.9	8.3
15	Iron (Fe)	mg/kg	45420	41710	14970	51980	25210
16	Nickel (Ni)	mg/kg	127.5	211.0	70.1	304.3	93.9
17	Zinc (Zn)	mg/kg	78.8	256.3	49.5	122.3	42.4
18	Manganese (Mn)	mg/kg	1328	1096	328	2981	411
19	Copper (Cu)	mg/kg	113.2	105.8	79.3	171.8	41.9
20	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL
21	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL
22	Chloride	mg/kg	146	11530	10612	49	9724
23	Magnesium	mg/kg	1193.3	535	1293.1	2156.8	1691.8
24	Organic Carbon	%	0.67	0.66	0.34	0.60	0.30
25	Boron	mg/kg	0.38	0.53	0.86	<0.05	0.56
26	Water Soluble Sulphate	mg/kg	51.4	1890.8	1828.1	33.7	27.0
27	Sulphur	mg/kg	17.2	630.3	609.4	11.2	9.0
28	Molybdenum	mg/kg	BDL	BDL	BDL	BDL	BDL
29	Organic Matter	mg/kg	11.6	11.4	5.9	10.4	5.3
30	Orthophosphate	mg/kg	28.5	9.4	8.0	16.7	9.3

SQ1: Between Patlipada&Dongripada Metro Station, SQ2: Upvan Lake, SQ3: Near Bakumnaka&Laxminagar Metro Station, SQ4: Raila Devi Talab, SQ5: Creek between Waghbil and Hiranandani road station

Soil samples were analyzed for Texture, pH, Electrical Conductivity (EC), Organic Carbon, Available Nitrogen (N), Available Phosphorus (P_2O_5), Available Potassium (K_2O), Available Sulphur, Available Iron, Available Manganese, Available Zinc, Available Copper, Available Boron, and Available Molybdenum. The soils of the proposed project were mostly sandy in texture with the sand content more than 85 percent. The pH value of study areas varied from 6.6 to 7.4 with an average 7.1. It was observed that the soil reaction was Neutral in nature. Electrical Conductivity of the soils varied from 250 to 30970 mS/cm with an average 10067 mScm. The organic carbon content of the soils varied from 0.30-0.60 with an average of 0.50 percent. Total Available nitrogen status varied from 127-947 with an average of 413 kg/ha. The maximum available nitrogen 947 kg/ha was found in sample location No SQ2 while minimum 127 kg/ha observed in sample location No SQ3. On the basis of the rating suggested by Subbiah and Ashija (1956) approximately 85 % of the soil samples were rated in low range (< 280 kg/ha). Plant available phosphorus contents in soils of project site varied from 5.82 to 20.83 kg/ha with an average value of 10.53 kg/ha. According to soil fertility index suggested by Muhar et al. (1963) all samples were found in higher range (medium range 10-24 kg/ha, high range > 24 kg/ha). The type of phosphorus ions present in soil solution depends on soil pH. In soils having neutral to slightly alkaline pH, the HPO_4^- ion is the most common

form. Potassium content in soil ranges from 188-840 kg/ha with an average of 622.2 kg/ha. According to Muhar et al. (1963) potassium was categorized as K_2O in low < 140 kg/ha, medium 140-280 kg/ha and high > 280 kg/ha. The K is relatively abundant in the earth's crust; most of it is not accessible to plant. The water soluble sulphur status varied from 9.0 -630 with an average value 255.4 mg/kg. Keeping this fact in view the soil under may be classified as deficient <10 ppm, medium 10-20 ppm and sufficient > 20 ppm category as per the categorization given by Hariram and Dwevedi (1994). According to these categories all the soil samples were found under higher fertility gradient. The available zinc varied from 42.40-256.30 mg/kg with the mean value of 105.9 mg/kg. Only zero percent were found in deficient range, by considering 0.6 mg/kg as the critical limits of zinc suggested by Takkar and Man (1975). Available Fe content in the soil ranged from 14970-51980 mg/kg with mean value of 35858 mg/kg. 100 percent samples was found in sufficient amount of available Fe considering 4.5 mg/kg as a critical limit suggested by Lindsay and Norvell (1978). Available Mn studied in soils varied from 328-2981 mg/kg with mean value of 1228.8 mg/kg. Considering 1.0 mg/kg as a critical limit for Mn deficiency (Lindsay and Norvell 1978), all samples were found in sufficient quantity. Available copper content ranged from 41.9-171.8 mg/kg with mean value of 102.4 mg/kg. Zero percent soil samples were found in deficient range, by considering 0.2 mg/kg as critical limit for copper deficiency (Lindsay and Norvell 1978). 100 percent were found in sufficient range. Results show that boron content in soils of study area varied from 0.4-0.9 mg/kg with an average of 0.6 mg/kg. These data suggest that availability of boron in soil is high as per critical limit <0.5 mg/kg (Katya and Rattan 2003).

Geology and Minerals: Thane district is divided into highland forming Sahyadri towards the eastern and western low lying sea shore. A major part of district is covered with basalt lava flows generally called as Deccan trap. Small area of the district is covered by the Alluvium, beach sand, coastal, laterites, trachytes and rhyolite. Thane district is rich in bauxite, granite, and clay. The geological & mineral map of Maharashtra is shown in **Figure 15.3**.

Landuse: The land use distribution is given in **Table 15.5**. Total developed area in the Thane District accounts to about 47.3 percent of the entire area.

TABLE 15.5: AREA COVERED UNDER EXISTING LAND USES

S. No.	Land use Class	Area (hectare)	Percent of Total area
1	Area under Residential Zone	2665.61	20.8
2	Area under Industrial Zone	1254.00	9.8
3	Area under Reservation	1267.65	9.9
4	Area under Road	742.97	5.8
5	Defence Area	122.00	1
6	Forest Area	3560.00	27.8
7	Green Zone Area	3211.77	25
8	Total	12823.00	100

Source: <http://thanecity.gov.in/uploadpdf/5-NURM-CDP-3-41345638666.pdf>

FIGURE 15.2: WATER AND SOIL SAMPLING LOCATION MAP

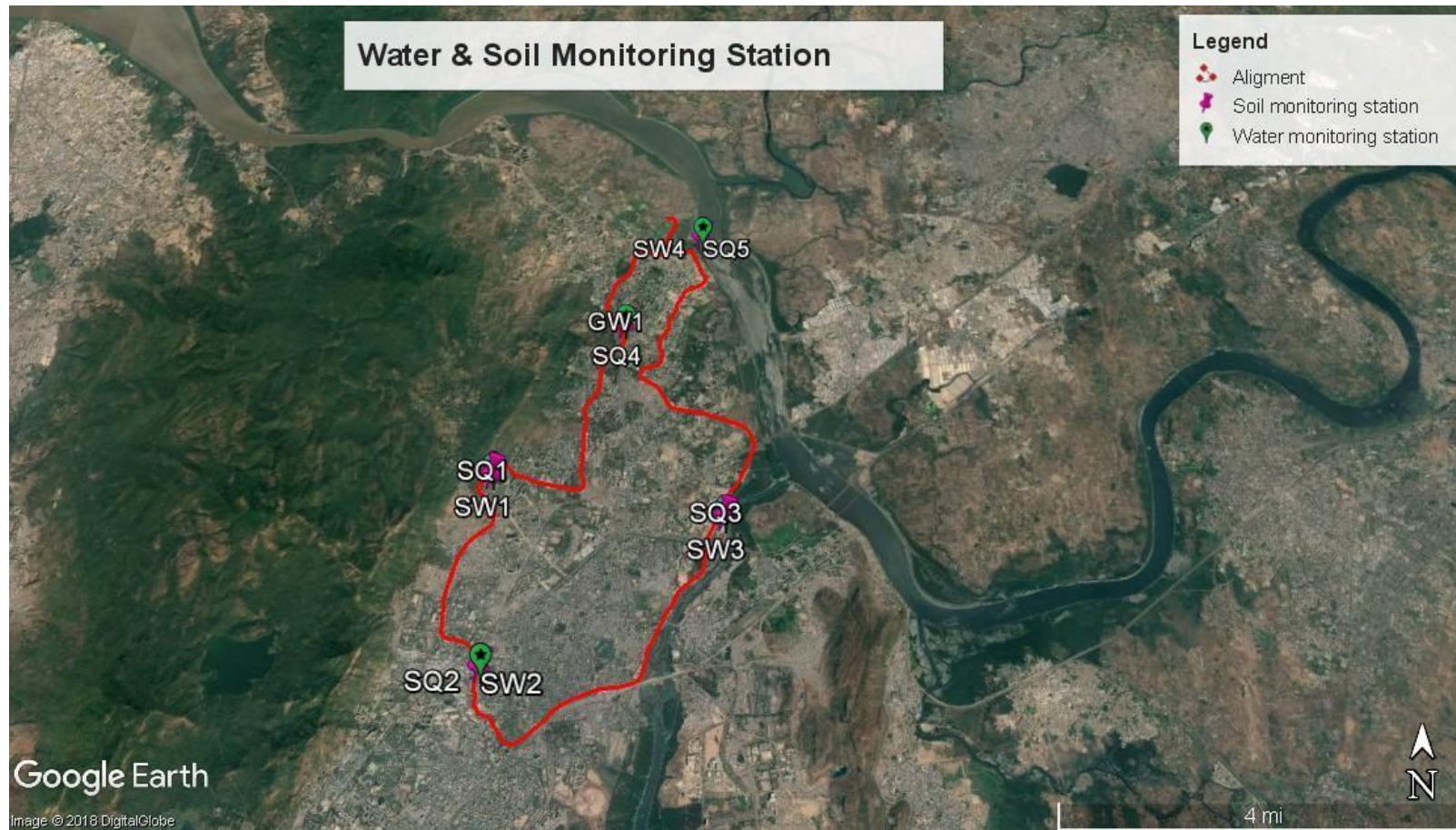
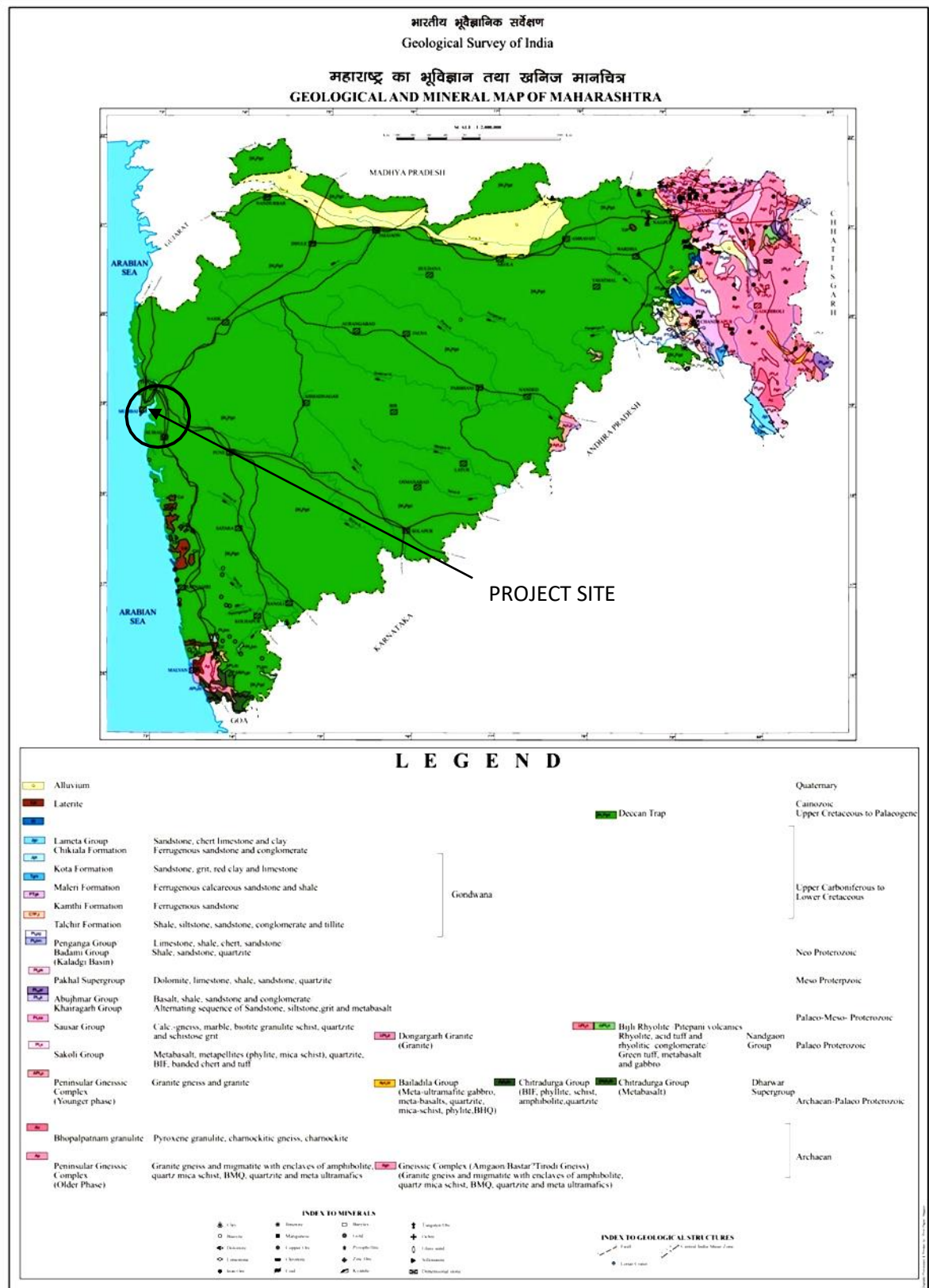


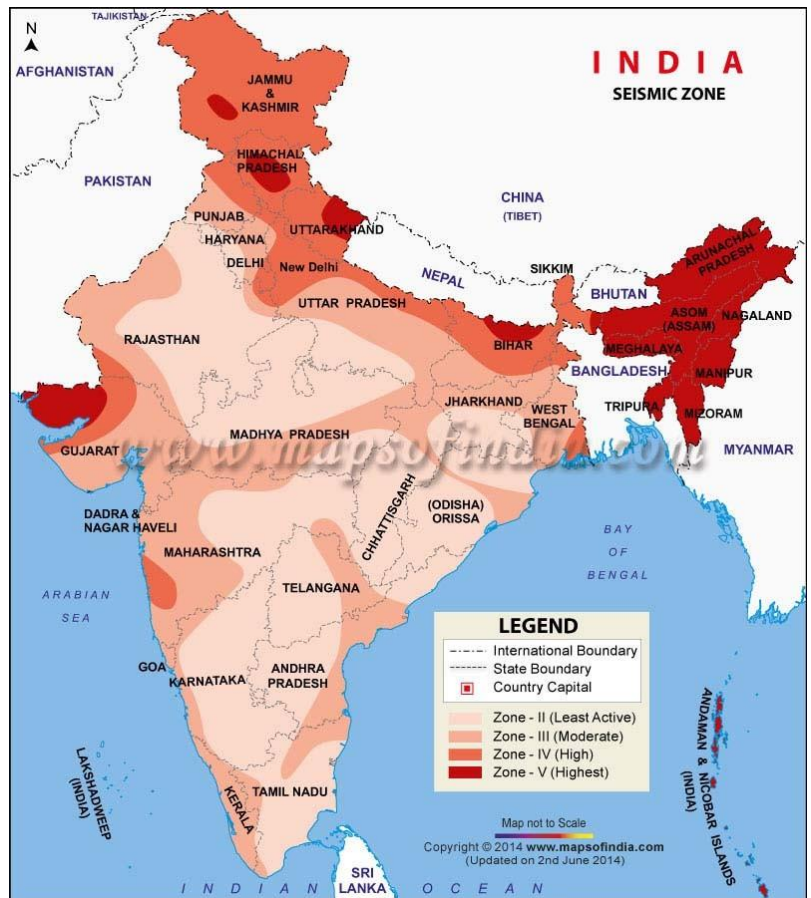
FIGURE 15.3: GEOLOGICAL MAP OF MAHARASHTRA SHOWING THE PROJECT AREA



Source: geological survey of India

Seismicity:Thane lies in the seismic Zone III, moderate as per IS: 1893-2002 (BIS, 2002)and corresponds to MSK intensity VII. Seismic zoning map of India is shown in Figure 15.4.

FIGURE 15.4: SEISMICITY MAP OF INDIA



15.1.2 Water Environment

Hydro-geological

Characteristics: Deccan trap Basalt of Upper Cretaceous to Lower Eocene age is the major rock type covering about 80% of the district, coastal alluvium is other formation occurring only in western end of the district.

Deccan Trap:Ground water mostly occurs in the weathered and fractured parts down to 10-15m depth. Intensity of

weathering is less in hilly region as seen in the eastern part of the district while it is higher in plain area. The yield of dug wells tapping phreatic aquifer ranges between 18 to 152cum/day, which have 5-12m depth range.

Alluvium: These are developed in the western part of the area along the coast and river courses and are lacustrine in nature. Along the coast, alluvium consists of clayey and mud deposits. The quality of water is slightly brackish and pumping from this formation has to be restricted to prevent ingress of seawater. The alluvium constitutes the potential aquifer in the area.

According to CGWB report for Thane district pre-monsoon (May 2012) depth to water level is 0.50 to 14.60m bgl and post-monsoon (Nov 2012) depth to water level is 1.20to 6.90m bgl.In major part of the district mean water level is less than 2m bgl. 2 to 5 m bgl is observed in the north western part around Palghar, Dahanu, Talasari and Pansipada and also in the form of isolated patches in the, central part of the district. The

deeper, mean water level of more than 5 m bgl is observed as isolated patches in northern part.

Drainage and Water Resources: The two Main Rivers flowing through the district are the Ulhas and the Vaitarna. The Ulhas originates from the north of Tunganli near Lonawala and meets the Arabian sea at Vasai creek. The river has many tributaries; two important of them (within the boundaries of this district) are Barvi and Bhatra. Vaitarna rises in the Triambak hills in Nashik district. The River enters the Arabian Sea through a wide estuary off Arnala. It has a number of tributaries; the most important of them are Pinjal, Surya Daherja and Tansa.

Water Quality

In order to assess the baseline water quality status of the study area, water samples were collected along the corridor in the project area at 5 representative locations. The sample locations from which water samples were collected are shown in **Figure 15.2** and details of water sample locations are given in **Table 15.6**. The samples were analyzed for physical and chemical constituents for the purpose of domestic and irrigation use. The results of water analysis are compared with CPHEEO manual for Drinking Water Specifications and IS 10500:2012. The results of analysis are presented in **Table 15.7**.

TABLE 15.6: WATER QUALITY MONITORING LOCATIONS

S. No.	Water Sample Location	Type	Coordinates
1.	Upvan lake	Surface water	19°13'14.1816"N 72°57'18.6480"E
2.	Railadevi Talab	Surface water	19°11'21.8940"N 72°57'21.8844"E
3.	Ulhas River Near to Balkumnaka & Laxminagar Metro station	Surface water	19°12'48.4452"N 72°59'39.5808"E
4.	Patlipada & Dongripada Metro station	Ground water	19°14'53.5164"N 72°58'34.6008"E
5.	Vasai Creek Wagbil and Hiranandanai Road railway station	Creek	19°15'58.8960"N 72°59'23.0236"E

TABLE 15.7: PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES IN PROJECT AREA

Sr. No.	Parameters	Unit	SW1	SW2	SW3	GW1	SW4
1	pH	–	8.4	7.5	6.6	7.1	6.9
2	Total Dissolved Solids	mg/lit	185	292	26453	384	26444
3	Total Suspended Solids	mg/lit	3	27	232	BDL	413
4	Total Alkalinity	mg/lit	97	152	148	249	158
5	Total Hardness	mg/lit	103	175	4512	297	4230
6	Dissolved Oxygen	mg/lit	5.6	5.8	2.3	4.6	6.4
7	COD	mg/lit	BDL	32	302	BDL	334
8	BOD	mg/lit	BDL	BDL	48	BDL	56
9	Chloride	mg/lit	25.4	31.3	12866.0	63.6	12426.0
10	Sulphate	mg/lit	3.8	41.6	1199.0	35.6	1178.0
11	Fluoride	mg/lit	0.11	0.15	1.35	0.20	1.00
12	Phosphate (Phosphorus)	mg/lit	BDL	BDL	3.75	BDL	1.64
13	Phenolic Compounds	mg/lit	BDL	0.64	BDL	BDL	BDL
14	Sodium	mg/lit	10.13	25.76	6358.00	35.42	7439.00
15	Potassium	mg/lit	BDL	0.25	238.60	BDL	254.40
16	Iron	mg/lit	0.037	0.560	1.410	BDL	4.820
17	Magnesium	mg/lit	9.48	18.49	676.8	23.46	857.3
18	Manganese	mg/lit	0.05	0.55	0.22	0.27	0.40
19	Mercury	mg/lit	BDL	BDL	BDL	BDL	BDL
20	Cadmium	mg/lit	BDL	BDL	0.048	BDL	0.052
21	Arsenic	mg/lit	BDL	BDL	BDL	BDL	BDL
22	Lead	mg/lit	BDL	BDL	0.416	BDL	0.463
23	Zinc	mg/lit	BDL	BDL	0.047	0.063	0.060
24	Aluminium	mg/lit	BDL	BDL	BDL	BDL	8.4
25	Nitrate	mg/lit	BDL	BDL	0.14	0.22	0.35
26	Nickel	mg/lit	<0.01	0.25	<0.01	0.24	1.03
27	Copper	mg/lit	BDL	BDL	0.042	BDL	0.066
28	Total Chromium (as Cr)	mg/lit	BDL	BDL	BDL	BDL	BDL
29	Calcium	mg/lit	63.9	39.1	676.8	79.7	658.0
30	Total Coliform	Nos./100ml	920	>1600	>1600	4	>1600
31	Phytoplanktons	nos/ml	4	178	4	4	156

32	Zooplanktons	nos/ml	240	60	50	70	80
33	Benthos						
	i) Population	no/m ²	31	28	34	32	27
	ii) Total Groups	No	2	3	3	3	3

SW1:Upvan lake, SW2: Railadevi Talab, SW3: Ulhas River Near to Balkumnaka & Laxminagar Metro station, GW1: Patlipada&Dongripada Metro station, SW4: Vasai Creek Wagbil and Hiranandanai Road railway station

Ground Water:

Physical Parameters: pH levels of the ground water sample that was collected near to Patlipada & Dongripada Metro station were detected within the acceptable limit.

Total Dissolved solids: TDS in ground water sample was within the acceptable limit but it is on higher side. Reverse osmosis process is recommended.

Hardness: As per IS 10500:2012 water having the hardness 200 mg/l are acceptable for drinking purpose. The ground water sample near Patlipada station has hardness 297 mg/l which falls under the permissible limit. However ion exchange process & lime soda ash softening is recommended.

Calcium & magnesium: Calcium was found to be exceeding the acceptable limit but it is within the permissible limit. Magnesium concentration is within the acceptable limit. Lime soda ash softening recommended that will remove the calcium hardness.

Others: Fluoride content is within the limit so no action is recommended. Alkalinity is 249mg/l but within the permissible limit. Nitrate, Chloride, Sulphate, Aluminium, Arsenic, Copper, Nickle, Zinc, Iron, Manganese, Phenolic compound, Chemical Oxygen Demand, BOD, Lead, mercury, cadmium was observed below the acceptable limit. Coliform was detected that shows the human and faecal contamination.

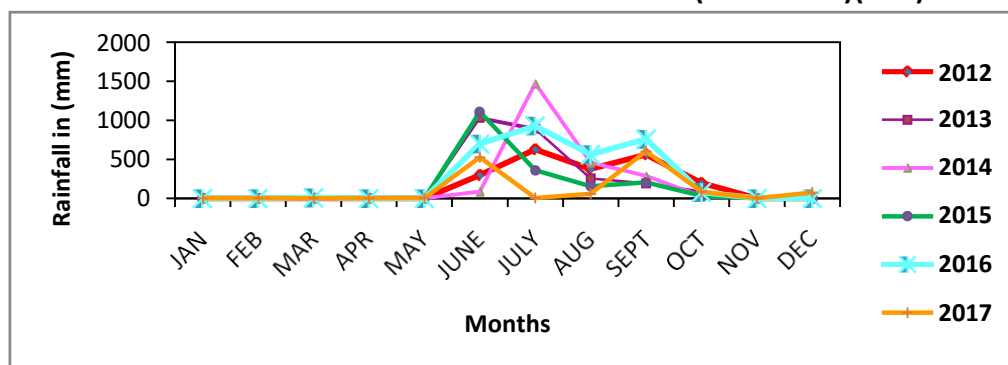
Surface water: Results for locations SW₁, SW₂ and SW₃ have been compared with the CPCB surface water quality criteria. Comparing the values of pH, DO, BOD and total coli form with 'Use based classification of surface waters' published by Central Pollution Control Board; it can be seen that the analysed surface waters is of class 'D' and can be used for propagation of Wild life and Fisheries. Bacteriological examination of surface water indicates the presence of total coliforms, which may be due to human activities.

The location of SW4 lies in the estuary, hence the results have been compared with IS-7967-1976 (reaffirmed-2014) criteria for controlling pollution of marine coastal area in terms of pH, DO, BOD, Coli forms, Heavy metals. It can be seen that the analysed creek water is not suitable for any usage as specified by the CPCB.

15.1.3 Meteorology and Air Environment

Climate and Rainfall: The Project site lies in Thane district of Maharashtra, falls under the tropical wet climate classification. The cold season is from December to February, followed by summer from March to June. The southwest monsoon season is from June to September. October and November months constitute the post-monsoon season. Average monthly rainfall data of Santacruz station was collected from IMD for the periods 2012-2017 and is reported in **Figure 15.5**. In last five year maximum average monthly rainfall (1469mm) was recorded in July 2014. During months of January to May zero rainfall was recorded.

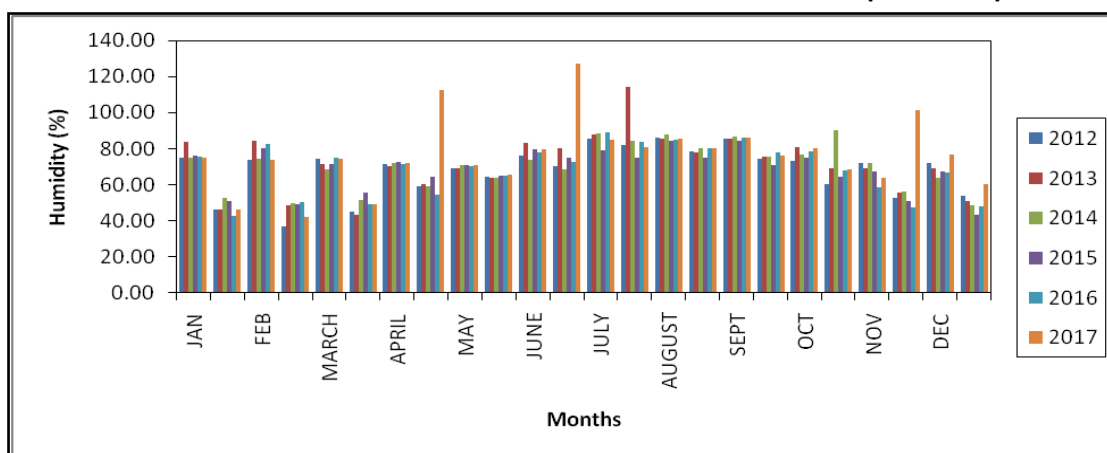
FIGURE 15.5: MONTHLY AVERAGE RAINFALL (2012-2017)(mm)



Source: IMD data, 2012-2017

Humidity: Monthly variation of Humidity data has been collected from the Santacruz IMD station has been given in the **Figure 15.6**. Summer months forms the driest part of the year when relative humidity is low, particularly in April and May. The climate is highly humid in monsoon, particularly in June and July. The average relative humidity in monsoon months goes as high as 127percent.

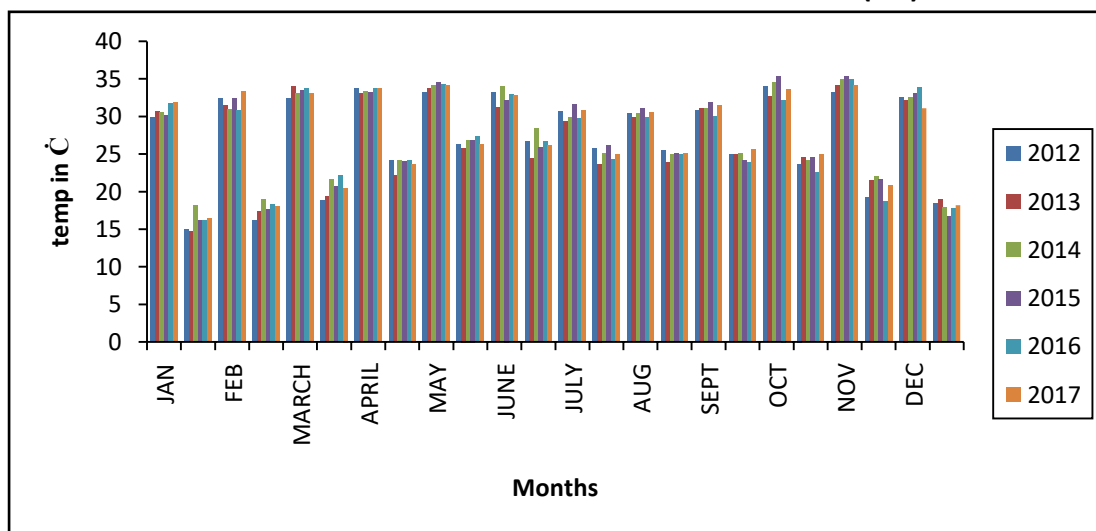
FIGURE 15.6: MONTHLY AVERAGE RELATIVE HUMIDITY (PERCENT)



Source: IMD data, 2012-2017

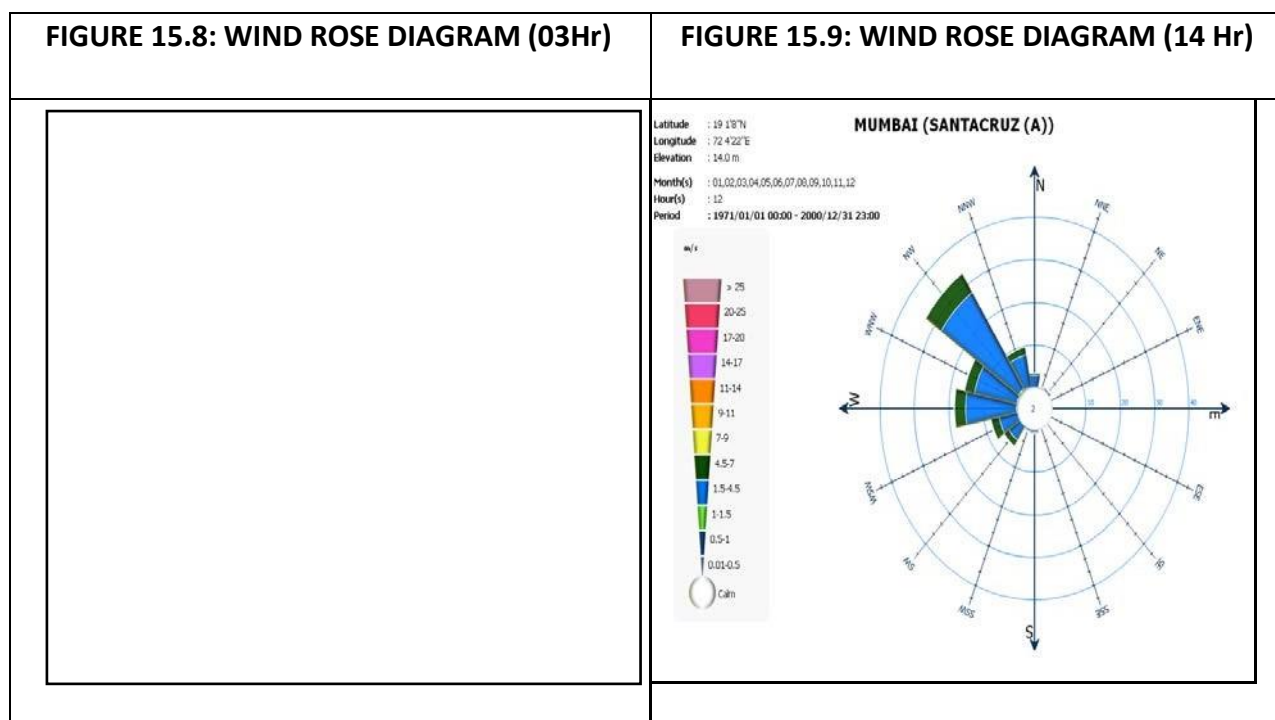
Temperature: Monthly variation in temperature data has been collected from the Santacruz station from 2012-2017 has been reported in **Figure 15.7**. It is clear from figure that May is the hottest month of the year with mean daily maximum temperature of about 34.89°C. With the onset of monsoon, temperature decreases appreciably in June but remains steady thereafter till September. The climate becomes cool in December and continues up to February. December and January are the coldest months of the year.

FIGURE 15.7: MONTHLY AVERAGE TEMPERATURE (OC)



Source: IMD data, 2012-2017

The wind rose diagram for the Santacruz station were collected from the IMD stationare shown in **Figure 15.8**and **15.9**.It was observed that in morning 9% of the time wind was blowing from West(westerly) during the 1971-2000 Period. During evening wind blows from the north-west 32% of the time. Average wind speed was 4.5-7m/s and calm condition was 42% and 2% during the 8AM and 5PM respectively.



Air Quality: Locations for ambient air quality monitoring was selected primarily on the basis of surface influence, demographic influence and meteorological influence. The technique used for sampling and analysis of pollutants is summarized below in **Table 15.9**.

TABLE 15.8: MONITORING PARAMETERS, ANALYTICAL METHOD, CODE OF PRACTICE AND DETECTABLE LIMITS

S. No.	Parameter	Technique	Code of practice	Min. Detection Limit
1	PM ₁₀	Gravimetric	IS-5182 (PART-23):2006 & CPCB Guidelines	10 µg/m ³
2	PM _{2.5}			5 µg/m ³
3	Sulphur Dioxide	Improved West and Gaeke	IS-5182 (Part-II):2001 & CPCB Guidelines	6.5 µg/m ³
4	Nitrogen Dioxide	Modified Jacob & Hochheiser	IS-5182 (Part-VI): 2006 & CPCB Guidelines	4 µg/m ³
5	Carbon Monoxide (CO)	Non Dispersive Infra-Red (NDIR) spectroscopy	IS: 5182 (Part-X) & CPCB Guidelines	0.01 mg/m ³

Total six monitoring stations were selected which are given below in **Table 15.10** and locations map for air monitoring stations is given below in **Figure 15.10**. The monitoring parameters included Particulate matter, Sulphur dioxide, Nitrogen dioxide, Carbon monoxide for twice in a week.

TABLE 15.9: AIR MONITORING LOCATIONS

S.No.	Locations	Location Name	Coordinates
1.	AAQ1	Upvan Lake	19 ⁰ 13'13.9044"N, 72 ⁰ 57'14.9868"E
2.	AAQ2	Kopri	19 ⁰ 10'54.8544"N, 72 ⁰ 57'51.5628"E
3.	AAQ3	Balkum Naka	19 ⁰ 12'57.3624"N, 72 ⁰ 59'29.2580"E
4.	AAQ4	Manorama Nagar	19 ⁰ 14'4.3476"N, 72 ⁰ 58'58.6704"E
5.	AAQ5	Waghbil	19 ⁰ 15'58.8960"N, 72 ⁰ 58'37.0236"E
6.	AAQ6	Patlipada	19 ⁰ 14'53.5164"N, 72 ⁰ 58'34.6008"E

FIGURE 15.10: AIR MONITORING LOCATION MAP

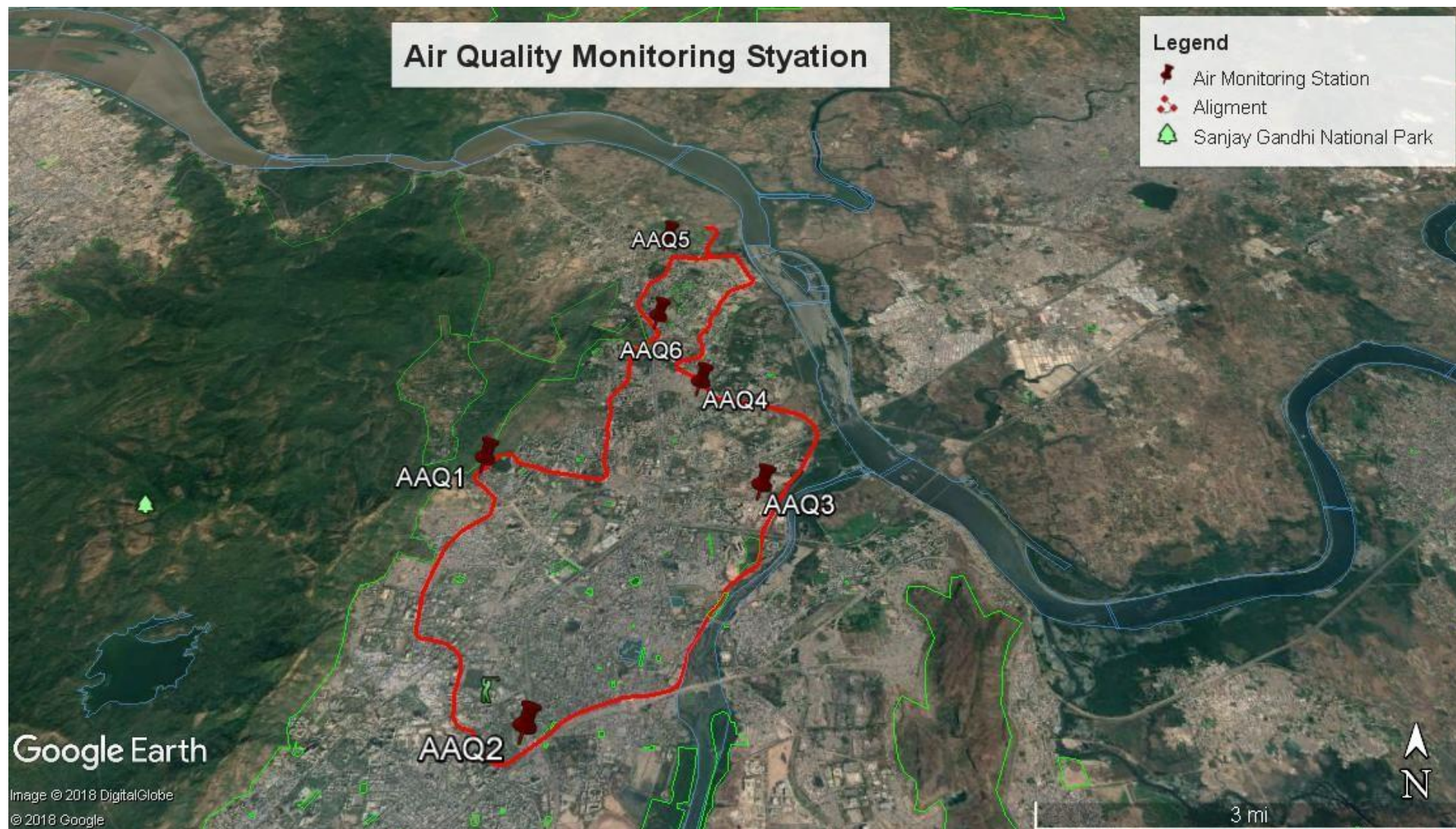


TABLE 15.10: AMBIENT AIR QUALITY STATUS

S. No.	Parameters	Locations	Concentration of Pollution($\mu\text{g}/\text{m}^3$)				
			Minimum	Maximum	Average	98 th percentile	CPCB standards $\mu\text{g}/\text{m}^3$
1.	Particulate matter (PM10)	AAQ1	58.6	73.7	66.15	73.40	100
		AAQ2	60.5	68.6	64.55	68.44	
		AAQ3	69.1	86.5	77.80	86.15	
		AAQ4	71.4	73.9	72.65	73.85	
		AAQ5	56.5	62.8	59.65	62.67	
		AAQ6	63.1	65.4	64.25	65.35	
2.	Particulate Matter (PM2.5)	AAQ1	18.2	28.2	23.20	28.00	60
		AAQ2	18.2	26.9	22.55	26.73	
		AAQ3	23.0	38.2	30.60	37.90	
		AAQ4	25.2	29.9	27.55	29.81	
		AAQ5	19.5	20.8	20.15	20.77	
		AAQ6	23.9	24.3	24.10	24.29	
3.	Sulphur Dioxide (SO ₂)	AAQ1	8.6	13.0	10.80	12.91	80
		AAQ2	7.7	10.4	9.05	10.35	
		AAQ3	8.1	13.5	10.80	13.39	
		AAQ4	11.6	12.3	11.95	12.29	
		AAQ5	12.9	14.0	13.45	13.98	
		AAQ6	11.5	13.2	12.35	13.17	
4.	Nitrogen Dioxide (NO ₂)	AAQ1	12.0	16.8	14.40	16.70	80
		AAQ2	10.0	15.5	12.75	15.39	
		AAQ3	10.1	20.0	15.05	19.80	
		AAQ4	16.2	16.5	16.35	16.49	
		AAQ5	16.5	18.3	17.40	18.26	
		AAQ6	16.0	16.9	16.45	16.88	
5.	Carbon Monoxide (CO)*	AAQ1	0.26	0.63	0.478	0.628	4 [#]
		AAQ2	0.28	0.64	0.507	0.638	
		AAQ3	0.25	0.65	0.460	0.641	
		AAQ4	0.32	0.74	0.528	0.730	
		AAQ5	0.31	0.65	0.502	0.649	
		AAQ6	0.29	0.69	0.530	0.683	

* **Note:** The 98th percentile is calculated statistically only to compare with NAAQS standards of short term values.

Carbon monoxide values are reported in mg/m^3

Particulate Matter (PM₁₀ and PM_{2.5})

PM₁₀ concentration observed during the period ranged from in 56.5µg/m³ to 86.5µg/m³. Maximum concentration was recorded at AAQ3 (Balkum Naka). The 98th percentile PM₁₀ values were observed less than the prescribed NAAQS of 100 µg/m³ at all location. The Graphical representation of PM10 concentration is shown in **Figure 15.11**

PM_{2.5} concentration observed during the period ranged from in 18.2 µg/m³ to 38.2 µg/m³. Maximum concentration was recorded at AAQ3 (Balkum Naka). The 98th percentile PM_{2.5} values were observed less than the prescribed NAAQS of 60 µg/m³ at all location. The Graphical representation of PM2.5 concentration is shown in Figure 15.12.

Gaseous Pollutant (SO₂, NO₂, CO)

Average SO₂ concentration at all six locations ranged from 9.05 µg/m³ to 13.45 µg/m³. Maximum concentration was observed at AAQ3 (Balkum Naka). 98th percentile values for all six locations are lower than the prescribed limit of 80µg/m³. The Graphical representation of SO₂ concentration is shown in Figure 15.13

FIGURE 15.11: PM₁₀ CONCENTRATION IN THE STUDY

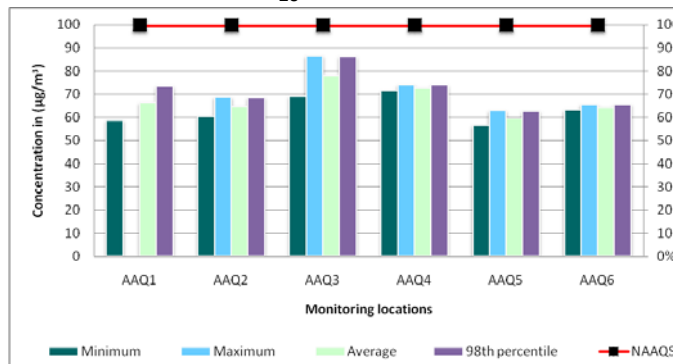


FIGURE 15.12: PM_{2.5} CONCENTRATION IN THE STUDY

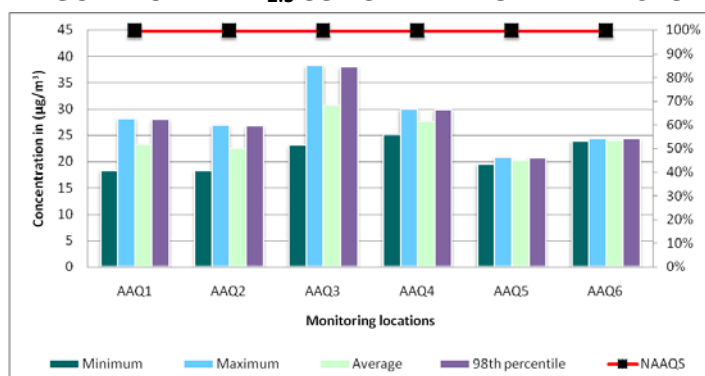


FIGURE 15.13: SO₂ CONCENTRATION IN THE STUDY

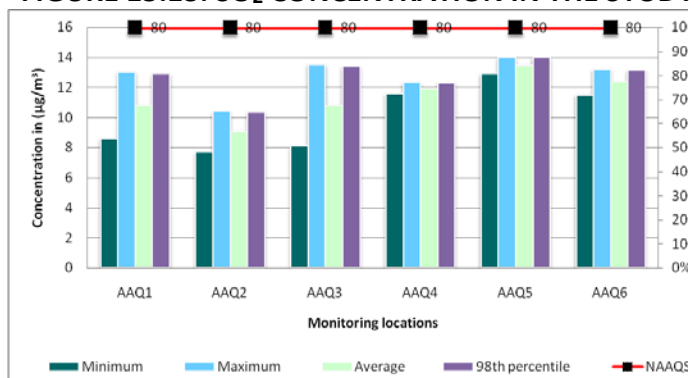
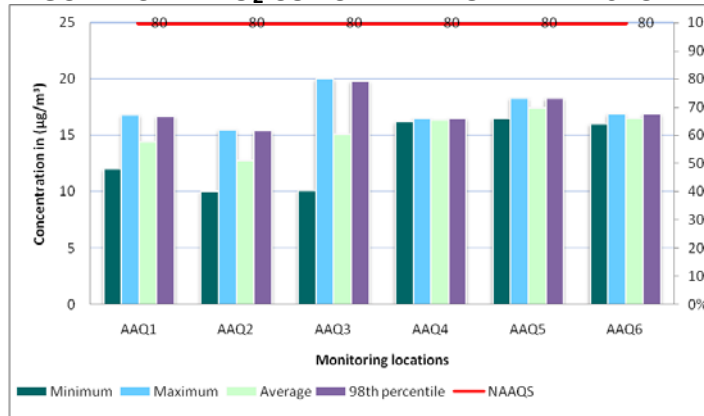
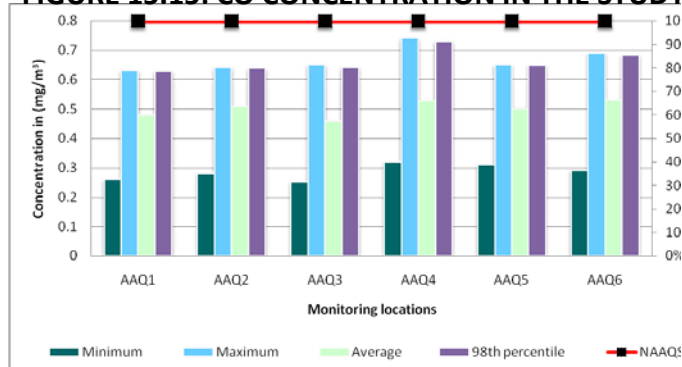


FIGURE 15.14: NO₂ CONCENTRATION IN THE STUDY



Average NO₂ concentration at all six locations ranged from 12.75 µg/m³ to 17.40 µg/m³. 98th percentile values for all location are quite lower than the NAAQS prescribed limit of 80 µg/m³. The Graphical representation of NO₂ concentration is shown in **Figure 15.14**

FIGURE 15.15: CO CONCENTRATION IN THE STUDY



Average CO concentration at all six locations ranged from 0.460 mg/m³ to 0.730 mg/m³. 98th percentile values for all location are quite lower than the NAAQS prescribed limit of 4 mg/m³. The Graphical representation of CO concentration is shown in **Figure 15.15**. From the above discussion it can be interfered that the ambient air quality is satisfactory with respect to all pollutants.

15.1.4 Noise Environment

The noise quality was monitored at six locations across the study area. Noise level was recorded for 24 hours for two days in April 2018 at hourly interval during morning;afternoon and evening such that peak and off peak hours are covered. Noise monitoring locations are given in **Table 15.11** and geographical locations are shown in **Figure 15.16**. The summarized results of noise level as Leq, L₁₀, L₅₀, L₉₀, L_{day}, L_{night}, L_{DN}, L_{MAX} and L_{MIN} are given in **Table 15.13**.

TABLE 15.11: NOISE MONITORING LOCATIONS

S.No.	Location	Location Name	Coordinates	Distance (m) & Direction	Zone
1.	NQ1	Upvan Lake	19°13'13.9044"N, 72°57'14.9868"E	34 , SE	Silence
2.	NQ2	Kopri	19°10'54.8544"N, 72°57'51.5628"E	113, NW	Silence
3.	NQ3	Balkum Naka	19°12'57.3624"N, 72°59'29.2580"E	226, NW	Residential
4.	NQ4	Manorama Nagar	19°14'4.3476"N, 72°58'58.6704"E	102, W	Residential
5.	NQ5	Waqhbil	19°15'58.8960"N, 72°58'37.0236"E	266, NW	Residential
6.	NQ6	Patlipada	19°14'53.5164"N, 72°58'34.6008"E	97, E	Residential

Ministry of Environment & Forests (MoEF) has notified the noise standards vide. Gazette notification dated February 14, 2000 for different zones under the Environment Protection Act (1986). These standards are given in **Table 15.12**.

TABLE 15.12: AMBIENT NOISE STANDARDS

Area Code	Category of Area	Limits in dB (A) Leq	
		Day time*	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone**	50	40

Source: CPCB guideline (as per The Noise Pollution (Regulation and Control) Rules, 2000)

FIGURE 15.16: NOISE MONITORING STATIONS

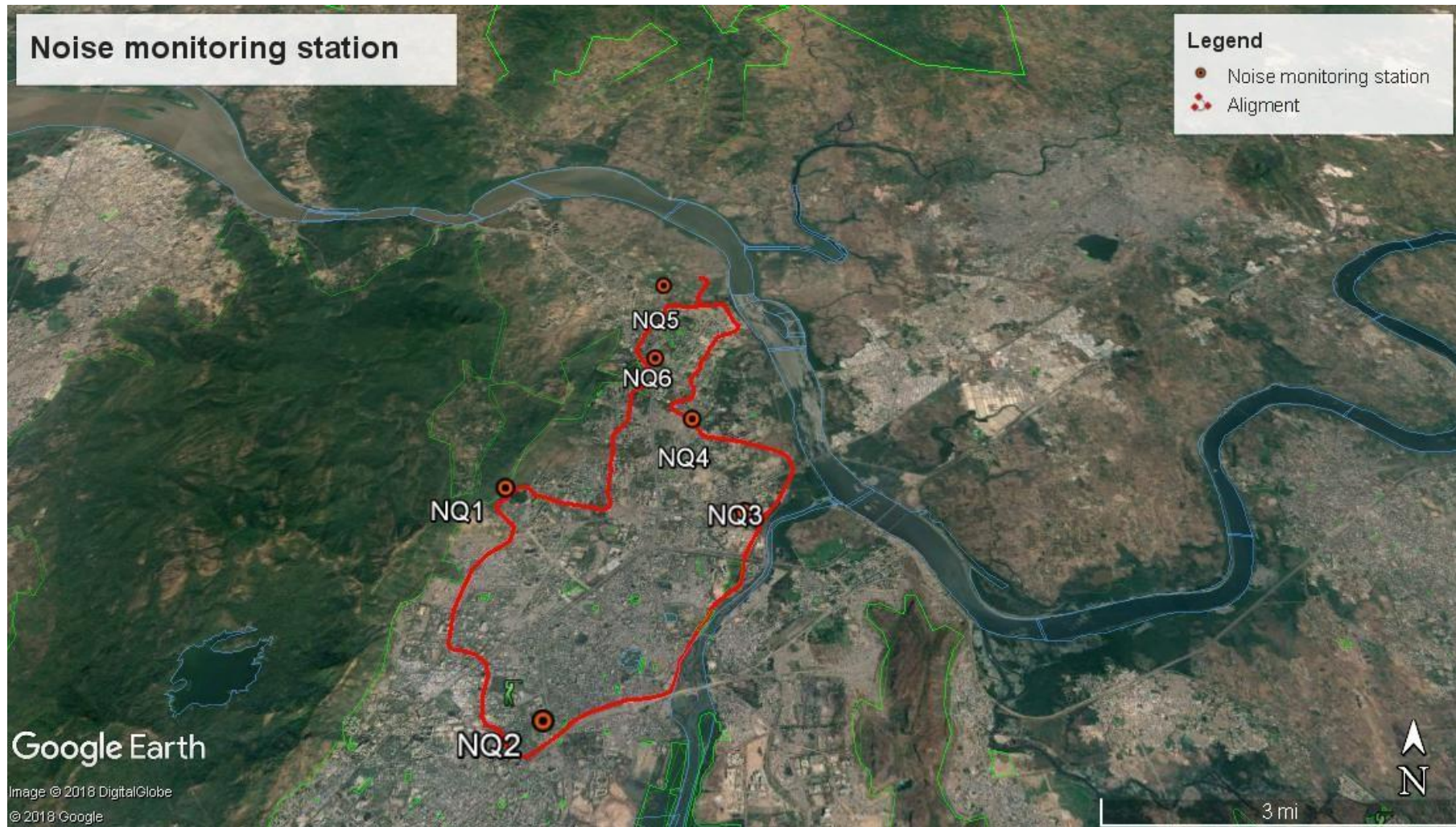


TABLE 15.13: AMBIENT NOISE LEVEL MONITORING RESULT in dB(A)

S.No.	Monitoring Location	Date	L _{eq} (24 Hrs)	L ₁₀	L ₅₀	L ₉₀	L _{max} (24 Hrs)	L _{min} (24 Hrs)	L _{day}	L _{night}	L _{DN}
1.	NQ1	23.04.2018	73.3	75.9	73.3	72.1	76.4	69.3	73.6	74.4	77.2
		24.04.2018	72.6	77.6	72.5	68.6	83.7	66.4	73.8	77.5	78.4
2.	NQ2	23.04.2018	69.6	72.5	69.6	68.2	73	64.3	70.4	69.7	73.5
		24.04.2018	70.8	75.5	70.7	64.5	77.2	64	71.5	72.7	75.2
3.	NQ3	23.04.2018	64.6	71.4	64.5	53	95.8	50.4	83.9	57.1	78.3
		24.04.2018	62.9	74	62.8	52.3	91	47.4	79.9	56.2	75.3
4.	NQ4	23.04.2018	76.8	87.7	76.7	67.3	95.1	62.1	85.9	72.5	84.8
		24.04.2018	75.9	86.3	75.8	67.9	99.9	60.8	89.2	75.1	87.8
5.	NQ5	23.04.2018	64.8	67	64.7	57.7	68.4	56.0	64.7	64.6	68.0
		24.04.2018	60.9	70.2	60.8	57.1	72.6	53.2	66.4	64.4	69.1
6.	NQ6	23.04.2018	62.5	64.8	62.5	60.9	72.3	58.8	64.7	62.2	67.2
		24.04.2018	62.6	68.5	62.5	58.6	68.8	55.3	65.1	63.8	68

NQ 1: Upvan Lake, NQ 2: Kopri, NQ 3: Balkum Naka, NQ 4: Manorama Nagar, NQ5: Waqhbil, NQ 6: Patlipada

The noise levels were compared with the ambient air quality standard in respect of Noise. Residential Area: The equivalent noise level ranged between 60.9 dB(A) (Waqhbil) to 76.8 dB(A) (Manorama Nagar). It was observed that noise levels during day and night time in the residential area are quite high at all locations. Silence area: The ambient noise levels in the silence area are exceeding the permissible limit.

15.1.5 Ecological Environment

An ecological study was conducted along the corridor during 26th May 2018 and 27th May 2018. For ecological study 10 m RoW, stations and depot was considered as core zone and 15 km area around the project as buffer zone. Primary data was collected for core zone through field survey. Secondary data was collected for buffer zone.

Forest cover

The vegetation of the area ranges from littoral forests to western sub-tropical hill forests and as per the revised classification of Indian Forest Types by Champion and Seth, the National Park has Southern Tropical Moist Mixed Deciduous Forest and Western Sub Tropical Hill Forest and some of the tree species are *Tectonagrandis*, *Terminaliatomentosa*, *Acacia catechu*, *Adina cordifolia*, *Mitragynaparviflora*, *Pterocarpusmarsupium*. Alignment is passing through Sanjay Gandhi National Park. Tungareswar National Park and Flamingo Sanctuary are located within 15 km from the project.

A. Flora

Core Zone: The tree species observed are listed in the Table 15.14. Total number of trees that need to be transplanted and felled will be 411 and 251 respectively. The inventory of trees in the corridor likely to be felled has been prepared and summarized in the **Table 15.16**. Estimated cost of compensatory afforestation is included in the Environmental Management Plan (EMP).

TABLE 15.14: TREE SPECIES IN CORE ZONE

S. No.	BOTANICAL NAME	COMMON NAME	LOCAL NAME
1.	<i>Mangifera indica</i>	Mango	Amba
2.	<i>Alstonia scholaris</i>	Devils tree	Satvin
3.	<i>Azadirachta indica</i>	Neem	Neem
4.	<i>Ficus glomerata</i>	Umbar	Umbar
5.	<i>Ficus religiosa</i>	Peepal	Pimpal
6.	<i>Borassus flaberriformis</i>	Tad	Tad
7.	<i>Samanea saman</i>	Indian rain tree	-
8.	<i>Terminalia catappa</i>	Badam	Badam
9.	<i>Neolamarckia cadamba</i>	Kadam	Kadam
10.	<i>Polyalthia longifolia</i>	Asoka	Khotaasok

Buffer Zone: The main tree species found in the buffer zone are listed in **Table 15.15**

TABLE 15.15: TREE SPECIES IN BUFFER ZONE

S. No	BOTANICAL NAME	Common Name	Local name
1	<i>Adina cordifolia</i>	Haldu, Karma	Haldu
2	<i>Acacia catechu</i>	Black catechu	Khair
3	<i>Bombax malabaricum</i>	Red silk cotton	Sawar
4	<i>Borassus flabellifer</i>	Toddy Palm	Tad

S. No	BOTANICAL NAME	Common Name	Local name
5	<i>Bauhinia racemosa</i>	Bidi leaf tree	Apta
6	<i>Brideliaretusa</i>	Spinous Kino tree	Asana
7	<i>Buteamonosperma</i>	Bastard teak	Palas
8	<i>Cordiamyxa</i>	Assyrian plum	Bhokar
10	<i>Careyaarborea</i>	Kumbha	Kumbh
11	<i>Erythriniaindica</i>	Indian coral tree	Pangara
12	<i>Ficusarnottiana</i>	Indian Rock Fig	Payar
13	<i>Ficusglornerata</i>	Cluster Fig tree	Umbar
14	<i>Garugapinnata</i>	Grey Down Balsam	Kakad
15	<i>Grewiatiliaefolia</i>	Dhaman	Dhaman
16	<i>Holopteleaintegrifolia</i>	Indian Elm	Vavla
17	<i>Lanneagrandis</i>	Indian Ash Tree	Shemat
18	<i>Holarrhenaantidysenterica</i>	Indrajao	Kuda
19	<i>Pongamiapinnata</i>	Indian Beech	Karanj
20	<i>Saccopetalumtomentosum</i>	Hoom	Humb
21	<i>Schleicheraoleosa</i>	Kusum	Kusum
22	<i>Terminaliabellerica</i>	Bahera	Behada
23	<i>Tectonagrandis</i>	Teak	Sagwan
24	<i>Zizyphusjuzuba</i>	Jujube	Bor

The inventory of trees in the corridors likely to be felled has been prepared and summarized in the **Table 15.16**. Total number of trees that need to be transplant and felled will be 411 and 251 respectively. Estimated cost of compensatory afforestation is included in the Environmental Management Plan (EMP).

TABLE 15.16: SUMMARY OF ENUMERATION OF AFFECTED TREES IN CORE ZONE

SR NO	CHAINAGE/LOCATION	Total Tree Number in RoW of 10m, station box and depot	Trees Fit for transplantation	Trees Not fit for transplantation (to be felled)
1.	NEW THANE ST	70	50	20
2.	RAMP	77	57	20
3.	RAMP-MODELLA CHOWK	0	0	0
4.	MODELLA CHOWK ST	0	0	0
5.	WAGHALE CIRCLE	14	10	04
6.	WAGHALE CIRCLE ST			
7.	LOKAMANYA NAGAR	8	06	02
8.	LOKAMANYA NAGAR ST	0		
9.	POKHARAN ROAD	26	20	06

10.	POKHARAN ROAD ST	0		
11.	NILAKANTH TERMINAL	18	10	08
12.	NILAKANTH TERMINAL ST	01	0	01
13.	GANDHI NAGAR	01	0	01
14.	GANDHI NAGAR ST	0	0	0
15.	KASHINATH GHANEKAR NATYAGRUHA	30	20	10
16.	KASHINATH GHANEKAR NATYAGRUHA ST	05	03	02
17.	PATLIPADA	17	12	05
18.	PATLIPADA ST	22	15	07
19.	DONGARIPADA	74	30	44
20.	DONGARIPADA ST	10	07	03
21.	VIJAY NAGARI	19	15	04
22.	VIJAY NAGARI ST	22	17	05
23.	WAGHBIL	47	30	17
24.	WAGHBIL ST	02	-	02
25.	WATER FRONT TCS	0	-	-
26.	WATER FRONT TCS ST	0	-	-
27.	NEW BRAHMAND	05	04	01
28.	NEW BRAHMAND ST	01	-	01
29.	AZAD NAGAR BUS STAND	25	20	05
30.	AZAD NAGAR BUS STAND ST	11	05	06
31.	MANORAMA NAGAR	28	20	08
32.	MANORAMA NAGAR ST	0	-	-
33.	KOLSHET INDUSTRIAL AREA	57	30	27
34.	KOLSHET INDUSTRIAL AREA ST	0	-	-
35.	BALKUM NAKA	32	20	12
36.	BALKUM NAKA ST	01	-	01
37.	BALKUMPADA	0	-	-
38.	BALKUMPADA ST	0	0	0
39.	SAKET	05	03	02
40.	SAKET ST	0		
41.	SHIWAJI CHOWK	10	07	03
42.	SHIWAJI CHOWK ST	0	0	0
43.	UP RAMP	0	0	0
44.	RAMP	02	-	02
45.	THANE JUNCTION ST	07	0	07
46.	UP TO KASARWADALI DEPOT	15	-	15

47.	DEPOT AT KASARWADALI	0	-	-
48.	TOTAL	662	411	251

B. Fauna

Fauna were studied through secondary data in core zone and buffer zone. Fauna and avifauna species are listed in **Table 15.17**.

TABLE 15.17: FAUNA IN STUDY AREA

S. No.	Animal Species	Forest Area			
		Tulsi	KrishanagiriUppavan	Yeur	Tungraeshwar
1.	Bibat	05	-	04	01
2.	Sambhar	20	-	07	-
3.	Chittal	274	14	07	-
4.	Bhekar	03	-	-	-
5.	Maakad	28	07	65	11
6.	Langoor	62	06	-	12
7.	Batbaankul	19	-	24	17
8.	Wild pig	03	-	07	04
9.	Junglimurgaa	07	-	02	06
10.	Mangooss	02	01	09	06
11.	Cat	-	-	05	01
12.	Owl	-	01	-	05
13.	Rabbit	-	-	03	-
14.	Peacock	03	-	-	02
15.	Snake	-	-	-	01

Bats: Seven species of Bats have been recorded in the area.

Avifauna: Five endangered birds species namely the Peafowl (*Pavocristatus*), Osprey (*Pandionhaliaetus*), white bellied sea eagle (*haliaetusleucoquaster*) , Hawks (*Accitridae*) and large Falcons (*Falco peregrines*, *Falco biarmicus* and *Falco chicuera*) are found in this area. The cormorant is a common bird of the area. The nocturnal birds include the Barn owl, the great Horned Owl, barred Jungle owlet and the spotted owlet

Reptiles: In Sanjay Gandhi National Park there are thirty eight species of reptiles of which seven are endangered. *Crocodiluspalustris*, *Python molurus*, *Najanaja*, *Ptyasmucosus*, *Viperarusselli* **Schedule –I** species are found inside the park.

Amphibia: Tree frogs, Bulll frog, Common toad, Fungoid frogs are seen in this area.

Mammals: Nearly 43 species of mammals are seen in Sanjay Gandhi National Park. Out of these 8 are endangered species and have been included in **Schedule –I and Schedule-II**. These are as follows: *Leopard pardus*, *Felis rubiginosa*, *Felis chaus*, *Viverricula indica*, *Padoxurus hermaphrodites*, *Canis aureus*, *Tetracus quadricornis*, *Tragulus meminna*.

C. Protected area

The proposed alignment passes along the existing Development Plan Road and outside the compound wall of Sanjay Gandhi National Park at various locations.

1. Near Dongripada Station (ch: 10728.923- 11177.940, 11500-11900), Near Lokmanyagar Bus depot (ch: 3803.497-4167.072).
2. Near Pokharan Road no. 1 station to Nilkanth Terminal (ch:5667.849-6523.323).

Eco-sensitive sites within buffer zone are listed in **Table 15.18**.

TABLE 15.18: ECOSENSITIVE AREAS WITHIN 15 km AROUND PROJECT

S. No.	Eco sensitive sites
1.	Thane Creek Flamingo Sanctuary
2.	Kanjur Mangroves
3.	Tungreshwar National Park
4.	Sanjay Gandhi National Park
5.	RF

D. Mangroves

The mangrove forest in the District belong to the group “Littoral and swamp Forest”. The mangrove forest consists mostly of evergreen trees and shrubs belonging to several unrelated families and share similar habitat preferences and a similar physiognomy. In the area, lower salinity species of mangroves are *Rhizophora apiculata*, *Avicennia officinalis* and *Kandelia candel*.

The proposed alignment passes along the existing and proposed Development Plan Road adjacent to the mangroves. *Avicennia marina* also known as Grey Mangrove are predominant in the study area. It is also categorised as tree belonging to family Avicenniaceae.

E. Coastal Regulation Zone (CRZ)

Ministry issued CRZ notification on January 6, 2011 as there were several amendments to CRZ notification 1991. CRZ definition is widened in 2011 notification to include the land area from HTL to 500 m on the landward side along the sea front as well as the land area between HTL to 100 m or width of the creek, whichever is less on the landward side along tidal influenced water bodies connected to the sea. CRZ is classified as following four zones:

1. CRZ I- ecologically sensitive areas such as mangroves, coral reefs, salt marshes, turtlenesting ground and the inter-tidal zone
2. CRZ II- areas close to the shoreline and areas which have been developed.
3. CRZ III- Coastal areas that are not substantially built up, including rural coastal areas.
4. CRZ IV- water area from LTL to the limit of territorial waters of India.

The alignment approximately from Ch: 14309-15343, Ch: 19800-22500, Ch: 22900-25400 is passing through CRZ 1A /CRZ II. Draft CRZ map is based on the Draft CRZ Notification 2018. project area falls in CRZ IA at waterfront station to waqhbil and Balkum Naka to Thane junction as depicted in **Figure 15.17** and **Figure 15.18** respectively. The proposed project needs CRZ clearance from MoEFCC.

15.1.6 Archaeological monuments/sites and heritage sites

No archaeological monuments/sites and heritage sites are located along the alignment.

FIGURE 15.17: CRZ ON WEST OF THANE CREEK (WATERFRONT STATION TO WAGHBIL STATION)

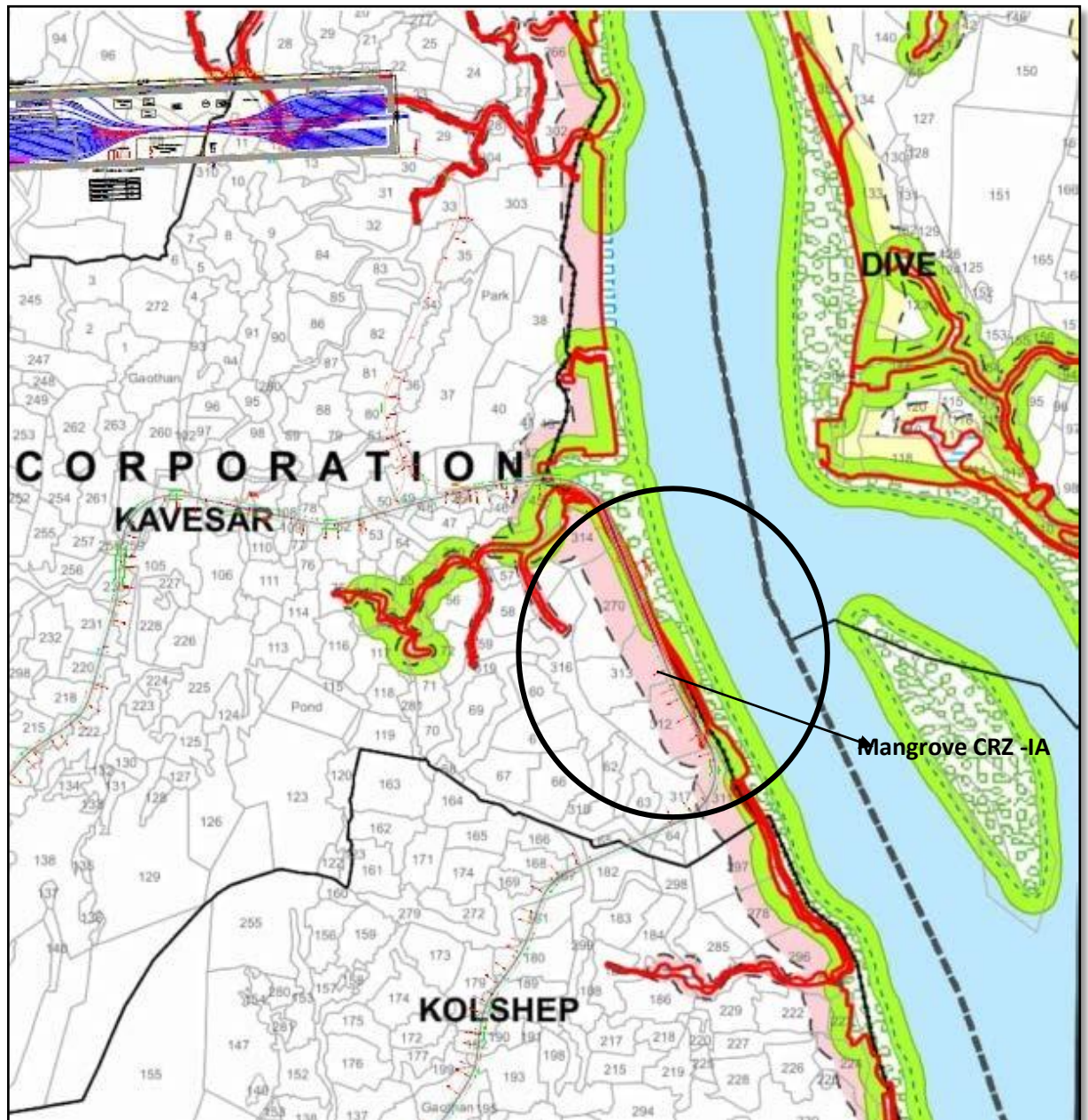
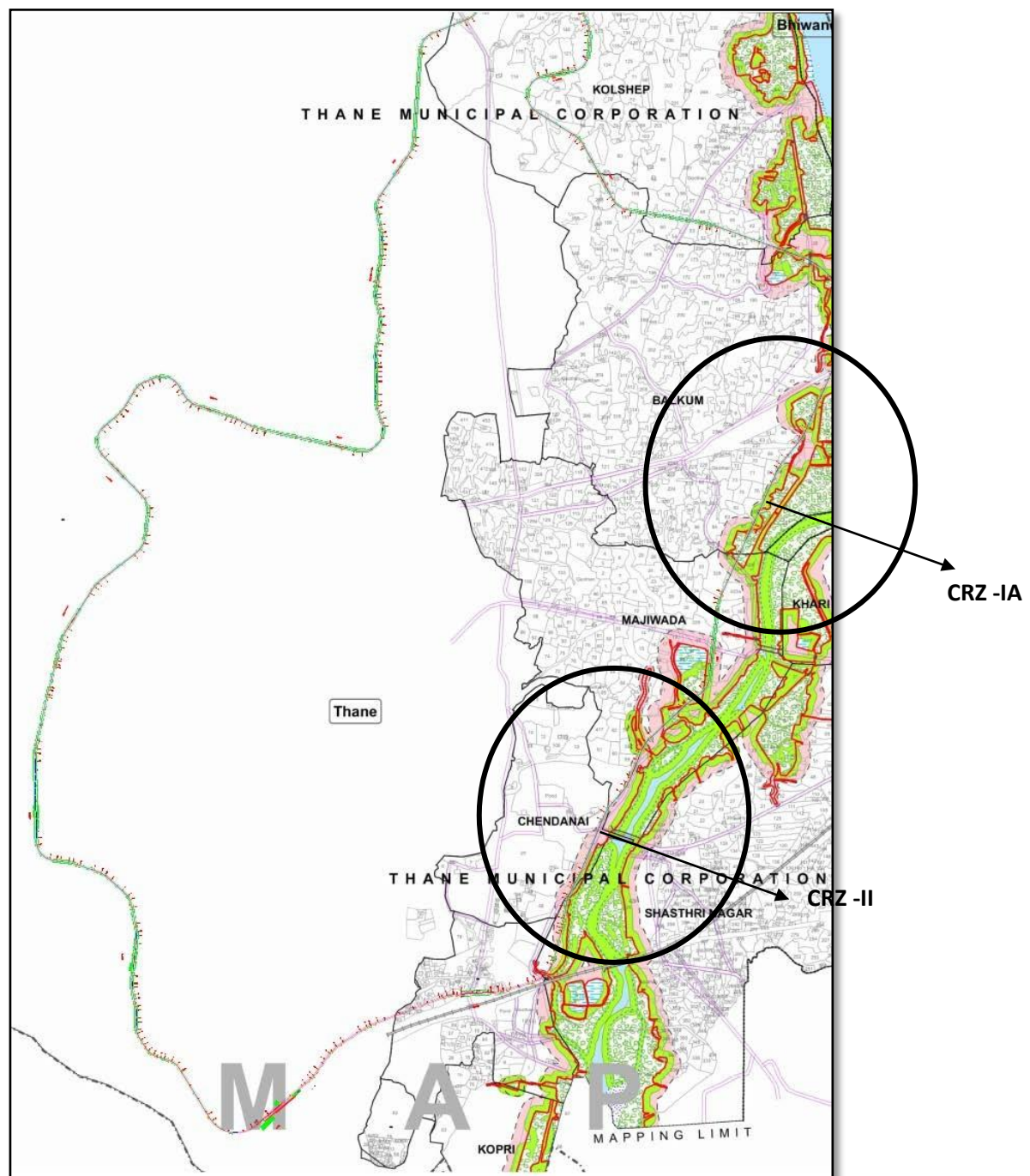


FIGURE 15.18: CRZ ON WEST OF THANE CREEK (SAKET TO BALKUM NAKA)



15.2 ENVIRONMENTAL LEGISLATION AND NORMS

The laws and norms that are applicable to the project are listed out in **Table 15.19**.

TABLE 15.19: ENVIRONMENTAL LEGISLATION AND NORMS

S. No.	Legislation/norms
1.	Environment (Protection) Act, 1986, amended
2.	Coastal Regulation Zone Rules 2011 with amendment dated 8 December 2014
3.	The Forest Conservation Act, 1980& its amendment
4.	Indian Wildlife Protection Act,1972 & its amendment
5.	Wetlands (Conservation and Management) Rules 2017
6.	The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010 with Ancient Monuments and Archaeological Sites and Remains (Amendment) Act, 2017
7.	Aircraft Act 1934 with Aircraft (Amendment) Act, 2007 (44 of 2007)& Ministry of Civil Aviation (Height Restrictions for Safeguarding of Aircraft Operations) Rules, 2015 that are further amended in 2018.
8.	The Maharashtra Felling of Trees (Regulation) Act, 1964 The Maharashtra (urban areas) protection and preservation of trees Act, 1975
9.	Transit Permit under Maharashtra Forest Rules 2014
10.	The Air (Prevention and Control of Pollution) Act, 1981 amended 1987
11.	The Air (Prevention and Control of Pollution) (Union Territories) Rules 1982, 1983)
12.	The water (prevention and control of pollution) Act, 1974 amended 1988
13.	Water (Prevention and Control of Pollution) Rules, 1975
14.	Hazardous and Other Wastes (Management, and Trans boundary Movement) Rules, 2016
15.	Construction and Demolition Waste Management Rules, 2016
16.	Solid Waste Management Rules, 2016
17.	Noise Pollution (Regulation and Control) Rules, 2000 & its amendment
18.	Maharashtra Regional and Town Planning Act, 1966
19.	Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015
20.	Indian Treasure Trove Act, 1878, modified up to the 01/09/1949
21.	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996
22.	The Maharashtra Jeevan Authority Act, 1976 amended in 2013

23.	Bombay Provincial Municipal Corporation Act, 1949
24.	Land acquisition Act, 1894
25.	Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013(RTFCTLARR Act)
26.	National Ambient Air quality Standards,2009
27.	Drinking water – Specifications IS 10500: 2012

15.3 POSITIVE ENVIRONMENTAL IMPACTS

Based on project particulars and existing environmental conditions, positive potential impacts have been identified that are likely to result from the proposed project and where feasible within the scope of this report these are quantified. The positive environmental impacts are listed below:

- Employment Opportunities,
- Benefits to Economy,
- Traffic Congestion Reduction, Quick Service and Safety,
- Traffic Noise Reduction,
- Reduction of Traffic on Road,
- Less Fuel consumption,
- Reduced air pollution.

15.3.1 Employment Opportunities

It is assumed that the civil works of the project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. During construction phase, about 8,900 people will be employed. During operation phase considering 45 person per km about 1180 persons will be employed for operation and maintenance of metro corridor. In addition to these, more people would be indirectly employed for allied activities.

15.3.2 Benefits to Economy

The project will facilitate movement of passengers between different parts of the Thane city. Introduction of this metro will result in the reduction in number of buses, usage of private vehicles and reduction in fuel consumption, vehicle operating cost and travel time of passengers and road accidents. It is likely that trade, commerce and allied services will benefit from better connectivity.

15.3.3 Traffic Noise Reduction

Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB¹ respectively. Introduction of Metro Rail is likely to lead to reduction in road vehicular traffic which ultimately reduces noise level.

15.3.4 Reduction of Traffic on Road

The reduction in number of vehicle kilometre gives benefits to economy by reduction in Vehicle Operating Cost (VOC), Fuel Consumption, Pollution Load, Accidents and Travel Time etc. On implementation of the project, the consumption of petrol, diesel and CNG will get reduced. The estimated number of vehicles kilometres that will be reduced due to construction of Thane Metro are given in **Table 15.20**.

TABLE 15.20: REDUCTION IN DAILY VEHICLE KILOMETERS

S. No	Mode	Daily Vehicle Km Reduced due to Metro in Horizon years		
		2025	2035	2045
1	Bus	73600	85000	100000
2	Car	91,717	143,220	168,431
3	Two Wheeler	153,363	273,694	321,873
4	Auto	393,701	697,858	820,703
5	Taxi	264,196	442,022	519,831

15.3.5 Reduced Fuel Consumption

Based on reduction of vehicle kilometres, reduction in fuel (diesel, petrol & CNG) consumption is reported in **Table 15.21**. It is estimated that about 18.47 million litre of total fuel will be saved daily in year 2025 and 27.58 million litre in 2045.

TABLE 15.21: DAILY REDUCTION IN FUEL CONSUMPTION

S.No.	Year	Diesel (million liters)	Petrol (million liters)	CNG (million Kg)
1	2025	4.124	3.310	11.039
2	2035	5.137	5.503	13.423
3	2045	6.043	6.471	15.065
4	Total	15.304	15.284	39.527

The saving of Diesel, Petrol and CNG will directly benefit the country in monetary terms. Net saving on fuel expenditure at current price level (June 2018) is given in **Table 15.22**.

¹Source: Relation between traffic volume & noise levels, Ellebjerg (2013)

The estimated total savings on fuel will be of Rs948.82 million in year 2025, Rs1487.60 million in year 2045.

TABLE 15.22: DAILY NET SAVING ON FUEL EXPENDITURE (RsMILLION)

S. No.	Fuel	2025	2035	2045
1	Diesel	296	369	434
2	Petrol	276	459	540
3	CNG	377	458	514
4	Total	948.82	1285.73	1487.60

15.3.6 Reduced Ambient Air Pollution

Ambient emissions from operation of Metro rail are limited to those from backup DG equipment. System-level generation of CO₂ from generation of grid electricity which powers Metro are not included in the ambient emissions. The major vehicular pollutants that define the ambient air quality are: Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons Carbon dioxide, Sulphur dioxide. In addition to the above pollution, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are by products of vehicular emissions. The reduction of ambient air pollutants with the present corridors are presented in Table 15.23.

TABLE 15.23: AMBIENT POLLUTION REDUCTION (TON/YEAR)

S.No.	Pollutant	Horizon Year		
		2025	2035	2045
1	Carbon Monoxide (CO)	544	623	671
2	Hydro-Carbons (HC)	144	169	180
3	Nitrogen Oxide (NOx)	208	246	286
4	Particulate Matter (PM)	20	23	25
5	Carbon Dioxide (CO ₂)	37091	43284	48943
6	Sulphur dioxide (SO ₂)	1.73	1.97	2.17

15.4 NEGATIVE ENVIRONMENTAL IMPACTS

Based on project particulars and existing environmental conditions potential negative impacts likely to result from the proposed development are quantified. Negative impacts are 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.

15.4.1 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:

- Displacement and loss of livelihood of Project Affected People (PAPs)
- Change of Land use;
- Loss of trees;
- Utility/Drainage Problems
- Impact on Historical and Cultural Monuments, and
- Impact on Local Transport Facilities

15.4.1.1 Project Affected People (PAPs)

This impact does not form part of this Report.

15.4.1.2 Change of Land use

Land will be required permanently for stations and running sections. Both government and private land will be acquired for the project. The details are given in SIA part.

15.4.1.3 Ecological impact

Impact on Birds

The alignment is passing along the existing Development Plan Road outside the compound wall of Sanjay Gandhi National Park which is home to five endangered species, namely the Peafowl, osprey, White bellied sea eagle, Hawks and large Falcons. Potential impacts on birds include habitat loss or degradation, loss or deterioration of some roosting, nesting and/or feeding habitat. Noise pollution has been shown to have a negative impact on species diversity in certain circumstances and that nest productivity can vary significantly between noisy and quiet areas.

Impact on Mammals

As the proposed alignment passing adjacent to Sanjay Gandhi National Park and SGNP is

home to many REET Species.

The proposed corridors pass adjoining the SGNP reserve forest (near Dongripada Station, Lokmanyagar Bus depot). There are approximately 662 trees along the corridors 251 trees are unfit for transplantation. These trees are likely to be felled during the construction. 411 trees will be transplanted. Trees are major assets in purifications of urban air, which by utilizing CO₂ from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO₂ conversion will get effected and the losses are reported below:

- | | | | |
|------|---|---|---------------|
| i) | Total number of Trees | : | 251 |
| ii) | Decrease in CO ₂ absorption due to loss of trees | : | 4600 kg/year |
| iii) | Decrease in Oxygen production due to tree loss | : | 10,339kg/year |

15.4.1.4 Utility/Drainage Problems

The proposed metro corridors are planned to run through the urban area above the ground i.e. elevated. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, 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. Plans and cost of such diversions are covered in the section on Civil Engineering.

15.4.1.5 Impact on Archaeological Monuments/sites and heritage assets

No archaeological monuments/sites and heritage assets are located along the corridors.

15.4.1.6 Impact on Local Transport Facilities

The metro system has been proposed to cater the additional demand of present and future traffic requirement. The drivers of local transport facilities like buses, taxis, autos and rickshaws may be utilized to cater the requirement of transport from metro stations to work place and vice-versa. Additional employment opportunities are also anticipated due to the proposed metro.

15.4.2 Impacts due to Project Design

Impacts due to project design are seen in following ways:

- **Right of way, Alignment and Architecture**

As the alignment and stations are predominantly elevated, visual intrusion will be experienced. Noise during operation will be higher, elevated stations result in reduced energy consumption compared to underground stations. Stations give rise to accumulation of passengers and likely congestion especially in case commercial development is resorted to.

- **Uses of Energy and water at stations and depot**

Energy for climate control, lighting and other facilities and water for drinking and non-drinking purposes at stations and depot will be required.

- **Risk Due to Natural Hazards**

Engineering construction shall be done so as to meet codal provisions. No other natural hazards such as due to climate change are foreseen.

15.4.3 Impact Due to Project Construction

The most likely negative impacts related to the construction works are:

- Ecological Impact
- Soil erosion and Land Subsidence
- Traffic diversion
- Air pollution
- Increased water demand
- Impact due to labour camp
- Impact due to supply of construction material
- Impact due to muck disposal
- Impact due to construction/demolition waste Disposal
- Impact due to hazardous waste
- Impact due to Pre-casting yards and Material stockpiling
- Impact on Ground water flow
- Impact on ground water and surface water quality
- Impact on archaeological monuments/sites and heritage sites
- Noise pollution
- Vibration and risk to existing buildings.

15.4.3.1 Ecological impact

Impact on Birds

The alignment is passing along the existing development road adjoining the Sanjay Gandhi National Park which is home to endangered species. Potential impacts on birds include habitat loss or degradation, loss or deterioration of some roosting, nesting and/or feeding habitat.

Noise pollution has been shown to have a negative impact on species diversity in certain circumstances and that nest productivity can vary significantly between noisy and quiet areas.

Impact on Mammals

As the proposed alignment along the existing development road adjoining the Sanjay Gandhi National Park and SGNP is home to many REET Species. There may be some mortality of small, common species during construction. Species which move away from the areas of disturbance during construction might possibly return after construction is completed. However certain species might not return due to disturbance during operation.

15.4.3.2 Soil Erosion and Land Subsidence

Run off from unprotected excavated areas can result in excessive soil erosion, especially when the erodibility of soil is high. Land subsidence is anticipated at stations which will be constructed by cut and cover method.

15.4.3.3 Traffic Diversion

During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road.

15.4.3.4 Air Pollution

Air pollution occurs due to excavation, loading and unloading of construction materials, and emissions from vehicles, construction equipment and DG sets etc. It also occurs in sites of muck disposal, debris disposal and pre-casting yards. Air pollution from road

based vehicles especially particulates are found to cause diseases of brain, heart, lungs and kidneys.

During the period of construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: CO, HC, NO_x, PM, CO₂ and VOC will be about 45tons, 1.4ton, 94tons, 2 tons, 5847 tons and 15 tons respectively. Such transportation is estimated to result in fugitive dust emission of about 11.1 tons during the period of construction.

15.4.3.5 Increased Water Demand

Water consumption during construction is of the order of 252 KLD.

15.4.3.6 Impact due to Labour Camp

During construction phase waste water will be generated from the Labour camps. Improper disposal of waste water can pollute the surface water and ground water. Construction workers are more prone to infectious diseases due lack of sanitation facilities (water supply and human waste disposal) and insect vectors. However, this phenomenon will be temporary and restricted to close vicinity of construction site. About 8,900 persons are likely to work during peak construction activity. Estimated water requirement comes out to be about 623KLD. Quantity of waste water and solid waste generated will be about 498 KLD and 1335 Kg per day respectively. Sewage and municipal solid waste generated from labour camp will be treated before disposal.

15.4.3.7 Welfare of Labour on construction site

Facilities such as shelter at workplace, canteen, first aid and day crèche are statutory requirement and essential to productivity.

15.4.3.8 Safety of Labour

Safety of labour during construction is a statutory requirement and also has impact on progress of work.

15.4.3.9 Impact due to Supply of Construction Material

Construction material such as aggregate and earth are sourced from approved quarries such that environmental impacts as well as wastage of natural resources are minimized and mitigated.

15.4.3.10 Impact due to Muck disposal

The alignment of the project is mostly elevated with 3 km underground. The construction activity involves cut and cover, tunneling, excavation and fill. All these activities will result in excavation of about 9.25 lakh cum and volume to be disposed is 4.65 lakh cum. Muck disposal if not properly done can result in air and water pollution, noise, diversion of green areas and temporary displacement of populace.

15.4.3.11 Impact due to construction/demolition waste Disposal

Debris disposal can result in air and water pollution, noise, diversion of green parks and temporary displacement.

15.4.3.12 Impact due to Hazardous Waste

Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc. Unsafe disposal can result in water and soil pollution, diversion of green parks and temporary displacement.

15.4.3.13 Impact due to Pre-casting yards and Material stockpiling

Sites for casting of structural concrete elements and material stockpiling can result in air and water pollution, noise, diversion of open areas like green parks and temporary displacement.

15.4.3.14 Impact on Ground Water flow

Tunnelling can impact ground water flow from aquifers while extraction of ground water during construction of underground stations can lower ground water table. A comprehensive hydro geological impact study should be taken before starting construction.

15.4.3.15 Impact on Ground and Surface Water Quality

Ground water contamination can take place if sewage from labour camp or chemical substances from construction site or dumped muck or construction/demolition waste or used water from the RMC plant percolate to the ground water table.

15.4.3.16 Impact on Archaeological Monuments/sites and heritage assets

No Archaeological Monuments/sites and heritage assets will be disturbed.

15.4.3.17 Noise Pollution

For noise prediction various combinations of equipment were assessed for different construction activities i.e Viaduct, Elevated Station, Underground station, at Grade Section, Construction Yard, Depot as listed in Table 15.24. For Prediction of Noise levels (Leq), Model of US Department of Transportation has been used.

For prediction, no ground attenuation has been considered as ground was assumed to be undisturbed, consolidated and hard. Usage factor (number of hours of operation of different equipment) as per construction practices in metro projects in India and standard (FHWA,USA) noise emission levels of equipment are taken. The metal barricade used in construction is assumed to be shielding. Noise prediction has been carried out for two conditions a) without any shielding and b) with shielding which provides noise attenuation of 5 dB(A).

Estimation of noise levels has been done upto a distance of 3000ft (914 m). Distances have been worked out (Table 15.25) upto which noise levels due to combination of equipment are equal to or less than average base line monitored noise levels i.e 71.25 dB(A). These levels are typical and will vary with specifications of the equipment, usage pattern, number of construction agencies, existing structures/trees which act as barrier to noise transmission.

TABLE 15.24: CONSTRUCTION EQUIPMENT NOISE EMISSION LEVEL

Particular	Equipment	Equipment Noise level (in Leq dBA at 50 ft)	Number of hours of operation	Predicted Noise level (Leq) dB(A) at 50 ft
Case 1				
Viaduct Activity 1	Press Pile	70	0.5	69.07
	Auger drill	84	0.5	
	Generator	81	0.5	
Viaduct Activity 2	Rotatory Hydraulic rig	84	5	78.95
	Generator	81	5	
Viaduct Activity 3	Chiseling	88	2	78.00
	Generator	81	2	

Particular	Equipment	Equipment Noise level (in LeqdB(A) at 50 ft)	Number of hours of operation	Predicted Noise level (Leq) dB(A) at 50 ft
Case 2				
Viaduct	Impact Pile Driver	101	12	98.01
	Crane	88	1	
Case 3				
Elevated Station Activity 1	Press Pile	70	0.5	69.07
	Auger drill	84	0.5	
	Generator	81	0.5	
Elevated Station Activity 2	Rotatory Hydraulic rig	84	5	78.95
	Generator	81	5	
Elevated Station Activity 3	Chiseling	88	2	78.00
	Generator	81	2	
Case 4				
Elevated Station	Impact Pile Driver	101	12	98.01
	Crane	88	1	
Case 5				
Underground station	Excavator	81	24	86.06
	Concrete Pump truck	81	24	
	Generator	81	24	
	Crane	88	1	
Case 6				
At Grade Section	Dumper	76	24	89.19
	Dozer	85	24	
	Compactor	82	24	
	Grader	85	24	
Case 7				
Construction yard	Concrete mixer	85	24	91.98
	Truck	88	24	
	Truck	88	24	
Case 8				
Depot	Dumper	76	24	92.21
	Dumper	76	24	
	Grader	85	24	
	Grader	85	24	
	Compactor	82	24	
	Compactor	82	24	
	Dozer	85	24	
	Dozer	85	24	

TABLE 15.25: DISTANCE AT WHICH $Leq \leq$ AMBIENT NOISE LEVEL

Cases	Distance (M) At Which $Leq \leq 71.25$ Db(A)	Distance (M) At Which $Leq \leq 71.25$ Db(A)
	(Without Shielding)	(With Shielding)
Viaduct Activity 1	15.24	15.24
Viaduct Activity 2	38.11	22.58
Viaduct Activity 3	38.11	22.87
Viaduct	335.17	190.55
Elevated Station Activity 1	15.24	15.24
Elevated Station Activity 2	38.11	22.58
Elevated Station Activity 3	38.11	22.87
Elevated Station	335.17	190.55
Underground station	91.46	53.35
At Grade Section	121.95	68.60
Construction yard	167.68	99.09
Depot	175.30	99.09

15.4.3.18 Vibration and Risk to Existing Buildings

If significant impacts due to vibration are expected, mitigation measures have to be implemented and building condition survey have to be conducted before, during and after construction. Damage to structures is a possibility in case of pile driving or trains passing within 7.5 m from normal buildings or unreinforced structures or between 15m to 30m from historical buildings or buildings in poor condition; heavy truck traffic within 30m, major construction within 60m, freight trains within 90m or pile driving within 180m can cause disruption of operation of sensitive instrumentation (*Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013*). Threshold criteria are listed in **Table 15.26**.

TABLE 15.26: GUIDELINE VIBRATION DAMAGE THRESHOLD CRITERIA

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent/Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous / frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment. *Source: Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013*

Typical vibration levels due to working of construction equipment for a wide range of soil conditions are summarised in **Table 15.27**.

TABLE 15.27 VIBRATION SOURCE LEVELS OF CONSTRUCTION EQUIPMENT

Equipment		PPV at 25 ft (inch/sec)	ApproxLv* at 25 ft (Vdb)
Pile Driver (Impact)	Upper Range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	Upper Range	0.734	105
	typical	0.17	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	73
Large Bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded Trucks		0.076	86
Jackhammer		0.035	79
Small Bulldozer		0.003	58

*RMS velocity in decibels (VdB) re 1 µinch/second

Source: Transit noise and vibration impact assessment, Federal Transit Administration 2006

Peak particle velocity (PPV) of the equipment adjusted for the distance (D) has been estimated conservatively (no mitigation measures) at different distances and presented in **Table 15.28**.

TABLE 15.28: ESTIMATED VIBRATION LEVELS FOR DIFFERENT CONSTRUCTION EQUIPMENT (PPV in/sec)

Equipment		Distance (m)									
		5	10	15	20	25	30	35	40	45	50
Pile Driver (Impact)	Upper Range	2.86	1.01	0.55	0.36	0.25	0.19	0.15	0.13	0.11	0.09
	typical	1.21	0.43	0.23	0.15	0.11	0.08	0.07	0.05	0.04	0.04
Pile Driver	Upper	1.38	0.49	0.27	0.17	0.12	0.09	0.07	0.06	0.05	0.04

Equipment		Distance (m)									
		5	10	15	20	25	30	35	40	45	50
(sonic)	Range										
	typical	0.32	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01
Clam shovel drop (slurry wall)		0.38	0.13	0.07	0.05	0.03	0.03	0.02	0.02	0.01	0.01
Large Bulldozer		0.17	0.06	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Loaded Trucks		0.14	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.00
Jackhammer		0.06 6	0.02 3	0.01 3	0.008	0.006	0.004	0.00 4	0.00 3	0.002	0.002
Small Bulldozer		0.00 6	0.00 2	0.00 1	0.001	0.001	0.000	0.00 03	0.00 02	0.000 2	0.0002

Where sonic pile driver is used the vibration level will be within permissible limit at 10 m. If significant impacts due to vibration are expected, mitigation measures have to be implemented and building condition survey have to be conducted before, during and after construction. In case impact pile is used for hard rock than the vibration level will be within the permissible limit at 15 m.

15.4.4 Impacts Due to Project Operation

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
- Vibration
- Water supply and sanitation at Stations
- Energy Consumption at stations
- Congestion Around Stations
- Impact due to depot

15.4.4.1 Noise Pollution

During the operation phase Noise levels from running of trains at particular distance from the source are predicted and presented in **Table 15.29**.

TABLE 15.29: NOISE LEVELS (LDN) IN dB(A) AT DIFFERENT DISTANCES

S.No.	Location Name	Distance (m)	Existing Noise (dB)	Project Noise (dB)	Combined Noise Level (dB) Without Barrier
1	Balkumb	34	77.2	57	77
2	Kopri	113	73.5	50	74
3	Manorma Nagar	226	78.3	45	78
4	Patlipada	102	84.8	50	85
5	Upvan	266	68	44	68
6	Waghbil	97	67.2	51	67

Measured noise level are more than the prescribed limits. As such bringing the composite i.e. metro noise level plus existing ambient noise level to satisfy the prescribed limits will require a mitigation measure to be implemented at the receptor which will be more expensive than the measures which can be implemented at the metro alignment. Therefore the objective of noise mitigating measures recommended in this report to bring the metro noise level to satisfy prescribed limits by use of noise barrier on the viaduct and elevated stations.

At average commercial speed of 32kmph with 6 cars per racks and 156 services per day (peak events 14 /hr) noise level due to metro will be 55 dB(A) at distance of 55 m from the alignment.

A great part of the alignment passes through the residential area for which prescribed limits is 55 dB(A). However the alignment passes along the existing development road adjoining the Sanjay Gandhi National Park (SGNP) for which the prescribed limit will be 50 dB(A) which will be experienced at 92 m. Considering 55 dB(A) as the cutoff noise level to be achieved will lead to the conclusion that noise barrier will have to be installed over entire length of the elevated section. Therefore the recommendation in this report is based on comparison of metro noise level with existing ambient noise level.

It is seen from Table 15.29 that metro noise level is 57 dB(A) to 44 dB(A) which is less than the measured level.

However with the objective to reduce level to standard limit inside this sensitive area to the extent possible, noise barrier for elevated section is recommended on both sides of the viaduct in section which falls along the existing development road adjoining the Sanjay Gandhi National Park. Metro Noise level estimated at 1m will be 80 dB(A) and absorptive Noise barrier will be used to reduce the metro noise level by 20 - 25 dB(A). Subject to approval of safety authorities, the viaduct will be covered in this section with suitable material to reduce disturbance to birds.

15.4.4.2 Vibration

During operation phase the sources of the vibration and noise induced by the trains are mainly the rolling stock, track and the interaction between them. The vibration of the transit structure excites the adjacent ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the remainder of the building structure. The intensity of vibration depends on operational and vehicle parameters, track system, geology and condition of receiving building. Primary effect of ground borne vibration will be rattling of window panes and rumble noise which cause annoyance to the occupants.

15.4.4.3 Water Supply, Sanitation and Solid Waste Disposal At Stations

The water demand at stations arises from cleaning and air conditioning of stations and drinking and toilet demands for staff. Total water requirement for the station will be 518 KLD (185 KLD for Underground station, & 333 KLD for Elevated station) that will be met through by public water supply system after taking necessary approvals. Daily sewage flow is considered as 80% of the flushing water requirement hence total sewage generated as 266 KLD. Solid Waste generated at the stations will be approximately of the order of 17cum.

15.4.4.4 Energy Consumption at Stations

Energy is required at stations for facilities like lighting, passenger information, access, security, climate control, escalators/elevators etc.

15.4.4.5 Congestion Around Stations

Commencement of metro services results in passenger rush at stations which in turn results in congestion around stations.

15.4.4.6 Impacts due to Depot

The Maintenance facilities for New Thane-Wagbil-Thane Junction corridor of Thane MRTS are proposed to be provided at TMC land near Kasarvadavali Depot for about 41 rakes of 6 cars for maintenance and repairs of the rolling stock operational on corridor. The depot will have infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signaling& Telecomm.; Automatic Fare Collection etc.

The depot area will be levelled through cut and fill method within the depot. Impacts anticipated at depot sites are:

- Water supply
- Effluent and Sewage Generation
- Oil Pollution
- Noise Pollution
- Surface drainage changes
- Loss of trees
- Waste disposal

i. Water Supply

Water supply will be required for different purposes in the depot. A three day cycle is assumed for outside Cleaning (wet washing on automatic washing plant) and thirty day cycle for outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area, Floor, walls inside/outside and roof manually). Water quantity required in the depot for train maintenance purpose is estimated at 68.47 KLD. During operation Approx. 100 staff will be working in the depot. Water requirement for staff working in depot is calculated as 11.8 KLD. Water demand will be met from supply water by Municipal Corporation. Water demand for horticulture will be met from recycled water.

i. Rain Water Harvesting

To augment storage of groundwater, it is proposed to construct roof top rainwater harvesting structure in Admin block. Average annual rainfall of Thane is 2293.4 mm. considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of depot is estimated as 11,696 cubic meter per year. Estimated cost for the rainwater harvesting structure for depot is Rs15 lakh.

ii. Sewage and Effluent

About 55 KLD of Effluent and 9 KLD of Sewage will be generated from Depot. The wastewater will be treated and will be recycled to use at depot horticulture purpose. The remaining domestic waste /sewage generated at the Depot will be collected at one suitable point inside the depot from where it will discharge to the nearest manhole of existing sewerage system.

iii. Oil Pollution

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

iv. Noise Pollution

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise.

v. Surface Drainage

In case of filling in low-lying area of depot sites, the surface drainage pattern may change. Suitable drainage measures will be adopted to drain off the area suitably in the nearby water body.

vi. Waste generation

In addition to solid waste different types of waste will be generated during operation phases from depot and which will consist of waste oil, waste tube lights/LED's, batteries, rubber, plastic, various ferrous/non-ferrous scrap, wooden scrap, paper waste.

15.5 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

15.5.1 Mitigation measures

This section includes measures for:

- Compensatory afforestation
- Right of Way, Alignment, Track design and Architecture
- Spatial Planning of Stations and Inter-Modal Integration
- Robust Design
- Provisions for Green Buildings and solar power
- Use of Energy and Water
- Supply of Construction Material
- Pre-casting yards and Material Stockpiling
- Construction Material Management and Housekeeping,
- Safety Management Measures,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Construction and Demolition Waste Management
- Muck disposal
- Utility Plan,
- Air Pollution Control Measures,
- Noise Control Measures during construction,
- Vibration Control Measures during construction,
- Traffic Diversion/Management,
- Soil Erosion and subsidence Control,
- Noise Control Measures during operation
- Vibration Control Measures during operation,
- Water Supply, Sanitation and Solid Waste management,
- Rain water harvesting,
- Disaster and Risk Management.

15.5.1.1 Compensatory Afforestation

The Department of Forests, Government of Maharashtra is responsible for the conservation and management of trees in the project area. According to the results of the present study, it is found that about 251 trees are likely to be felled along the corridors and 411 trees will be transplanted. It is proposed to plant five saplings for each

tree to be cut. Hence, total 3,721 trees need to be planted. The estimated compensatory afforestation cost will be about **2.04 Crore**. The native plant species and miscellaneous indigenous tree species recommended for afforestation. 3,721 trees, on maturing will absorb about 81,118 kg of CO₂ per year and will release 1,82,329 kg of Oxygen per year.

TABLE 15.30: DETAILS OF COMPENSATORY PLANTATION & TRANSPLANTATION

A) Compensatory plantation cost	
Trees to be cut (no.)	251
Compensatory plantation against tree cut + compensatory plantation against tree transplant (1255+2055) (no.)	3310
Rate of plantation (Rs.)	1026
Cost of plantation (Rs.)	3396060
Rate of maintenance per year (Rs.)	113
Cost of maintenance (Rs.)	374030
Year of maintenance (no.)	5
Total Maintenance (Rs.)	1870150
Sub Total of compensatory plantation including Maintenance	5266210
B) Transplantation Cost	
Tree to be transplant (no.)	411
Rate of transplantation(Rs.)	15402
Transplantation cost (Rs.)	6330222
Rate of maintenance per year (Rs.)	4300
Cost of Maintenance (Rs.)	1767300
Year of maintenance (no.)	5
Total Maintenance (Rs.)	8836500
Sub total cost of transplantation including Maintenance (Rs.)	15166722
Grand Total (A+B) (Rs.) two Crore forty three lakh twenty nine thousand & thirty two rupees only	20432932

15.5.1.1 Right of Way, Alignment, Track design and Architecture

Alignment has been kept elevated where adequate width of right of way on roads is available. Geometric design of the alignment will be such as to optimize curvature. Track design will incorporate welded rails and elastic fittings. Viaduct and elevated stations shall be shaped to minimize visual intrusion.

15.5.1.2 Spatial Planning of Stations and Inter-Modal Integration

Adequate and well-laid out space shall be designed for concourses and platforms, escalators, elevators and staircases, lighting, turnstiles for normal and abnormal operating conditions; optimal height / depth of the stations, forced ventilation shall be provided. Physical and operational integration of metro with other modes shall be planned. Adequate design of stations and multimodal integration prevents and mitigates congestion at stations and safety is improved. Consumption of energy for climate control, lighting and other facilities at stations is significantly reduced by proper design of passenger flow inside stations, space & facilities inside stations.

15.5.1.3 Robust Design

Engineering construction shall be done so as to meet codal provisions.

15.5.1.4 Provisions for Green Buildings and solar power

Green building refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. Green buildings help in better preservation of environment as in such structures there are provisions for better saving of energy, water and CO₂. Such buildings also have better waste management arrangements. All stations and Depot buildings can be designed as green buildings.

For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on the roof of elevated stations and in Depots. Feasible solar plant size works out to 246.4kw for each station considering 80% of roof top is available for solar panels. Total annual electricity generation from stations works out to 7392MWh which corresponds to 1,84,800MWh for 25 years life span. The installation cost for solar system is about Rs30 crore. Installation of these solar panels can mitigate CO₂ of the order of 1,51,536ton which will be equivalent to 2,42,458 trees over life time. Feasible solar plant size workout to 10.35 MW for depot considering 50% of roof top is available for solar panel. Total annual electricity generation from depots works out to 15,525 MWh which corresponds to 3,88,125MWh for 25 years life span. The installation cost for solar system is about Rs62.10 crore. Installation of these solar panels can mitigate CO₂ of the order of 3,18,263 ton which will be equivalent to 5,09,220 trees over life time.

15.5.1.5 Use of Energy and Water

Requirement of electrical energy for climate control, lighting and other facilities at stations shall be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Installations for solar power will be implemented at stations and Depot where feasible.

Water supply in stations for air conditioning, cleaning and use of staff and passengers will be procured from municipal supply. Water for depots will be sourced from municipal supply.

15.5.1.6 Supply of Construction Material

The procurement source of the construction materials will be decided by the Contractor, but it will be from the licensed supplier.

15.5.1.7 Pre-casting yards and Material Stockpiling

Sites for casting of structural concrete elements and material stockpiling will be decided before start of construction. Land for these sites will be temporarily acquired such that displacement of persons is not involved to the extent possible.

15.5.1.8 Construction Material Management and Housekeeping

Procedures for storage, handling and transport of construction material shall be prescribed in SH&E method statement approved for construction.

Housekeeping is to keep the working environment cleared of all unnecessary waste, thereby providing a first-line of defence against accidents and injuries. It is the responsibility of Contractor and all site personnel. Some of the measures are listed below:

- 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.
- 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 shall be removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. shall be covered while moving.
- Unused/surplus cables, steel items and steel scrap 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 locations.
 - Empty cement bags and other packaging material shall be properly stacked and removed.
 - Proper and safe stacking of material is of paramount importance at yards, stores and such locations 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.

15.5.1.9 Safety Management Measures

Prior to the construction, identification of safety hazard would be made by Project Authority to establish the safety programmes following rules, regulations and guidelines. The comprehensive safety programmes will include deployment of a full time safety engineer who will prepare safety plan/schedule for their implementation during construction and operation. The personnel working would wear protective headgear, footwear and other special garments that applicable code requires. The weatherproof first aid boxes will be made available at appropriate locations.

15.5.1.10 Labour Camp

The contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour will be provided as per Section 32 of BOCWA. All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Adequate health care is to be provided for the work force. In addition the following facilities will be provided in the labour camps sanitation facilities like toilets and drains, shelter at workplace, canteen facilities, first aid facilities, day crèche facilities, health awareness campaigns to prevent Infectious Diseases, facilities for water supply and waste water treatment and solid waste management.

15.5.1.11 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 the request of officer of the Project Implementation Unit. Measures to conserve energy include but not limited to the following:

- Optimizing the use of tools, plants and equipment to perform tasks with correct power, cable size and joint can control voltage drops,
- Use of energy efficient motors (90% efficiency or more) and pumps (at least 80% efficiency),
- Replacing inefficient lamps with the most efficient lamp for the purpose, taking into account size, shape, colour and output of the lamp,
- Adequate and uniform illumination level at construction sites suitable for the task,
- Use of energy efficient air conditioner,
- Engine of DG set shall comply with CPCB norms,
- Planning in advance and selecting location to receive and store material such that these are at the least distance from the place of use.
- Maintenance schedule
- The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be used where feasible.

15.5.1.12 Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file an application for obtaining authorization with Maharashtra Pollution Control Board (MPCB). Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc. Hazardous Waste needs to be stored in a secure place and adequately labelled and packaged. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection.

15.5.1.13 Construction and Demolition Waste Management

Construction and Demolition (C&D) waste is part of solid waste that results from land clearing, excavation, construction, demolition, remodelling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, river sand, soil etc.) and energy, reduce transportation over long distances for dumping, and

reduce space occupied at landfill sites. C&D waste generated from metro construction has potential use after processing, grading solid waste and recycling. Part of this waste will be hazardous in nature.

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transport recyclable materials to construction sites.
- Sale of metal scrap and other saleable waste to authorized dealers.
- Identification of intended transport means and route.
- Obtaining permission, where required, for treatment of the hazardous component and its disposal.
- The treatment and disposal sites will be identified in consultation with local agencies such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Before dumping, recyclable material will be removed. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.

15.5.1.14 Muck Disposal

The excavated material shall be graded such that part can be re-used in construction; balance will be disposed. Before excavation, the Contractor will be required to test the soil quality including heavy metals and the results will be compared with standards. If the soil is contaminated, disposal will be done with due treatment or isolation of such muck.

Disposal sites will be identified by Project Authority in consultation with TMC such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. The following activities will be involved for muck disposal:

- Material will be stock-piled with suitable slopes
- Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.
- Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.

15.5.1.15 Utility Plan

The proposed Metro alignment run along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. Large 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 alignments. These utility services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- The elevated viaduct does not pose 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, the utility is crossing the proposed Metro alignment.

15.5.1.16 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) along haul roads and emission from vehicles and construction machinery. Mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The contractor shall take all necessary precautions to minimize 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.

- 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.
- 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 design and implement blasting techniques so as to minimize dust, noise, and vibration generation and prevention fly rock.

15.5.1.17 Noise Control Measures during construction

Techniques such as impact pile driving can be substituted by press piling where feasible. During construction exposure of workers to high noise levels can be minimized by job rotation, automation, protective devices, noise barriers, and soundproof compartments, control rooms etc. Measures to mitigate noise impact in construction zones shall be implemented by the contractors the cost of which is included in the project engineering cost.

15.5.1.18 Vibration Control Measures during construction

Techniques such as impact pile driving can be substituted by press piling where feasible. At locations where the alignment is close to protected monuments, heritage assets or other sensitive structures, the contractor shall prepare a monitoring scheme including building condition survey prior to construction at such locations. In case construction of underground stations or tunnelling by NATM in hard rock which require controlled blasting, laid down precautions and procedures in accordance with The Explosives Rules 2008 shall be implemented.

15.5.1.19 Traffic Diversion/Management

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 worker visibility, road widening, traffic segregation, one-way movements, segregation of work zones, signs, traffic diversions, acquisition of service lanes, etc. Various construction technologies like cut and cover can be employed to ensure that traffic impedance is minimized. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

During operation decongestion scheme should involve taxi and auto rickshaw stands, a halting space for public buses, drop off-pick up for owned modes. Parking space at stations if any is to be planned well. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

15.5.1.20 Soil Erosion and subsidence Control

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, temporary mulches, seeding or other methods as necessary to control erosion shall be implemented. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. In general, construction works are stopped during monsoon season. To manage land subsidence measures including maintaining adequate distance of the trench from existing structures adjacent to the trench, measures to support the walls of the trench as well strengthen soil underneath adjacent structures will be required.

15.5.1.21 Noise Control Measures during operation

During operation use of ballast-less track with elastic and absorbent fittings is a standard provision for noise control. At depots use of green belt with vegetation of thick foliage helps reduce noise; where site layout permits barrier blocks of less-vulnerable buildings can be used; alternatively freestanding barrier walls can be built. Cost of noise barriers required to be deployed during operation is not included in the project engineering cost and is therefore estimated as part of EMP cost. Absorptive Noise barriers for elevated section are recommended on the section passing adjacent to Sanjay Gandhi National Park. The estimated cost for the noise barrier is 5.72 Crores.

15.5.1.22 Vibration Control Measures during operation

Vibration during operation can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of railseat assembly from the concrete plinth with insertion of resilient and shock absorbing pad. Deep and narrow trenches in the ground can be implemented at vibration-sensitive structures.

15.5.1.23 Water Supply and Solid Waste Management

Water requirement for construction will be met through municipal supply or through sewage treated and re-used. During operation water supply, sanitation and toilets are needed at the stations. Drinking water and raw water requirement for elevated stations can be provided from municipal source in consultation with local agencies. During operation rainwater harvesting will be carried out at stations and elevated corridors. Non-hazardous municipal solid waste generated in stations will be collected and transported to local municipal bins and thence to disposal site by municipality.

15.5.1.24 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 at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and into the underground tanks. A recharge tank shall be constructed at suitable distance. The water collected will percolate down to the subsoil through numerous layers of sand, gravel and boulders. Total elevated length of the corridors including station length is about 26.06 km. Average annual rainfall of Thane is

2293.4 mm. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of elevated stations and elevated section is estimated as 5,08,011 cubic meter per year. Estimated cost for the rainwater harvesting for viaduct and elevated stations is Rs**2.9 crore**. This is not included in the EMP cost.

15.5.1.25 Management Plan for Depot

- Water supply
- Rain water harvesting
- Waste Water Treatment
- Oil Pollution
- Surface Drainage
- Green Belt Development
- Solid Waste Disposal
- Top Soil Preservation, reuse and dust control.

a) Water Supply

Water will be sourced from municipal supply. This will be supplemented by re-use of used water from coach wash. Total water requirement is estimated as 11.8 KLD for staff and 68.47 KLD for train maintenance. Estimated cost for water treatment plant will be 207 Lakhs.

b) Rain Water Harvesting

To augment storage of groundwater, it is proposed to construct roof top rainwater harvesting structure in Admin block. Average annual rainfall of Thane is 2293.4 mm. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of depot is estimated as 11,696 cubic meter per year. Estimated cost for the rainwater harvesting structure for depot is Rs**15 lakh**.

c) Waste water Treatment

About 55 KLD of Effluent and 9 KLD of Sewage will be generated from Depot. The wastewater will be treated and will be recycled to use at depot horticulture purpose. The remaining domestic waste /sewage generated at the Depot will be collected at one suitable point inside the depot from where it will discharge to the nearest manhole of existing sewerage system. Estimated cost for STP and ETP will be 134 Lakhs and 152 Lakhs Respectively.

d) Oil Pollution

Oil spillage from during change of lubricants, cleaning and repair processes in the maintenance Depot cum workshop for maintenance of rolling stock should be trapped in oil and grease traps and disposed off to authorised collectors, so as to avoid any underground/ surface water contamination. These traps need to be installed before effluent treatment plant.

e) Surface Drainage

The Storm water of the depot will be collected through the drain. Rain water harvesting pits are provided at different locations in the drains and for surplus storm water, the drainage system is connected to a nearby disposal site. The estimated cost for drainage will be 103 Lakhs.

f) Green Belt Development

The greenbelt development / plantation in the depot area harmonizes the depot with surrounding environment and acts as pollution sink / noise barrier. It will check soilerosion. In addition to the compensatory afforestation, green belt is recommended around the perimeter of the Depot. Treated sewage and effluent can be used for green belt development. The estimated cost for green belt will be 69 Lakhs.

g)Solid Waste Disposal

Solid waste generated from the Depot which includes hazardous waste will be taken away by the cleaning contractor weekly and recycled/treated and disposed of at designated waste disposal sites.

h) Top soil preservation, reuse and dust control

Top soil which is found to be rich in nutrients based on soil sampling shall be preserved during construction and re-used for horticulture post-construction. Permanent plantation on un-paved area shall be done. Complete dust interception can be achieved by a 30 m belt of trees. Even a single row of trees may bring about 25 percent reductions in airborne particulate matter.

i) Solar Power

Depot area can be utilised for renewable energy by installing roof top solar power plant. Feasible solar plant size workout to 10.35 MW for depot considering 50% of roof top is

available for solar panel. Total annual electricity generation from depots works out to 15,525 MWh which corresponds to 3,88,125MWh for 25 years life span. The installation cost for solar system is about Rs 62.10 crore. Installation of these solar panels can mitigate CO₂ of the order of 3,18,263 ton which will be equivalent to 5,09,220 trees over life time.

15.5.1.26 Disaster Risk Management

Disaster risk is the combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage. The main opportunity in reducing risk lies in reducing exposure and vulnerability. Disaster Risk Management includes the following actions:

- Reduction and prevention: Measures to reduce existing and avoid new disaster risks, for instance relocating exposed people and assets away from a hazard area. In case of mass transit like Metro such measures are not actionable.
- Mitigation: The lessening of the adverse impacts of hazards and related disasters. For instance implementing strict land use and building construction codes. This aspect is accounted for in design and construction of the project.
- Transfer: The process of formally or informally shifting the financial consequences of particular risks from one party to another, for instance by insurance. This is not yet available.
- Preparedness: The knowledge and capacities of governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of hazard events or conditions, for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Risk Management process² comprises the following stages:

- Description of the system that is at risk
- Identify the potential hazards or sources of risk (the list of initiating events or scenarios of events leading to the undesired outcome – technological and human)
- Risk analysis to estimate the likelihood of the scenarios or events occurring and each scenario's consequence
- Compare and rank the various risk drivers

- Action plan in response to the identified major risks
 - Regular monitoring, review and updation of the process.
1. For example, the system at risk needs to be defined as to include inter-modal integration.
 2. Examples of potential hazards are fire risk or security alarms or failure of train control or motive power or passenger doors / escalators / platform screen doors on trains or in stations; staff training and work environment; inadequate maintenance.
 3. Action plan shall include the following.
 4. Procedures and Records
 5. Evaluation of progress and effectiveness of EMP and EMoP, response to inquiries, complaints and requests for information surveillance, incident reporting, corrective and preventive actions, emergencies, training and emergency exercises, response to emergencies,
 6. Identification of resources: Sources of repair equipment, personnel, transport and medical aid for use during emergency will be identified.
 7. Emergency systems: Back-up systems for ventilation, communication and train control, lighting etc shall be established.
 8. Evacuation procedures: Evacuation procedures will be prepared in consultation with local administration and notified. To ensure coordinated action, an Emergency Action Committee shall be constituted.
 9. Communication System: Primary and back-up system shall be put in place
 10. Review and Updation: Drawing inputs from the incident reporting system the Action Plan shall be reviewed at pre-decided intervals and upon occurrence of defined ``trigger events`` and suitably updated.

15.6 ENVIRONMENTAL MONITORING PLAN & ENVIRONMENT MANAGEMENT SYSTEM

Environment monitoring and environment management system is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action.

15.6.1 Environment Monitoring Plan

Environmental monitoring should be an integral part of works towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation phases of the project. 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. The estimated environmental monitoring cost during construction and operation is about **Rs 2.13 crore**.

Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels, water quality and ecology. At this stage it is not possible to visualize the exact number of locations where environmental monitoring must be carried out. However keeping a broad view of the sensitive receptors and also the past experience an estimate of locations has been made and are summarized in **Table 15.31**.

TABLE 15.31: CONSTRUCTION STAGE MONITORING SCHEDULE

Parameter	Frequency per year	Locations	Years
Air Quality	2x24 hours, 2 times in a month	11	5
Noise	2x24 hours, 2 times in a month	11	5
Water	Once in six month, twice in a year	10	5
Soil	Once in six month, twice in a year	10	5
Ecology	Four times in a year	Along corridor, depot	5

These numbers could be modified based on need when the construction actually commences.

Water Quality

The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. Water quality should be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per IS: 10500. The monitoring points could be ground and surface water.

Air Quality

Air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter (PM_{2.5} and PM₁₀), SO₂, NO_x, CO and HC. The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of MMRC.

Noise Monitoring

The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of MMRC.

Ecological Monitoring

The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridors at least 4 times in a year during construction phase in order to maintain the ecological environment. The plantation/afforestation of trees by Department of Forest, Government of Maharashtra will be review four times a year during construction phase.

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 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.

15.6.1.1 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 and ecology during operation phase of the project. The parameters monitored during operation will be Particulate Matter (PM_{2.5} and PM₁₀), SO₂, NO_x, CO and HC for ambient air quality. Water quality parameters that will be monitored will be as per IS: 10500. The monitoring schedule is presented in **Table 15.32**. Monitoring should be carried out by NABL Accredited/MoEF recognized private or Government agency under the supervision of MMRC. Project Operator will be responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE 15.32: OPERATION STAGE MONITORING SCHEDULE

Parameter	Frequency per year	Locations	Years
Air Quality	2x24 hours, in a week for each season, three seasons in a year	7	3
Noise	2x24 hours, in a week for each season, three seasons in a year	7	3
Water	Once in six month, twice in a year	6	3
Soil	Once in six month, twice in a year	6	3

The environmental monitoring results will be submitted to management quarterly during construction phase and semi annually during operation phase.

15.6.2 Environment Management System (EMS)

Environment Management System is intended to facilitate implementation, tracking and reporting of mitigation and monitoring measures proposed for the project. Roles and responsibilities are summarized in **Table 15.33** and **Table 15.34**.

TABLE 15.33: ROLES AND RESPONSIBILITIES - SECURING APPROVALS/CLEARANCES

S. No	Issues	Provision of Law & Regulations	Approving Authority
Pre-Construction Stage			
1.	Prior Environmental Clearance	EIA Notification 2006 and its amendments	SEIAA

S. No	Issues	Provision of Law & Regulations	Approving Authority
2.	CRZ clearance as The alignment approximately from Ch: 14309-15343, Ch: 19800-22500, Ch: 22900- 25400 is passing along the existing and proposed Development Plan Road in CRZ 1A /CRZ II.	CRZ Notification 2011 with amendment	Coastal Zone Management Authority. Maharashtra and SEIAA
3.	Forest Clearance as alignment passing along the proposed Development Plan Road adjacent to SGNP near Dongripada Station, Lokmanyagar Bus depot.	Forest (Conservation) Act 1980 Forest Right Act, 2006	Regional officer, nodal officer, DFO, DC, CF,CCF, State Secretary
4.	Forest Clearance as alignment passing along the existing and proposed Development Plan Road adjacent to Mangroves in Vasai Creek near balkumnaka to laxminagar and saket to shiwaji complex	Forest (Conservation) Act 1980 Forest Right Act, 2006	Forest Department

S. No	Issues	Provision of Law & Regulations	Approving Authority
5.	NOC from AAI is required if permissible height of buildings above AGL at any proposed Metro station is breached. As proposed elevated station height is lesser than the max permissible height from AAI.	Aircraft Act 1934 with Aircraft (Amendment) Act, 2007 (44 of 2007) & Ministry of Civil Aviation (Height Restrictions for Safeguarding of Aircraft Operations) Rules, 2015 amended 2018	AAI
6.	Permission for tree cutting/felling and transplantation	“The Maharashtra Felling of Trees (Regulation) Act, 1964 The Maharashtra (urban areas) protection and preservation of tree Act, 1975	Tree authority (in the respective municipal council)
7.	Transit Pass permit	Transit Permit for felled trees under Maharashtra Forest Rules 2014	DFO
8.	Protection of Air Quality Consent to Establish depot (<i>Amendment dated 9 Dec 2016 exempting from Consent has been quashed by NGT in Dec 2017</i>)	Compliance to National Ambient Air Quality Standards. Air (Prevention and Control of Pollution) Act, 1981 amended in 1987; Air (Prevention and Control of Pollution) Rules, 1981	SPCB

S. No	Issues	Provision of Law & Regulations	Approving Authority
9.	Protection of Water Quality Compliance to National water Quality Standards Treatment and discharge of sewage Consent to Establish depot	Water (Prevention and Control of Pollution) Act, 1974 amended in 1988; Water (Prevention and Control of Pollution) Rules, 1975	SPCB
10.	Horizontal and Vertical Clearance for Construction of bridges		Chief Executive Officer, Maharashtra Maritime Board
Construction Stage			
11.	Consent to Establish and operate batching plant, material yards	Air (Prevention and Control of Pollution) Act 1981 Water (Prevention and Control of Pollution) Act 1974,	State Pollution Control Board
12.	Permission for withdrawal of groundwater for construction (not recommended)	Environment (Protection) Act, 1986	Regional Director, Central Ground Water Board and DC/DM of the state
13.	Authorization for handling, storage and Hazardous Waste	Hazardous and Other Wastes (Management & Trans boundary Movement) Rules, 2016	State Pollution Control Board;
14.	Authorization for Disposal of Construction and Demolition Waste	Construction and Demolition Waste Management Rules,	Approval of C&D waste management plan from Local authority if

S. No	Issues	Provision of Law & Regulations	Approving Authority
		2016	generation is more than 20t/day or 300 ton/months
Operation Stage			
15.	Consent to Operate Depot under red category (Railway locomotive workshop/Integrated road transport workshop/Authorized service centres)	Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act ,1981	State Pollution Control Board

TABLE 15.34: ROLES AND RESPONSIBILITIES –PREPARATION AND IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND ENVIRONMENTAL MONITORING PLAN (EMOP)

Sl. No.	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
Location and Design Phase				
1.	Displacement and private property acquisition, impact of environmentally sensitive areas.	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
2.	Loss of trees and water bodies		DPR and design consultant	PIU
3.	Visual intrusion	To design aesthetic structures of viaduct and stations on elevated sections.	DPR and design consultant	PIU
Pre-construction Phase				
4.	Displacement and private property acquisition.	Implement R&R Plan	PIU	PIU
5.	Loss of trees and water bodies	Implement compensatory forestation	Forest Department	Forest Department

6.	Site measures	Prepare Safety, Health and Environment (SH&E) Manual and secure approval.	Contractor	PIU
7.	Water supply; sewage and solid waste disposal	Requirement for construction to be planned so as to avoid use of ground water.	Contractor	PIU
8.	Environmental Management and Monitoring	Implement institutional requirements for implementation of EMP and EMoP.	Contractor	PIU
Construction Phase				
9.	Soil erosion, fugitive dust generation, muck disposal and C&D waste management	Implement suitable construction methods and as per SH&E Manual	Contractor	PIU
10.	Air and noise Pollution	Vehicles and machinery are to be maintained to emission standards; machinery noise muffles etc and personal protective gear to workers.	Contractor	PIU
11.	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures	Contractor	PIU
12.	Water pollution	Implement measures such as precipitation tanks on site	Contractor	PIU
13.	Soil pollution	Implement measures to prevent ingress of toxic / heavy metals	Contractor	PIU
14.	Labour camp: water supply; sewage and solid waste disposal; health	Implement measures as per SH&E Manual	Contractor	PIU
15.	Facilities on site and workplace safety		Contractor	PIU
16.	Incident Management	Prepare Incident Management Plan with reporting formats.	Contractor	PIU
17.	Environmental	Prepare Environmental		

	Monitoring	Monitoring Plan.		
18.	Availability of institutional capacity	Implement training and establish environment unit.	Contractor	PIU
19.	Tree protection/ Cutting and Disposal	- Contractor shall prepare an action plan for number of trees to be affected/felled and trees proposed to be planted as per compensatory afforestation norms - The indigenous plants to be planted in the project area - Other than Contractor, no one is allowed to cut the identified trees which are falling in a ROW - Biomass shall not be stored at site for more than 15 days	Contractor	PIU
Operation Phase				
20.	Noise Pollution	Implement and maintain noise barriers on viaduct	PIU	PIU
21.	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures.	PIU	PIU
22.	Water supply, sanitation, sewage and solid waste disposal at stations and depots	Implement prescribed measures including rain water harvesting at stations and depots; green belt and water recycling at depots.	PIU	PIU
23.	Sewage and effluent disposal	Implement STP and ETP at depots.	PIU	PIU
24.	Incident Management	Implement Incident Management Plan.	PIU	PIU
25.	Environmental Monitoring	Implement Environmental Monitoring Plan.	PIU	PIU

The range of documentation required to be generated and maintained as part of EHS before and during construction and during operation is as follows:

- Controlled documents of mandatory environmental Approvals and clearances along with record extensions thereof

- Controlled documents of approved SH&E Manual, EMP and EMoP with revisions thereof and time schedule of such revisions if any.
- Controlled documents of formats of site inspection checklists with revisions thereof and time schedule of such revisions if any
- Reports of site inspections, monitoring data, reports of internal or external audit, observations of PIU and local statutory agency if any like Pollution Control Board, local municipal authority, Forest Department etc. and subsequent remedial action taken by Contractor if any.
- Records of coordination meetings of PIU/GC and Contractor with subsequent remedial action taken by Contractor if any.
- Records of incident reporting and remedial action taken by Contractor if any and followup of such incidents.

A typical EMS organization is depicted in **Figure 15.19**. One indicative activity i.e., approval of EMS documents is shown in this organisation chart.

15.6.2.1 Training

The training for engineers and managers will be imparted by MMRC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. Apart from training, programmes should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such programmes is estimated as **Rs 9.60 lakh**. Details are given in **Table 15.35**.

TABLE 15.35: COST FOR TRAINING PROGRAMME

S. No.	ITEM	Cost (Rs.)
1	Curriculum Development and course preparation 1 month Rs.50000/month	50,000
2	1 Extension Officer (1 year) Rs.35, 000/month	42,0000
3	Instructor 20 sessions of 10 days each	24,000
4	Demonstration/Presentation Aids	1,00,000
5	Material etc	150000
Total		960,000.00

15.6.2.2 Establishment of Environmental Division

It is recommended that Project Authority establishes an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and

an Environment Engineer. The task of the division would be to monitor implementation of environmental mitigation measures and environmental monitoring and it should report directly to Chief Engineer of the Project Authority. Progress of the division should be reviewed by an Environmental Advisor once in a year. The Environmental Advisor should be an experienced expert familiar with environmental management in similar projects. Cost for the first ten years (including 10% annual increase) is given in **Table 15.36**. The estimated cost is Rs 2.44 crore.

TABLE 15.36: Environmental Division Cost

S. No	Head	Cost (Rs lakh)
A	Capital Cost	
	Office Furnishings (Computer, furniture etc) LS	2.50
B	Recurring Cost	
	Man Power Cost (For 12 months)	
	Environmental Engineer @ Rs. 50,000/month	6.00
	Environmental Assistant @30000/month	3.60
	Office Maintenance @ Rs. 15,000/month	1.80
C	Sub Total (A+B)	13.90
	Miscellaneous expenses, LS (10 % of C)	1.39
	Total cost for 1 Year	15.29
	Total cost for 10 years @ 10% annual increase	243.68

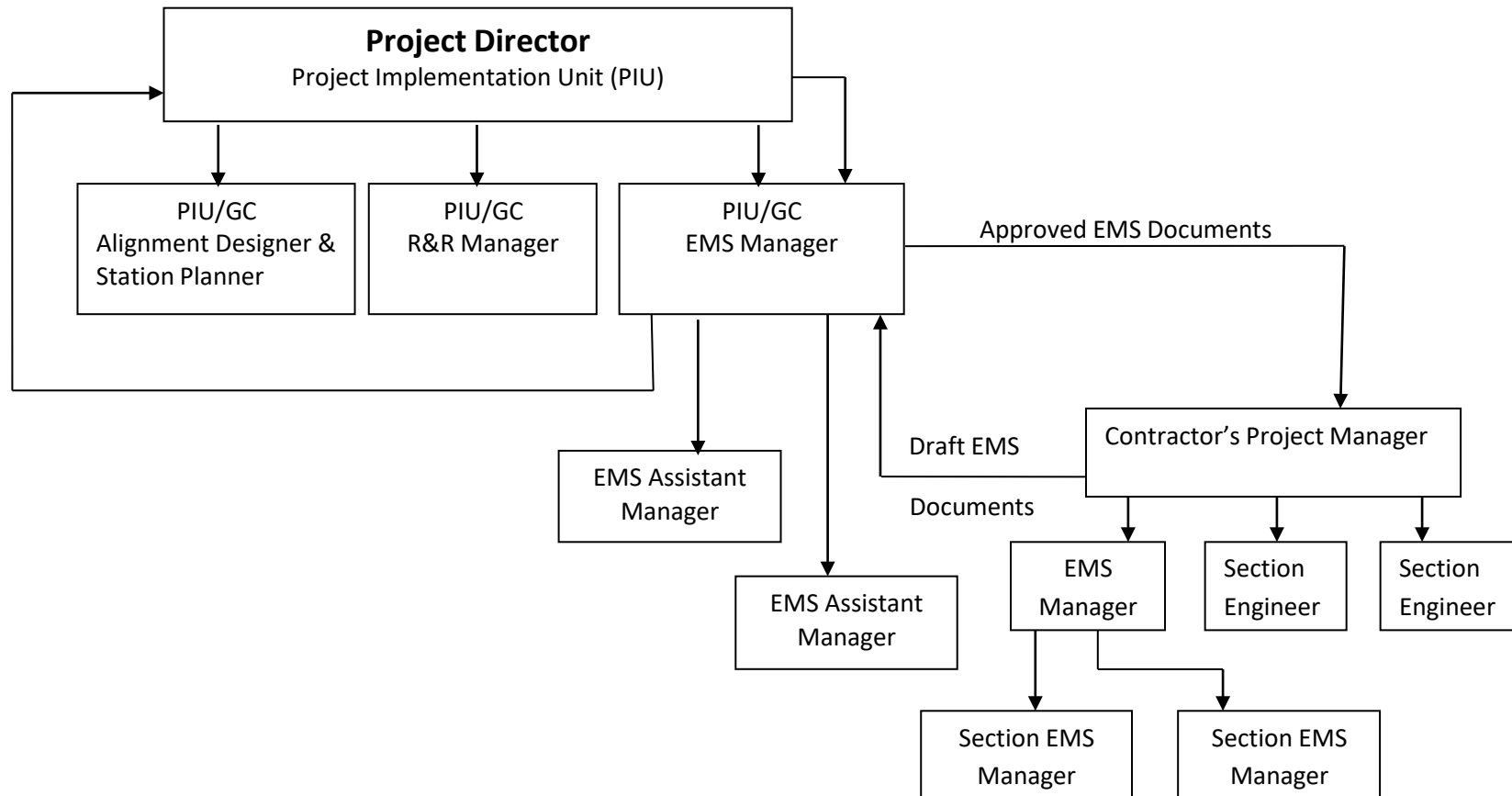
15.7 SUMMARY OF ENVIRONMENTAL COST ESTIMATE

Estimated environmental cost for the proposed metro corridors is about **Rs 13.09 crore**. Summary of cost estimate is given in the following **Table 15.37**.

TABLE 15.37: SUMMARY OF ENVIRONMENTAL COST ESTIMATE

S No	Item		Amount in (Rs) crore
1	Compensatory Afforestation		2.04
2	Mangrove management cost		0.40
3	Forest management cost		0.25
4	Environmental Monitoring	Construction	1.88
		Operation	0.26
5	Training and Extension		0.1
6	Noise Barrier		5.72
7	Environment Division		2.44
	Total		13.09

FIGURE 15.19: EMS ORGANIZATION



* GC: General Consultant as Project Management Consultant

15.8 SOCIAL IMPACT ASSESSMENT

Development of proposed metro rail corridor in Thane involves acquisition of land for stations, running sections, TSS, Depot and for other facilities. Acquisition of this private land may cause social disruption and economic loss for the families/people who are likely to be affected. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimize any negative impacts through SIA. The present preliminary SIA study is only for the requirement of Detailed Project Report (DPR). The objectives of this study are to (i) socio-economic profile of affected families/people in the project area, (ii) examine potential impacts of project on socio-economic condition of affected families/people, and (iii) develop socially, culturally and economically appropriate measures for mitigation of adverse effects of the project

15.8.1 Approach and Methodology

The SIA which includes RAP has been prepared in accordance with the State and national policy and guidelines. The input tasks are desk research, site visits and identification and enumeration of affected structures and families, sample socio-economic survey and local public consultation.

15.8.2 Land Requirement and Acquisition

The project shall require the acquisition/transfer of 28.6479 ha of land. Out of the total land, 21.8491 ha is private land and 6.7988 is government land.

15.8.3 Potential Social Impacts

Impact on Structures: The number of affected structures as identified on the basis of alignment drawings and site visit. There are 80 structures likely to be affected in proposed corridor. Majority of structures are affected in Dongripada, near Shivaji Chowk and Shivai Nagar. Out of the total structures, 40 are commercial and 36 are residential. About four are other structure includes bus stop, Govt. structures, community toilet and temple (**Table 15.38**).

TABLE 15.38: STATION/VIADUCT WISE AFFECTED STRUCTURE

STATION/AFFECTED AREA	Type of structures			
	Commercial	Residential	Other	Total
RAILA DEVI	0	19	0	19

STATION/AFFECTED AREA	Type of structures			
	Commercial	Residential	Other	Total
LOKMANYA NAGAR BUS DEPOT	10	0	1	11
SHIVAI NAGAR	12	2	0	14
NEELKANTH TERMINAL	3	0	0	3
DONGRIPADA	13	0	2	15
PATLIPADA	1	0	0	1
NEAR SHIVAJI CHOWK	0	15	0	15
NEW THANE	1	0	0	1
WAGLE ESTATE	0	0	1	1
TOTAL	40	36	4	80

Note: Other structures include bus stop, Govt. structures, community toilet and temple.

Table 15.39 depicts corridor wise fully affected structures. Out of the total structures about 68 structures are fully affected. Among the total fully affected structures, majority (36) is residential structures and 30 are commercial structures.

TABLE 15.39: STATION WISE FULLY AFFECTED STRUCTURES BY TYPE OF STRUCTURES

STATION/ AFFECTED AREA	Type of structures			
	Commercial	Residential	Other	Total
RAILA DEVI	0	19	0	19
LOKMANYA NAGAR BUS DEPOT	10	0	1	11
SHIVAI NAGAR	6	2	0	8
NEELKANTH TERMINAL	0	0	0	0
DONGRIPADA	14	0	0	14
PATLIPADA	0	0	0	0
NEAR SHIVAJI CHOWK	0	15	0	15
NEW THANE	0	0	0	0
WAGLE ESTATE	0	0	1	1
TOTAL	30	36	2	68

Out of the total partially affected structures four are residential, 11 are commercial and five are residential cum commercial structures. It is observed that majority of structures which are likely to be affected either partially or fully are commercial (**Table 15.40**).

TABLE 15.40: STATION WISE PARTIALLY AFFECTED STRUCTURES BY TYPE OF STRUCTURES

STATION/ AFFECTED AREA	Type of structures			
	Commercial	Residential	Other	Total
RAILA DEVI	0	0	0	0
LOKMANYA NAGAR BUS DEPOT	0	0	0	0
SHIVAI NAGAR	6	0	0	6

STATION/ AFFECTED AREA	Type of structures			
	Commercial	Residential	Other	Total
NEELKANTH TERMINAL	3	0	0	3
DONGRIPADA	1	0	0	1
PATLIPADA	1	0	0	1
NEAR SHIVAJI CHOWK	0	0	0	0
NEW THANE	1	0	0	1
TOTAL	12	0	0	12

Out of the total structures which are likely to be affected due to development of proposed metro rail project, 45 structures are *pucca*, 15 are *semi-pucca* and remaining 19 structures are *kutchha* (Table 15.41).

TABLE 15.41: STATION WISE CONSTRUCTION OF AFFECTED STRUCTURES BY TYPE OF STRUCTURES

STATION/ AFFECTED AREA	Type of structures			
	Pucca	Semi-Pucca	Kutchha	Total
RAILA DEVI	0	0	19	19
LOKMANYA NAGAR BUS DEPOT	11	0	0	11
SHIVAI NAGAR	14	0	0	14
NEELKANTH TERMINAL	3	0	0	3
DONGRIPADA	15	0	0	15
PATLIPADA	1	0	0	1
NEAR SHIVAJI CHOWK	0	15	0	15
NEW THANE	1	0	0	1
TOTAL	45	15	19	79

Impact on Families/Persons: About 132 families consisting 620 persons shall be affected due to the proposed metro project. Majority of families shall be affected in ShivaiNagar, LokmanyaNagar Bus Depot and Dongripada. Area/Station wise number of PAFs and PAPs are presented in **Table 15.42**. *Exact number of affected and displaced families/persons will be found out during detailed Census/Baseline Socio-Economic Survey (BSES) after peg marking of alignment on the ground.*

TABLE 15.42: IMPACT ON PAFs AND PAPs

STATION/AFFECTED AREA	Total affected structures	Total PAFs	Total PAPs
RAILA DEVI	19	19	89
LOKMANYA NAGAR BUS DEPOT	11	22	103
SHIVAI NAGAR	14	44	207
NEELKANTH TERMINAL	3	3	14

STATION/AFFECTED AREA	Total affected structures	Total PAFs	Total PAPs
DONGRIPADA	15	22	103
PATLIPADA	1	3	14
NEAR SHIVAJI CHOWK	15	15	71
NEW THANE	1	4	19
TOTAL	79	132	620

Note: PAF=Project Affected Families; PAP= Project Affected Persons

PAPs are estimated based on average family members per household calculated from sample socio-economic survey

Categories of affected families are given in **Table 15.43**. In total, there are 51 title holders and 81 non-title holders affected families. Out of the total titleholders, 48 PAFs are commercial and 3 PAFs are residential. Similarly, out of the total non-titleholders, 42 PAFs are commercial tenants and 39 PAFs are residential.

TABLE 15.43: TITLE HOLDERS AND NON-TITLE HOLDERS PAFs

STATION/VIADUCT	Type of PAFs		Total
	Titleholders	Non-titleholders	
RAILA DEVI	0	19	19
LOKMANYA NAGAR BUS DEPOT	9	13	22
SHIVAJI NAGAR	26	18	44
NEELKANTH TERMINAL	3	0	3
DONGRIPADA	11	11	22
PATLIPADA	1	2	3
NEAR SHIVAJI CHOWK	0	15	15
NEW THANE	1	3	4
TOTAL	51	81	132

Loss of Residence: Out of the total affected families 58 PAFs shall be displaced physically as their residential units are getting affected due to proposed project. Majority of residential PAFs will be displaced at Raila Devi and near ShivajiChowk.

Loss of Business: Out of the total affected families 69 PAFs shall be displaced physically as their commercial units are getting affected due to proposed project. Majority of residential PAFs will be displaced at Raila Devi and near ShivajiChowk.

Out of the total partially affected structures four are residential, 11 are commercial and five are residential cum commercial structures. It is observed that majority of structures which are likely to be affected either partially or fully are commercial (**Table 15.44**).

Impact on Community Structures: One religious structure at Wagle Estate and two community toilets at Dongripada are likely to be affected.

15.8.4 Socio-economic Profile of Project Affected Families

As the proposed alignment for Thane Metro Rail Project is part of proposed Development Plan Road (DP Road) in Thane City, the sample socio-economic survey has been conducted among the PAFs except those are affected due to DP Plan road.



Table 15.41 shows demographic characteristics (i.e. sex, age and marital status) of sample PAFs. Among the surveyed population it is observed that 57% are male and remaining 43% are female. The sex ratio is 753 per 1000 males. The persons of surveyed families have been categorized into four age groups. The distribution of person's age in various group shows that around 25% of the total persons belong to below 17 years; about 35% belong to the 18-34 years age group that is potentially productive group. A little more than one-third belongs to 35-39 years (34%). About 6% of total persons belong to above 60 years, who are dependent population. It is observed that majority of persons belong to 35 to 60 years age group and average age of surveyed population is 30 years. It is observed that out of total surveyed people, majority of them (65%) are married, and about 32% are unmarried.

TABLE 15.44: DEMOGRAPHIC CHARACTERISTICS OF SAMPLE PAFS

<i>Characteristics</i>	<i>Number</i>	<i>Percent</i>
Sex		
Male	182	57.05
Female	137	42.95

Sex ratio	753	
Age group		
0-17	78	24.45
18-34	112	35.11
35-59	109	34.17
60 & above	20	6.27
Mean $\pm$ SD	30.2	
Marital status		
Married	172	65.40
Unmarried	84	31.94
Widow/widower	7	2.66
n	263	
Total	319	100.0

Table 15.45 shows social characteristics like religious and social groups, family pattern and its size of PAFs and educational level of PAPs. The study result shows that about 87% of the surveyed families are Hindu followed by Muslim (12%) and others (1%) are Jains. About 50% belong to General Caste followed by OBCs (25%). About 16% are Scheduled Caste and 9% are Scheduled Tribe. Majority of surveyed families are nuclear (75%) followed by joint (17%). About 46% of families are medium and small in size each and remaining 8% families having more than seven members. The analysis indicates that out of the total surveyed people, about 9% are illiterate. So far as educational attainment is concerned 17% are educated up to primary class, 44% are educated up to upper primary, about one-third studied up to high school and 18% have studied up to higher secondary level. Other than this, about 11% of persons have attained college.

TABLE 15.45: SOCIAL CHARACTERISTICS OF SAMPLE PAFS

Characteristics	Number	Percent
Religious groups		
Hindu	66	86.8
Muslim	9	11.8
Jains	1	1.3
Caste groups		
SC	12	15.8
ST	7	9.2
OBC	19	25.0
General	38	50.0

Characteristics	Number	Percent
Family pattern		
Joint	13	17.1
Nuclear	57	75.0
Individual	6	7.9
Family size		
Small (2-4)	35	46.1
Medium (5-7)	35	46.1
Large (Above 7)	6	7.9
N		
Education (PAPs)		
Illiterate	26	8.8
Primary	51	17.3
Upper Primary	130	44.1
High School	53	18.0
Higher Secondary	31	10.5
College	4	1.4

Table 15.46 shows household main occupation, monthly income & expenditure, and earning and dependent members. The survey results in Table 15.39 shows that majority of head of the surveyed households are employed in some activities. Out of the total surveyed families, majority (52.63%) of them are involved in business, 28% are in other activities, 13.16% are in private job. The majority of families monthly income is between Rs. 12000 to Rs. 20000/-. The average income of a families is Rs.21184/- per month. Monthly per capita income is Rs.4859/-. Average family expenditure is Rs.17736/- per month. On an average earning member per family is one and dependent is two.

TABLE 15.46: ECONOMIC CHARACTERISTICS OF SAMPLE PAFS

Characteristics	Number	Percent
Household main occupation		
Business/Shop	40	52.63
Private Job	10	13.16
Govt. Job	5	6.58
Others	21	27.63
Household monthly income		
Rs. <12000	23	30.26
Rs. 12000 -20000	30	39.47
Rs. >20000	23	30.26
Average monthly income (Rs.)	21184	

Characteristics	Number	Percent
Average monthly per capita income	4859	
Monthly household expenditure		
Rs. <12000	32	42.11
Rs. 12000 -20000	30	39.47
Rs. >20000	14	18.42
Average monthly expenditure (Rs.)	17736	
Average monthly per capita expenditure	4068	
Earning members in family		
1 Member	58	76.32
2 Members	13	17.11
Above 2 Members	5	6.58
Dependent members in family		
< 2 members	12	15.79
2-3 Members	35	46.05
> 3 Members	29	38.16

Monthly per capita expenditure has been adopted from the report on household consumer expenditure based on 68th NSS round, 2011-12

15.8.5 Vulnerable Groups

Among 76 PAFs who were surveyed, 38 families (50%) belong to vulnerable category of whom 18 % would become BPL if they lose their livelihood due to the proposed project. About 4 % PAFs are in BPL category, 2% PAFs are female headed households, 15% are Scheduled Castes and 10% are Scheduled Tribes.

15.8.6 Awareness and Opinion about the Project

During socio-economic survey, questions were asked to the families regarding the awareness, source of information and opinion about the proposed metro rail project. The data suggest that considerable proportion of PAFs were aware of the metro rail project due to past survey work and from newspaper. While investigating the opinion of PAFs on proposed Thane Metro Rail Project, majority were found it good for the city overall development (49%), and one-third of PAFs reported that Metro Project will be helpful in order to increase job opportunities (34%) and improve city transportation system (12%). Further those highlighted the negative impact, out of them, 76% raise their grave concern that they may lose their house.

15.8.7 Preferred Location and R&R Options

Majority of surveyed families preferred to be located within the area if they are displaced due to the proposed metro rail project. 87% of families preferred

constructed houses and shops in resettlement site. 12% families preferred land for land and only 1% preferred cash assistance. Proximity to school, hospital and market followed by income from business activity, daily jobs are considered as main factors while providing alternate place to displaced families.

15.8.8 Key Findings of Public Consultation

During the period 18th to 25th June 2018, project level public consultations were conducted along the alignment; affected persons were invited to participate. The social experts briefed the participants about the objectives of the meeting regarding various social issues related to the project i.e., alignment plan, land acquisition, displacement, rehabilitation & resettlement and compensation etc.

Some of the views expressed, suggestion given or queries raised by the participants are as follows:

- Participants from proposed Dongripada station appreciated the need of the project. At the same time, they expressed their concern regarding displacement or demolition of their shops which is only source of livelihood for them. Further, respondent added that, shops can be resettled but what would be the intervention for their loss of livelihood. In this context they further added that previously at the time of construction of Shivai Nagar in 1998, they have lost their shops but did not get any type of compensation.

Respondents from Dongripada requested that the proposed Dongripada station can be shifted on Shivai Nagar main road on the service road as no one is using the road.

- Affected PAFs from Raila Devi (near Ramp) suggested that they are staying at the place from last 30-40 years and people are working in petty jobs or labourers and living with hand to mouth. Government should provide accommodation to project affected families.

Further they added that the resettlement area should be nearby only, as our livelihood, children education is nearby only. Participants from the BanjaraBasti (Raila Devi near ramp), strongly suggest that the affected families/people should get adequate compensation in order to re-instate the life of people.

Additionally, participants from Raila Devi (near ramp) suggested that behind the community, there is open place belong to mental hospital and alignment can be shifted so that many households need not to be shifted which may incur resettlement cost to local Govt.

- Participants from Kranti Nagar near ShivajiChowk reported that they are staying in this place from decades and this place is near to Thane Railway Station and

accessibility is higher. If Government want their land, they should need to resettle properly and house need to be provided.

It was observed during socio-economic survey as well as public consultations that people were curious and happy that metro will be reality but showed their grave concern regarding resettlement and rehabilitation of project affected families.



15.8.9 Applicable Laws, Guidelines for Land Acquisition, Rehabilitation and Resettlement

As per the observation received from Maha Metro, following guidelines and circulars of Government of Maharashtra are applicable for land acquisition, rehabilitation and resettlement compensation.

- Government Circular No. Misc.-03/2015/C.N34/A-2 dated 12th May 2015, 30th September, 2015 and LQN-01/2017/CN 12/A-2 dated 25th January, 2017, Revenue Forest Department, Government of Maharashtra, in the context of acquiring land of private sector by method of direct purchase through private negotiation for irrigation and other projects.
- Direct purchase method ensures that the property owners are negotiated directly for purchase of land by giving them an amount amicably accepted by the affected person which is 250% of the market value. In the process the concerned person is getting better price for the involved land and structure. This has been adopted for this DPR.

15.8.10 Institutional Arrangement

Executing Agency (EA): The Government of Maharashtra (GoM) and Government of India (GoI) will be the executing agency of the project. The GoM will be responsible for overall execution of the RAP. An independent Monitoring and Evaluation (M&E)

Agency/Specialist will be hired by GoM to monitor the implementation of the various provisions and activities planned in the RAP. The independent M&E Agency/Specialist will review the plan implementation in lights of targets, budget and duration that had laid down in the plan.

Implementing Agency (IA): MahaMetro will be responsible for implementation of the project. The Managing Director (MD) will be in charge of the overall project activities and will facilitate land acquisition, capacity building and implementation of RAP. MahaMetro will be responsible for coordinating with other concerned government departments, NGO, and R&R Supervision Consultant for land acquisition, planning and implementation of RAP which will include the disbursement of compensation, assistance, shifting and relocation of affected people. MahaMetro will be accountable to the GoM (i.e. the EA) for the implementation of the RAP.

Project Implementation Unit (PIU): The PIU headed by the Project Director (PD) is responsible for the overall execution of the project and planning and implementation of resettlement and rehabilitation component during preparation, implementation and post implementation phase of the project. The PIU will coordinate with all implementing agencies and monitoring the progress of the project.

Social Management Unit (SMU): MahaMetro shall set up a Social Management Unit (SMU) which shall look after land acquisition, resettlement and rehabilitation activities. A Sr.Social Development Officer (SSDO) will be appointed on full time by MahaMetro. The SMU shall ensure that all land acquisition issues are handled according to the approved Rehabilitation & Resettlement Plan. It will also monitor that all the procedural and legal issues involved in land acquisition are fulfilled. The SMU will assist for getting all the necessary clearances and implementation of the resettlement activities prior to start of any civil work.

A Resettlement and Rehabilitation Officer (RRO) may be appointed in this SMU to supervise and monitor overall activities of RAP and he/she will report day to day progress to SSDO. RRO will also work closely with the District Collector to expedite the payment of compensation for land acquisition and assistance to APs. The RRO will form Local Resettlement Committees (LRC) in each project affected areas consisting of local representatives and other stakeholders. Specific functions of the SMU in regards to resettlement management will include the following:

- Overall responsibility of planning, implementation and monitoring of land acquisition, resettlement and rehabilitation activities in the project;
- Ensure availability of budget for R&R activities;
- Liaison lined agencies support for land acquisition and implementation of land

acquisition and resettlement;

- Coordinating with line Departments.

SMU may also look after the Corporate Social Responsibility (CSR) activities of MahaMetro on long term basis for sustainable development of affected communities.

Non-Government Organization (NGO): An NGO will be appointed to extend implementation support to MahaMetro in the form of assisting affected families/persons during relocation and preparation of Income Restoration Plan (IRP). The NGO will help educating PAPs on proper utilization of compensation and rehabilitation grant and help them in getting financial assistance. The NGO will be supervised by SSDO, SMU.

Implementation Support Consultant(R&R): During implementation phase of RAP, MahaMetro will appoint a Implementation Support Consultant(R&R) through General Engineering Consultancy (GEC) to assist in implementation of resettlement plan. The consultant will carry out due diligence in the implementation of resettlement and rehabilitation programmes through periodic monitoring. The consultant will be responsible for (i) preparation of database of affected structures, families, persons, (ii) verification of database through field survey,(iii)improve monitoring system,(iv)capacity building of implementation staffs ,(v)regular follow up implementation activities and other relevant activities.

Grievance Redress Committee (GRC): Efficient grievance redressal mechanism will be developed to assist the PAPs resolve their queries and complaints. Grievances of PAPs will be first brought to the attention of field level staff of MahaMetro. Grievances not redressed by the staffs (field level) will be brought to the Grievance Redressal Committee (GRC). The proposed GRC will have representatives from PAPs, women, NGO and local body; Project Director (PIU), SSDO, SMU of MahaMetro and Land Acquisition Officer (LAO). The main responsibilities of the GRC are to: (i) provide support to PAPs on problems arising from land/property acquisition; (ii) record PAPs grievances, categorize, and prioritize grievances and resolve them; (iii) immediately inform the SMU of serious cases; and (iv)report to PAPs on developments regarding their grievances and decisions of the GRC.

Other than disputes relating to ownership rights under the court of law, GRC will review grievances involving all resettlement benefits, compensation, relocation, replacement cost and other assistance.

15.8.11 Training and Capacity Building

Establishing sufficient implementation capacity to launch and carry out those components of project resettlement that must be completed before civil works. Exposure visits and training through specialists in the field will be arranged for SMU staff.

15.8.12 Implementation Schedule of Resettlement Action Plan

The implementation of RAP will consist of four major stages:

- Identification of Cut-off Date (CoD) and notification for land acquisition. For non-titleholders the cut-off date shall be date of start of Census Survey.
- Verification of properties of PAFs/PAPs and estimation of their type and level of losses.
- Preparation of list of PAFs/PAPs for relocation/rehabilitation.
- Relocation and rehabilitation of the PAPs.

Timing of Resettlement

The resettlement process must be completed before the start of civil works on the particular corridor. Requisite procedure will be developed by the Maha Metro to carry out resettlement of PAPs located within Corridor of Impact (CoI), before the civil work starts on any section of the project. All activities related to the land acquisition and resettlement shall be planned to ensure that 100% compensation is paid prior to displacement and the affected people will be given at least four months of notice to vacate their property before civil work begins. Stretches which are free of encroachment and other encumbrances will be handed over first to the contractor.

Implementation Schedule

The period for implementation of RAP has been taken as two and half years. However, monitoring and evaluation will continue beyond the period of implementation. The R&R activities of proposed project are in three phases: project preparation, RAP implementation and Monitoring and Evaluation (M&E). RAP implementation schedule is given in **Figure 15.20**.

15.8.13 R&R Cost Estimate

In accordance with the observation received from Maha Metro, compensation cost for land shall be calculated @ 250% of the circle rate. This will include cost of land, value of assets attached to the land, solatium, one time resettlement and rehabilitation cost i.e transportation, compensation for livelihood, subsistence allowance etc. A tentative R&R cost has been calculated based on Schedule-II of Right to Fair Compensation and

Transparency in Land Acquisition, Rehabilitation and Resettlement Act,2013. The tentative R&R cost of proposed metro rail is **INR 50.44 million**.

FIGURE 15.20 RAP IMPLEMENTATION SCHEDULE

	Description	2018	2019	2020	2021	2022
A	Project Implementation					
1	Identification of required land for acquisition in DPR					
2	Preliminary Socio-economic survey for SIA in DPR					
3	Community /Public Consultation					
4	Preparation of Detailed SIA by Govt.after Notification					
6	Review/Approval of SIA					
7	Establishment of Grievance Redress Committee					
8	Census survey after peg marking on the ground					
9	Finalization of updated SIA and RAP					
10	Disclosure of SIA and RAP					
B	RAP Implementation					
11	Notification of Land Acquisition					
12	Joint Measurement Survey					
13	Suggestion & Objection of PAPs					
14	Hearing by Competent Authority					
15	Declaration of Award of Compensation as per RTFCTLARR,Act					
16	Resettlement and Rehabilitation provisions					
17	Shifting of PAPs					
18	Grievance Redress					
19	Schedule of Civil Work					
C	Monitoring and Evaluation					
20	Internal Monitoring					
21	External Monitoring					

Chapter – 16

DISASTER MANAGEMENT & SECURITY MEASURES

16. DISASTER MANAGEMENT & SECURITY MEASURES

16.1 DISASTER MANAGEMENT AND IMPERATIVES

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.

World Health Organization (WHO), defines disaster as "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."

16.2 NEED FOR DISASTER MANAGEMENT

Disaster brings about sudden and immense misery to humanity and disruptions to normal human life in established social and economic patterns. It has the potential to cause large scale human suffering.

Metro systems will carry thousands of passengers daily, therefore the effect of any disaster spread over in operational area (station, tunnels, viaducts etc.) is likely to be considerable. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro.

16.3 TYPE OF DISASTERS IN METRO SYSTEM

Metro specific disasters can be classified into two broad categories as Man-made and

Natural.

a. Man Made Disaster

- Terrorist attack
- Bomb threat/ Bomb blast
- Hostage Situations
- Release of Chemical or biological gas in trains, stations or tunnels
- Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
- Train accident and train collision/derailment of a passenger carrying train
- Sabotage
- Stampede

b. Natural Disaster

- Earthquakes
- Floods

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OBJECTIVES OF DISASTER MANAGEMENT PLAN

The main objectives of Disaster Management Measures are as follows:

- Save life and alleviate the sufferings.
- 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 as early as possible.
- Lay down the actions required to be taken by staff in the event of a disaster in Thane Metro Rail Corporation in order to ensure prompt handling of crisis situation in a 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.

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PREPAREDNESS OF STAFF FOR DISASTERS

Being a technologically complex system with a new set of staff, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the actions required to be taken up 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 are considered essential:

i. Fire Drill - This shall include

- Making announcements
- Protecting the area
- Summoning assistance
- Using firefighting equipment locally available
- Passenger evacuation in case of need

ii. Rescue of a disabled train

- Identifying causes, isolating fault.
- Announcement to passengers
- Passenger evacuation
- Coupling / Uncoupling of trains for clearing a failed train by an assisting train.
- Driving from an intermediate cab with Cab to Cab telephone communication from front cab.

iii. Detrainment of passenger between stations

- Blocking adjacent line
- Announcement to passengers.
- Use of emergency doors.
- Guiding passengers to next station.

iv. Passenger evacuation from station

- Announcement to passengers.
- Closing of booking offices.
- Opening of AFC gates/ Emergency exits
- Changing the direction of escalators.

- Crowd control with assistance of security staff and Police/Metro Police.
- Working of TVS system.
- Working of fire suppression and detection system

v. Drill for use of rescue & relief train

- The following items need to be noted
- Time taken by the staff to report for duty from the time of first information.
- Departure time of rescue and relief train.
- Testing of all vital systems like generators, control panel.etc.
- Demonstrating a few key functions

vi. Hot line telephone communication with state disaster management authority.

16.5.1 Authorities Coordination in Case of Disaster, Command & Control at the National, State & District Level

Authority coordination is essential for disasters of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. Following provisions have been considered for Thane Metro Rail:

i. National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:

- 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.
- 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:
 - The Prime Minister of India, who shall be the Chairperson of the National Authority, Ex officio;
 - Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.
- The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice-Chairperson of the

National Authority.

- iv. The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

ii. State Disaster Management Authority

Establishment of State Disaster Management Authority:-

- i. 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.
- ii. 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:
 - The Chief Minister of the State, who shall be Chairperson, ex officio;
 - Other members, not exceeding eight, to be nominated by Chairperson of State Authority;
 - The Chairperson of State Executive Committee, ex officio.
- iii. The Chairperson of State Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice- Chairperson of the State Authority.
- iv. The Chairperson of the State Executive Committee shall be Chief Executive Officer of the State Authority, the Chief Minister shall be the Chairperson of the Authority established under this section.
- v. The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

iii. 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:

- i. National Crisis Management Committee (NCMC) under chairmanship of

Cabinet Secretary

- ii. Crisis Management Group (CMG) under chairmanship of Union Home Secretary.
- iii. State Level Committee under the chairmanship of Chief Secretary.
- iv. District Level Committee under the Chairmanship of District Collector.

All agencies of Government at National, State and district levels will function in accordance with guidelines and directions given by these committees.

iv. 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:

- i. Prepare a disaster management plan setting out following, namely:-
 - Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
 - Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
 - The response plans and procedures, in the event of, any threatening disaster situation or disaster;
- ii. 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;
- iii. Regularly review and update the plan; and
- iv. Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

An effective system needs to be provided which includes Fire Detection and Suppression System, Smoke Management, Environmental Control System (ECS), Tunnel Ventilation System, Track-way Exhaust System (TES), Lighting System, Station Power Supply System, DG Sets & UPS, Seepage system, Water Supply and Drainage System, Sewage System, Station Area Lights and other facilities which may be deemed

necessary.

The above said provisions are suggestive and an exhaustive set of facilities have to be provided based on site conditions, location and other internal and external factors.

16.6.1 Measures in Case of Fire

Fire has been recognized as one of the most dreaded accidents on metros primarily because of large concentration of passengers at stations and in trains. Fire prevention and prompt response to any incident of fire or smoke emission is therefore the most important component of disaster management on Metros. For better management and safety from fire disaster on metro system, various signages like prohibition signs, warning signs, emergency escape signs etc. shall be installed as mentioned in NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems and National Building Code of India, 2016 part 4. Universally accepted measures for fire prevention include:

- Rigid observance of nonsmoking regulations
- Total ban on carriage of inflammable/ explosive substance within metro premises and in trains
- Non accumulation of garbage in the metro station premises and inside trains
- All staffs posted at stations must ensure instructions are rigidly enforced by regular checks.
- Installation of fire alarms and detection systems.

A. Fire and Smoke

In the event of fire and / or smoke either in train , station premises, right of way including the tunnel or other metro premises, every Metro Rail official whether on duty or not shall,

- Report the occurrence to the nearest Station Controller (SC) or Chief Controller (OCC). A reporting system shall be developed as per NFPA Guidelines and officials shall be trained accordingly.
- Take all possible steps to extinguish fire like using portable fire extinguishers, blankets, water, sand etc. that is available on site depending on the source of fire. Standards steps/measures to extinguish may be followed from NBC of India, 2016 and NFPA 130.
- Disconnect electric supply, if required

- Prevent the fire from spreading
- Seek assistance of Fire services.

B. Fire in a Train

The guidelines set out below are based on the content analysis of past accidents on other Metros and are in the nature of best practices. Since every fire incident is unique, the train operator is to exercise quick judgment based on:

- The nature of fire whether localized or widespread in passenger area.
- The extent of occupation of the train-number of passengers-if the number is manageable he will ask passengers of the affected coach to move away to other coaches.
- Proximity of the next station – passenger evacuation and handling of emergency is much easier at station than in between stations. Train Operator (TO) has to exercise his judgment about those extreme cases where the train has to be stopped forthwith to save life by prompt evacuation or taken to the next station expeditiously.

C. Fire in Train at the Station Platform

The Train Operator shall open all train doors on the platform side and ask passengers to vacate the train. He will inform OCC and Station Controller and take assistance from station staff as required.

D. Special Instructions for underground sections

Entire underground Metro network is equipped with Tunnel Ventilation system, capable of Centralized operation from OCC and also local operation from Station Control Rooms.

In the event of a 'fire incident' the system is designed to:

- Provide smoke free evacuation route
- Make available adequate fresh air
- Remove smoke and heat
- Cut off supply to the fire affected area during emergency.

A water pipeline should run along the entire underground Metro corridor. These pipelines have hydrants fixed every 15 m where hose pipes can be connected. The pipes are of great help to quickly extinguish any fire outbreak. Each underground section should equip with one to three cross passages between the up and down tunnels. These passages can be used for speedy evacuation of commuters in case of emergency. There is a Fire Detection and Suppression system equipped to automatically activate alarms for Vents, Fans and Dampers & Suppression equipment. The system is operated from a panel located in the Station Control Room.

E. Fire Suppression System

A wet Fire Main System covers the station area as well as the entire length of the tunnels. In addition there are automatic sprinklers, inert gas based suppression systems and portable fire extinguishers at various locations. Immediately on receipt of information about a train with fire incident held up between stations – Auxiliary System Controller (ASC) will

- Identify the location of fire (front/rear of the train)
- Identify affected ventilation zone/s
- Other trains held up needing increased ventilation
- Help OCC to decide the correct direction of passenger evacuation.
- Identify the appropriate TVS Master mode and operate TVS system.
- Inform TO through TC the direction of evacuation.

Before starting evacuation, ASC/ Traction Power Controller (TPC) shall check for the adequacy of Tunnel Lighting and correct Operation of TVS & ECS and Tunnel lights can be switched on from Station control room by BMS controller/ nominated E&M staff.

F. Fire at Metro Station Premises

The fire can be at the following locations:

- In areas, where the passengers enter for purchasing tickets or leave the station after performing their train journey including lifts, staircases and escalators.
- Concourse
- Auxiliary electrical substations.

In case of fire in areas where passengers enter/leave the station premises, the endeavor of station staff should be to cordon off the area so that it is not approachable for intending Metro users or by Metro passengers leaving the station

area.

16.6.2 Measures in Case of Collision of Trains

In the event of a train collision involving Metro trains, any employee witnessing, discovering or being involved in a train collision shall inform the Operations Control Center (OCC) and provide the following information-

- Callers name and identification,
- Reason for the call,
- Train identification,
- Location of the collision (Line identification , track (UP/DN), OHE mast no., nearest station if not at station),
- Need for medical assistance,
- Presence of smoke or fire

If the employee making the first report is a Train Operator (TO), Traffic Controller (TC) shall instruct the Train Operator to secure the train, inform the passengers about the incident, check if any passenger or employee needs medical attention. The TO will inform TC accordingly. If the other TO has not communicated with OCC, TC will ask TO to collect similar information about the second train and report.

A. Train Operator (TO) shall

- Look for presence of smoke or fire. Furnish details of visible damage, if any coaches are derailed or
- If the other track is obstructed.
- The OCC /TC shall instruct Train Operators of trains in approach of the collision site, in both directions, to stop their trains at stations and report their positions.

B. Duties of Train Operator:

- In the event of collision taking place involving his train, the train operator shall inform OCC by giving as many details as possible.
- In case of adjacent track is infringed, he will first protect the adjacent track to avoid multiple accidents as per prescribed procedure.
- He will inform passengers about the incident advising them about rescue and relief arrangements being made.
- He shall quickly assess the situation particularly in respect of passenger's injury and again inform OCC with as much details as available seeking medical and other

assistance as required.

- He will render first aid to passengers and check for injury and damage to the train (both his train and other train).
- Shall seek OCC's permission for passenger evacuation.
- Shall await further instructions from OCC.

C. Duties of Station Controller:

- The Station Controller on receipt of information about collision at his station shall inform OCC.
- Arrange for immediate medical assistance as required.
- Inform Metro rail police/Local police.
- Mobilize the staff for evacuation of passengers and rendering of first aid to the injured and their hospitalization as required.
- Inform passenger waiting at the station of the likely delays.
- Station controller will evacuate passengers as per instructions of OCC.

D. Duties of Traffic Controller:

- On receiving information about train collision the Traffic Controller shall block all movement on both the tracks to protect the site of accident.
- Inform Maha-Metro Disaster Management Team members.
- And other designated Maha-Metro departments and Personnel.
- Mobilize medical assistance as required.
- Inform the train depot to be in readiness to move rescue and relief train.
- Instruct Station Superintendent to depute staff for evacuation of passengers and providing medical aid to the injured.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Activate ventilation system based on condition of the scene (for tunnel section only).
- Arrange for Public Address announcements to be made to passengers in trains and at stations.
- Initiate operating procedure to relieve train congestion at collision site by: a) Single track operation (Single Line Working), b) Turning trains on both sides of collision site (Short Loop Operation) etc.
- The OCC Chief Controller shall inform the Disaster Management Team, ED/OP,

GM/OP and all controllers in OCC, the Police/Metro Police and Security Controller to secure the accident scene and Station Superintendent/Station Controllers on the affected line. Chief Controller shall also inform emergency services. All controllers in OCC shall inform their respective officers, maintenance/emergency team and others as applicable.

E. Medical Assistance

The TO/SC requesting medical assistance to OCC shall provide an estimate of the likely number of people requiring medical assistance and also indicate the most convenient access point for medical personnel to enter. (The names and addresses of person requiring/receiving medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/at OCC).

16.6.3 Measures in Case of Train Derailment

A. Duties of Train Operator:

- i. The TO becoming aware that his train has derailed shall stop the train immediately if not, already stopped and secure the train.
- ii. Inform passengers of the problem and action being taken.
- iii. Inform OCC providing following information:
 - Train Operator identification
 - Location (line identification, Track (UP/DN), & Mast No.)
 - Train description (Train no. & train set no.)
 - Adjacent track obstructed or clear.
 - Passenger injury or presence of smoke or fire.
 - Seek instruction for passenger evacuation.

B. Duties of Traffic Controller:

- TC shall instruct TOs of trains approaching the derailment site on both tracks to stop their trains and report their positions.
- TC shall immediately notify DMT and all concerned Metro departments, Police/Metro Police and Security Controller to secure the accident site and Station Superintendents on the affected line for informing waiting passengers at stations about the likely delay. OCC/TC will also arrange to inform passengers aboard trains held up.
- Mobilize medical assistance as required.

- Inform the depot to be in readiness to move the rescue and relief train.
- Instruct Station Managers to depute staff for evacuation of passengers and providing medical aid to the injured in case of derailment between stations.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Activate ventilation system based on condition of the scene (for tunnel section only).
- Arrange for Public Address announcements to be made to passengers in trains and on stations.
- Request assistance of Police / Metro Police / Security/ Watch & Ward for crowd control at critical stations.
- Initiate operating procedure to relieve train congestion at derailment site by:
 - Single track operation (Single Line Working),
 - Turning trains on both sides of derailment site (Short Loop Operation) etc.

C. Medical Assistance:

The employee requesting medical assistance to OCC shall provide an estimate of likely number of people requiring medical assistance and will also indicate the most convenient access point for medical personnel to enter. (The names and addresses of passengers requiring medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/in OCC).

16.6.4 Measures in Case of Terrorist Actions

Increase in terrorist actions against public transport worldwide, indicates that public transport systems are becoming more vulnerable and potential targets for terrorist. It is clear that preventing terrorist activities is the primary responsibility of security agencies and state police.

However, concern for passenger wellbeing and their security and adverse effects of such mishaps on the public image of transport systems itself, requires best possible level of preparedness for prevention of such threats within Metro premises. Key components of such preparatory and preventive action include:

- Encouraging and guiding passengers to be cautious themselves.

- An awareness program – appealing users to be on the alert and report any suspect package.
- Well thought out crisis communication to prevent misinformation, confusion, panic and shock.
- Clear procedures and systems of communications need to be established for emergencies and regularly tested, in order to ensure a working communication during crisis situation.
- Frequent mock drills to test effectiveness of passenger evacuation systems including the collaboration and response of passengers.
- Training all frontline staff to prevent dangerous situations and handle incidents.
- Once they have happened act with courage, promptitude and alertness, reassuring passengers and providing regular information for their guidance.
- Terrorist attack may take place anywhere in the metro rail's jurisdictions, however when it takes place, on the right of way particularly underground section, at metro station and in running trains it may have serious impact in terms of human distress and restoration of normal operation. On receipt of information of any terrorist act on Metro Trains, stations or on the Right of Way, OCC will take prompt action to get the entire metro network cleared of all passengers.

A. Terrorist attack at Station

Duties of Station Superintendent/Station Controller:

- Shall visit the affected spot, assess the extent of impact on human life and also how it may affect train services.
- Shall inform the OCC about details of incident.
- Sound the hooter and get the station premises vacated of all the passenger
- Depute staff to announce at 5 minute interval, through the station PA system what has happened and what the passengers are expected to do without getting panic.
- Mobilize resources to render first aid and evacuate the injured.
- In case any person is seen moving in a suspicious manner, he may be detained for interrogation with the help of security staff.
- Passengers found near the affected area may also be asked about their firsthand knowledge of the occurrence and their statement with name and addresses

recorded.

- Inform Police/Metro Police and depute station security staff to protect and cordon the site to preserve the clues and leave the site undisturbed for police investigation.

Duties of Traffic Controller/Chief Controller:

Immediately on receipt of the information about terrorist attack, Chief Controller shall:

- Inform Police/Metro Police and security personnel and ask them to rush to the spot of occurrence.
- Mobilize Medical Assistance and/ or Fire Services to reach the spot.
- Inform the DMT and other Maha-Metro departments and personnel.
- Hold trains at stations. Train movement shall only be resumed after confirming that the running of train through the affected station is safe, till the position becomes clear regular announcement to be made to passengers in train and at station of the likely delay and evacuation procedures started. The entire Metro network shall remain closed till rescue and search operations have been completed. Revenue operations shall only be started after ensuring that the system is fully safe and secure.

B. Terrorist Attack in Train:

Of all the cases of terrorist attack, those within a train will have most disastrous consequences and very prompt action will be necessary to restrict the damage to men and material. Such a situation may include:

- A Bomb on the track which detonates under a train.
- Detonation of Bomb / igniting of inflammable material inside a train.
- Release of chemical / biological gases in a train.
- Criminal interference with train running equipments which causes fire in the coaches while on run.
- Other terrorist activities incapacitating the train on run.

C. Bomb Blast on Track:

There may be derailment of the train with large scale damage to the train and fixed

structures as well as injury to the passengers in the train. In case of derailment, the train will immediately come to a stop. The Train Operator shall immediately inform Traffic Controller about the occurrence and ask for immediate assistance as required. TO shall seek permission for evacuation of passengers. In case the situation does not permit detrainment from one end, it may be arranged from both ends. The injured passengers should be evacuated as soon as the Medical Team arrives on the spot.

D. Bomb Blast inside the Train:

The Train operator shall:

- Inform Traffic Controller
- Inspect the impact of explosion and if the train is in a position to move, he will try to take the train to the next station at reduced speed.
- In case he is not able to take the train to the next station, Shall stop the train and inform the Traffic Controller about the incident.
- Shall seek assistance of fire services and medical services as required, take the permission of the TC to detrain the passengers.
- Shall make an on the spot assessment of the situation including the injury/death of passengers and inform the Traffic Controller for immediate appropriate action.
- The TO shall make announcement to the passengers through the train PA system about the situation and ask them to remain calm indicating that action has already been taken to arrange for detrainment of passengers.
- The TO will arrange evacuation of the passenger when authorized by OCC.
- This will help in reaching prompt assistance to the injured and disabled passengers on arrival of the Security and Medical Team.
- Train Operator will thereafter arrange to detrain the injured passengers with the help of security and medical staff.

E. Release of Chemical Poisonous or biological gases in tunnels, trains or at stations

Whenever other terrorist activities described above produce loud noise, explosion, fire and smoke, release of lethal or harmful gases works silently and can only be generally inferred from-

- Unusual smell
- Passengers or employees complaining of Breathing problems- including choking/fainting, Severe eye/Skin irritation and Vomiting etc.

Receiving any such complaint the Train Operator or Station Controller/ Station Manager will take serious note of it and immediately inform OCC to take prompt action to handle the emergency as case of suspected release of poisonous gases. If gas release is detected in a train, TO will inform OCC and expeditiously bring the train to the next station, open train doors and request all passengers to detrain. He will personally check with station staff, security and Police/Metro Police that the train has been completely vacated.

To prevent further spreading of gas in platform area and to help Police and Medical teams to investigate and identify the gas he will close the train doors. In the event of gas release in station premises, the station should be fully vacated and kept closed unless certified free of contamination by medical authorities.

Whereas, release of gases on the Right of Way in Rail corridors may not have serious impact, with gas spreading into atmosphere. In tunnel sections it will be necessary to

- Locate the presence of gas in specific ventilation zones.
- Activate appropriate TVS modes to dilute the gas.
- Degasify the tunnel portion or the entire tunnel, depending upon the severity of the case informing civil authorities of the likely discharge of gas in certain areas which may require to be protected.
- Pending this, the affected portion or the entire tunnel will have to be vacated of all passengers and staff.

Normal operation should only be resumed after running of a trial train with Police, Medical and metro authorities confirming that the section has been made free of contamination.

16.6.5 Measures in Case of Natural Calamities

On being informed about an earthquake in the city of Thane or experiencing the same, OCC Traction Power Controller (TPC) will switch off Traction power Supply in a manner which does not shut down station supplies informing the Traffic Controller who will instruct the TOs to stop their trains and report their position.

In the event of a significant earthquake, TO experiencing the impact or being informed by passengers or OCC will bring his train to a stop and inform OCC the location of the train.

- If at station, he will not move the train, inform OCC and advice passengers to remain inside the train.
- After receiving OCC instructions that the earthquake has subsided, the trains waiting at stations will detrain passengers.
- For the trains held up between stations, TOs to visually check the track. If the track is unaffected and there are no visible obstruction after informing OCC/TC, train can be moved at walking speed up to the next station where passengers shall be detrained.
- Train Operator (TO) will keep passengers informed of the problem and requests them to maintain calm.

In case of any doubt, OCC will arrange for passenger evacuation on the right of way as per procedure. Normal operation of revenue trains shall only be resumed after the track and structures department issuing of a certificate of fitness for normal operations which will be issued after detailed physical inspection. OCC and Station Superintendent/Station Controllers will continuously inform passengers of the situation and likely time for commencement of train services.

16.7 SECURITY MEASURES, ESSENTIALS OF SECURITY MANAGEMENT, SECURITY SYSTEM DESIGN PARAMETER

16.7.1 Security Measures & Essentials of Security Management

Metro Rail System has emerged as the most reliable mode of urban transportation system in India. The inherent characteristics of metro system make it an ideal target for terrorists and miscreants. Metro systems are typically open and dynamic systems which carry thousands of commuters. Moreover, high cost of infrastructure, its economic impacts to the society, being the life line of city with high news value pose greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally and 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 terror threat.

The public transportation system is increasingly becoming important for urban areas to prosper in the face of challenges such as reduction in congestion and pollution. Therefore, security system for public transportation like metro rail plays an important

role in helping the system to become the preferred mode choice for commuters. Therefore, provision of an excellent and reliable security system is a prerequisite for metro system for increasing its market share. Metro railway administration must ensure that security model keep pace with the rapid expansion of the metro and changing security scenario.

16.7.2 Security System Design Parameter

Security means protection of human, intellectual assets and infrastructure either from criminal interference, destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. Three important pillars of security are as follows:

- The Human factor;
- Procedures; and
- Technology

Staff interaction with passengers create 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. The staff members should be skillful, trained, drilled and experienced. 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 tested in advance. There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems differ i.e., detection of the plan before an attack, deny the access for carrying out an attack and mitigation measures after an attack.

16.7.3 Different Phases of Security

There are three different phases associated with the security system in metro. These phases are as under:

i. Prevention

These are the measures which can prevent a security breach from taking place. These can be identified by conducting risk assessment and gathering intelligence. Prevention begins with the daily operational security problems. Care has to be given in controlling unused, damaged properties which could otherwise prove to be a breeding ground for more serious crimes.

ii. Preparedness

Plans have to be prepared to respond to incidents and to mitigate the impacts. Staff have to be accordingly trained to carry out the exercises. The results of the risk assessment will give basis for such plans.

iii. Recovery

Urban transport system should have laid down procedures/instructions for quick recovery of normal service after an incident. Financial health is important for the recovery 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.

16.7.4 Responsibilities and Partnerships

The responsibility of the Security lies with the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the State Government to ensure secured travel in Thane Metro.

16.8 SECURITY SYSTEMS RECOMMENDED FOR THANE METRO

For providing an efficient security system in metro station areas the following provisions are suggested:

- i. CCTV coverage of all metro stations with 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.
- ii. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowded stations i.e at interchange may also be required.
- iii. 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 crowded stations.
- iv. 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.

- v. 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.
- vi. Bomb Blanket at least one per station and depot.
- vii. Wireless sets (Static and Handheld) as per requirement of security agency.
- viii. Dragon light at least one per metro station.
- ix. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
- x. Dog Squads (Sniffer Dog), at least one dog for 4 metro stations. Dog Kennels alongwith provision for dog handlers and MI room will also be provided by metro train depot administration including land at suitable places line wise.
- xi. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration.
- xii. Bullet proof jackets and helmets for Quick Response Team (QRTs) and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 metro stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.
- xiii. Furniture to security agency for security room and checking point at every entry point at stations. Scale is one office table with three chairs for security room & office and one steel top table with two chairs for checking point.
- xiv. Ladies frisking booth - 1 per security check point (AFC) Wooden Ramp - 1 per DFMD for security check points.
- xv. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.
- xvi. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.
- xvii. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.
- xviii. Iron grill at station entrance staircases, proper segregation of paid and unpaid areas by providing appropriate design grills etc.
- xix. Proper design of emergency staircase and fireman entry to prevent unauthorized entry.

CHAPTER - 17

DETAILED COST ESTIMATE

17. DETAILED PROJECT COST ESTIMATES

17.1. CAPITAL COST ESTIMATE

17.1.1. Coverage

Cost estimate for Thane Metro Ring corridor has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. at July 2023 price level.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) Route km length of alignment, (ii) Number of units of that item and (iii) Item being an independent entity. All items related with alignment, construction, permanent way, OHE, Signaling & Telecommunication, etc. have been estimated at rate per Route km/km basis.

Cost of station structures, other electrical services at these stations and Automatic Fare Collection (AFC) installations at all stations have been assessed in terms of each station as a unit. Similarly, for items like Rolling stock costs have been estimated in terms of number of units required for each item. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed based on each item, taken as an independent entity.

Cost Estimate has been updated based on the rates for individual components as per Benchmarking of Cost Estimates for Metro Rail Projects by MoHUA published in February' 2019, escalated @ 5% per annum.

Basic cost is exclusive of taxes and duties. i.e. GST and Custom duty. Taxes and duties mainly comprising of latest prevalent GST & Custom duty are worked out for each corridor. Public procurement order-2017, issued by Department of Industrial Policy on minimum Indian component in Procurement in Metro Rail systems have also been taken into consideration.

17.1.2. Land Requirement

- a. Finalization of alignment, location of stations, entry / exits etc. has been done with the objective of keeping land requirement to the bare minimum. For this purpose, alignment, stations, depots, parking and Property Development (PD) have been planned in the State Government land unless and until it becomes unavoidable to plan these facilities in Central Government land or private land. The summary of land requirement for the Corridor is as **Table 17.1**.

TABLE 17.1: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
Central Govt	Alignment / Stations, ancillary buildings & Misc.	0.4368	0	0.1115
	Parking cum PD	0	0	0
	Total	0.4368	0	0.1115
State Govt	Alignment / Stations, ancillary buildings & Misc. RSS, etc	5.6470	0	1.8363
	Depot	0	0	0
	Parking cum PD	0.7150	0	0
	Casting Yard	0	50	0
	Total	6.3620	50	1.8363
Private	Alignment / Stations, ancillary buildings & Misc., RSS, etc	2.5748	0	1.9355
	Depot& entry/exit	18.6343	0	0
	Parking cum PD	0.64	0	0
	Total	21.8491	0	1.9355
Grand Total		28.6479	50	3.8833

- b. The land area for piers of elevated alignment, elevated stations falling over the existing road and entry/exit falling on road / State Government land has not been accounted for in the land requirement and costing as present land use is not getting affected by these facilities. Land requirement for other metro utilities like ramp, off the road elevated stations, depot, RSS, ancillary buildings etc. have been accounted as far as per details in subsequent paras.
- c. Rate of Central Govt. land required on permanent basis has been taken from Circle rates. No solatium has been applied to the basic land cost.

- d. Rate of State Govt. Land required on permanent basis has been taken from Circle rates. No solatium has been applied to the basic land cost. In case, State Govt. is in a position to provide its land free of cost or at reduced rates, it will further improve the financial statistics of the project.
- e. Rate of Central Govt. land and State Govt. land required on temporary basis for 5 years construction period, has been taken @ 1% Per annum on Circle rates. No solatium has been applied to the basic land cost.
- f. Rate of Private land have been taken from Circle rates. As per Policy of Govt. of Maharashtra, compensation for land in Urban areas (Municipal corporation and Municipal Council areas) is computed as under:
 - Cost of land as per Ready Reckoner rates.
 - Solatium = 150% of cost of Land which includes R&R cost and other administrative charges
- g. Efforts have been made to provide parking for maximum possible stations. Details of land required for parking is mentioned separately in relevant chapter.
- h. Rates of Structures have been taken from Circle rates after applying depreciation (depending on age of structures). Additional 4% water charges, 4% sanitary charges & 4% Electrical charges has been taken into account for calculation of structures rates.
- i. The total cost of Land including escalation for first three years works out to be **Rs. 3,414.20 Crore** for Thane Metro based on Ready Reckoner. However, latest RR rates shall be applicable during the time of acquisition.

17.1.3. Items other than Land

As explained above, the rates of items other than land are based on Benchmarking of Cost Estimates for Metro Rail Projects by MoHUA published in February 2019. The rates of cost components at July 2023 price level are given in **Table 17.2**. As per soil conditions mentioned in Chapter 5, TBM will be working in mixed soil conditions. The TBM should be capable of excavating soils and rocks both, hence combination of scrappers and disc cutters will be used under such situations. Secondly, Thane is situated in seismic zone III of the seismic zonation map of India. Therefore, suitable seismic coefficient commensurate to seismic Zone III have to be adopted in the design of the structures. Considering the topography of Thane for the UG section by T.B.M in alignment & formation and

UG section civil works, the per km cost for alignment & Formation has been estimated to Rs. 165 Crore.

Similar Geotechnical conditions and seismic zonation have been observed in Pune. Serial number of items in the table denotes the serial number of item in detailed cost estimate. On other items, Escalation of 5% per annum is applied to bring the rates at current price level of July'2023.

TABLE 17.2: BASIS OF RATES OTHER THAN LAND

S. No.	Item	Unit	Rate (Rs. In Crores)
2.0	Alignment and Formation		
2.1	Elevated section including viaduct length in station	R. Km.	46.10
2.2	Underground section by T.B.M and cut & cover section excluding station length	R. Km.	165.00
2.3	Elevated to at-grade depot entry	R. Km.	11.62
3.0	Station Buildings		
3.1	Elevated Station Buildings (140mx21.95m)		
a	Elevated station - Civil Works	Each	32.39
b	Elevated station - EM Works excluding lifts & escalators etc.	Each	4.98
c	Automatic Fare Collection System	Each	4.36
3.2	Underground Station (190m length) incl. EM works, lifts, escalators, VAC etc. by Cut & Cover		
a	Underground Station - Civil works (LAR of Pune Metro)	Each	165.00
b	Underground Station - EM works and Lifts & escalators etc.	Each	52.33
c	Automatic Fare Collection System	Each	4.36
4.0	Maintenance Depot including OCC Building		
a	Civil works	Each	130.82
b	EM works + Machinery & Plant + General Works	Each	80.98
5.0	P-Way		
5.1	Ballastless track for elevated & underground Section	Route Km.	8.22
5.2	Ballasted track for Depot	Track Km.	4.86
5.3	Ballasted track for Depot entry/exit	Route Km.	8.22
6.0	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators		
6.1	Elevated section including SCADA	R. Km.	9.34
6.2	UG Section	R. Km.	14.33
6.3	For Depot	Track Km.	2.49
6.4	RSS cum TSS	Each	56.07
7.0	Signalling and Telecom.		
7.1	Signalling for Main line	R. Km.	5.48

S. No.	Item	Unit	Rate (Rs. In Crores)
7.2	Signalling for depot	Track Km.	3.99
7.3	Telecommunication at Stations	Per Station	5.61
7.4	Telecommunication for Depot	Each	4.36
7.5	Platform Screen Doors (UG stations)	Per Station	3.74
8.0	Environment and R & R incl. Hutments etc.		
a	Environmental Cost	As per details given in respective chapter 15 of DPR	
b	R & R		
9.0	Misc. Utilities works		
a	Civil works	R. Km.	3.74
b	Electrical Works	R. Km.	3.74
10.0	Capital Expenditure on Security		
a	Civil works + EM works	Per Station	0.46
11.0	Staff Quarters		
a	Civil works	R. Km.	1.46
b	EM works	R. Km.	0.36
12.0	Multimodal Integration and Last mile connectivity	Per Station	3.74
13.0	Rolling Stock	Each	8.00

17.2. INNOVATIONS PROPOSE TO REDUCE THE COST

The type of viaduct, tunnel and other structural, track parameters are adopted similar to that adopted in other metro projects being executed nationwide. This shall encourage indigenous development and manufacturing of components that are being presently imported. Such steps shall induce progressive increase in local content in procurement, construction etc.

17.3. COSTING OF ENTIRE PROJECT

17.3.1. Corridor-Wise Capital Cost Estimate

Detailed capital cost estimate for Thane Metro ring corridor is given in **Table17.3.**

TABLE 17.3: CAPITAL COST ESTIMATE

July 2023, Price Level					
Total Length = 28.50 Km, From = 0m to 27400.2m, UG = 3.01 Km, Elevated = 24.390 Km & Depot Entry = 1.10 Km					
Stations = 22, Elevated = 20 No's & U/G by Cut & cover = 2 No's.					

Sr.No	Item	Unit	Rate (in INR Cr)	Quantity	Amount (in INR Cr)
1	Alignment & Formation				
1.1	Elevated section including viaduct length in station & entry to Depot	R. Km.	46.10	24.39	1124.33
1.2	Underground section by tunnel boring machine (TBM) and cut & cover	R. Km.	165.00	3.01	496.65
1.3	Elevated to at-grade depot entry	Each	11.62	1.10	12.78
	Sub Total - alignment & formation				1633.76
2	Station Buildings - Elevated Station Buildings including Architectural Finishes, Lifts & Escalators				
2.1	Elevated station - Civil Works excluding Viaduct	Each	32.39	20.00	647.86
2.2	Elevated station - EM Works, Lifts & escalators etc.	Each	4.98	20.00	99.67
2.3	Elevated station – AFC	Each	4.36	20.00	87.21
3.2	Underground Station (190m length) incl. EM works, lifts & Escalators				
a	Civil Works excluding Viaduct	Each	165.00	2.00	330.00
b	UG station - EM Works, Lifts & escalators etc.	Each	52.33	2.00	104.66
c	UG Station - AFC	Each	4.36	2.00	8.72
	Sub- total Station Building				1278.13
3	Depot Augmentation for additional Rolling stock for Phase II				
3.1	Civil works	LS			130.82
3.2A	EM works + Machinery & Plant + General Works	LS			80.98
	Sub-total Depot				211.80
4	Permanent Way				
4.1	Ballastless track for elevated & UG	R.Km	8.22	27.40	225.31
4.2	Ballasted track for depot	T.Km	4.86	11.80	57.34
4.3	Ballastless track for Depot Entry/Exit	R.Km	8.22	1.18	9.05
	Sub-total Permanent Way				291.69
5	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators				
5.1	Elevated section including SCADA	R. Km.	9.34	25.49	238.18
5.2	For Depot	Track Km.	2.49	11.80	29.40
5.3	RSS cum TSS	Each	56.07	2.00	112.13
5.4	UG Section	R. Km.	14.33	3.01	43.13
	Sub-total Traction and Power Supply				422.84
6	Signalling and Telecom				

6.1	Signalling				
a	Signalling for Main Line	R.Km	5.48	28.50	156.24
b	Signalling for Depot	R.Km	3.99	11.80	47.40
	Sub-total Signalling				203.28
6.2	Telecommunication				
a	Telecommunication at Stations	Per station	5.61	22.00	123.34
b	Telecommunication at Depot	per depot	4.36	1.00	4.36
c	PSD at UG Stations	per station	3.74	2.00	7.48
	Sub-total Telecom				135.18
7	Enviornment & R & R incl. Hutments etc.				
7.1	Environmental Cost				11.56
7.2	R & R	incl. in land cost			0.00
	Sub-total Enviornment & R&R				11.56
8	Misc. utilities etc				
8.1	Civil works	R. Km.	3.74	28.50	106.52
8.2	Electrical Works	R. Km.	3.74	28.50	106.52
	Sub-total Misc				213.05
9	Security				
9.1	Civil works + EM works	Per Station	0.46	22.00	10.14
	Sub-total Security				10.14
10	Staff Quarters				
10.1	Civil works	R. Km.	1.46	28.50	41.50
10.2	EM works	R. Km.	0.36	28.50	10.14
	Sub-total Staff quarters				51.64
12	Multimodal Integration and Last mile connectivity	Per station	3.74	22.00	82.23
13	Rolling Stock	Per coach	8.00	150.00	1200.00
	Total Base Cost Excluding Land cost				5,745.30
14	General Charges				287.27
	Total Taxes (GST & Custom Duty)				1,166.62
	Contingency @ 3%				172.36
	Total cost incl GC and excl. Contingency at current price level (Excl. Land & Taxes)				6,204.93
	Total cost incl GC, Contingency and Taxes at current price level (Excl. Land)				7,371.55
	Total Escalation				1,214.45
	Total cost including escalation				8,586.00
	Interest During Construction (IDC)				312.71
	Land cost				3,170.05
	PPP for AFC (incl. GC, contingency, tax & escl etc.)				131.34
	Total Completion Cost including Land				12,200.10

17.3.2. Taxes and Duties

Taxes and duties are worked out for Thane corridor. The components is presented in **Table 17.4**. Current rates of GST (i.e. 18% on Metro projects) have been taken into consideration and have been applied as per prevalent practice. Taxes & duties have been worked out in **Table 17.5**.

TABLE 17.4: TAXES AND DUTIES COMPONENTS

S.No.	Tax Component		%
1	Basic Customs duty	=	8.2500%
2	IGST (CGSTportion)	=	9.7425%
3	IGST (SGSTportion)	=	9.7425%
4	Total Customs Duty	=	27.735%
5	General GST	=	18.0000%
6	General CGST	=	9.0000%
7	General SGST	=	9.0000%

TABLE 17.5: TAXES & DUTIES (RS. IN CRORES)

S. No.	Description	Total cost without Taxes & duties	Imported Materials (%)	Indegenious Materials (%)	Taxes and duties								
					Basic Customs Duty	IGST (CGST portion)	IGST (SGST portion)	Total Customs Duty	GST RATE	CGST	SGST	Total (CGST SGST)	GST & Total Taxes & Duties
1	Alignment & Formation												
	Elevated	1124.33	0%	100%	0.00	0.00	0.00	0.00	18%	101.19	101.19	202.38	202.38
	Underground	496.65	0%	100%	0.00	0.00	0.00	0.00	18%	44.69	44.69	89.39	89.39
	Depot Entry	12.78	0%	100%	0.00	0.00	0.00	0.00	18%	1.150	1.150	2.30	2.30
2	Station Buildings												
	Elevated station - civil works	647.86	0%	100%	0.00	0.00	0.00	0.00	18%	58.308	58.308	116.62	116.62
	Elevated station-EM works	99.67	20%	80%	1.64	1.942	1.942	5.53	18%	7.716	7.716	15.43	19.88
	AFC – Elevated	87.21	20%	80%	1.44	1.699	1.699	4.838	18%	6.28	6.28	12.56	17.40
	Underground station-civil works	330.00	0%	100%	0.00	0.00	0.00	0.00	18%	29.70	29.70	59.40	59.40
	Underground station-EM works	104.66	20%	80%	1.73	2.039	2.039	5.81	18%	7.35	7.35	15.07	20.88
	AFC - UG	8.72	40%	60%	0.29	0.34	0.34	0.97	18%	0.471	0.471	0.942	1.912
3	Depot												
	Civil works	130.82	0%	100%	0.00	0.00	0.00	0.00	18%	11.774	11.774	23.55	23.55
	EM and M&P works	80.98	10%	90%	0.67	0.789	0.789	2.25	18%	6.56	6.56	13.12	15.37
4	P-Way	291.69	20%	80%	4.81	5.68	5.68	16.18	18%	21.00	21.00	42.00	58.18
5	Traction & power supply												
	Traction and power supply	422.84	50%	50%	17.44	20.598	20.598	58.64	18%	19.028	19.028	38.056	96.69
6	S and T Works												
	Signalling	203.28	50%	50%	8.39	9.90	9.90	28.19	18%	9.15	9.15	18.30	46.49
	Telecommunications	135.18	50%	50%	5.58	6.58	6.58	18.75	18%	6.08	6.08	12.16	30.91

7	Environmental works	11.56	0%	100%	0.00	0.00	0.00	0.00	18%	1.041	1.041	2.08	2.08
8	Misc.												
	Civil works	106.52	0%	100%	0.00	0.00	0.00	0.00	18%	9.587	9.587	19.17	19.17
	EM works	106.52	0%	100%	0.00	0.00	0.00	0.00	18%	9.587	9.587	19.17	19.17
9	Security												
	Civil works & EM works	10.14	0%	100%	0.00	0.00	0.00	0.00	18%	0.913	0.913	1.83	1.83
10	Staff quarters												
	Civil works	41.50	0%	100%	0.00	0.00	0.00	0.00	18%	3.735	3.735	7.47	7.47
	EM works	10.14	0%	100%	0.00	0.00	0.00	0.00	18%	0.913	0.913	1.83	1.83
11	Multimodal Integration	82.23	0%	100%	0.00	0.00	0.00	0.00	18%	7.401	7.401	14.80	14.80
12	Rolling stock	1200.00	40%	60%	39.20	46.764	46.764	132.728	18%	64.80	64.80	129.60	262.73
13	General Charges	287.27	0%	70%	0.00	0.00	0.00	0.00	18%	18.098	18.098	36.196	36.196
14	Total	5745.30			81.58	96.342	96.342	274.264		446.17	446.17	892.352	1166.618
	Total taxes & Duties										SAY		1166.62
Total Central GST & Basic Customs duty													624.10
Total State GST													542.52
15	Lifts & Escalators	94.95	60%	40%	3.13	3.70	3.70	10.53	18%	5.127	5.127	10.254	20.784

17.4. SUMMARY OF CAPITAL COST

The abstract of capital cost estimate of Thane Metro is given in **Table 17.6**.

TABLE 17.6: ABSTRACT OF COST ESTIMATE

(Rs. In Crore)

S.No	ITEM	TOTAL AMOUNT
1	Alignment and Formation	1,633.76
2	Station Buildings incl. Civil works, EM works, ECS, TVS, Lift, escalators & Architectural Finishes etc	1,278.13
3	Depot including civil, EM, Machinery & plants, general works & OCC building	211.80
4	P-Way for main line, depot and depot connectivity	291.69
5	Traction & power supply for main line and depot incl. OHE, ASS, GIS etc.	422.84
6	Signalling and Telecom. etc.	338.46
7	Environment	11.56
8	Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management	213.05
9	Capital Expenditure on Security including civil and EM works	10.14
10	Staff Quarters including civil, electrical works	51.64
11	Capital Expenditure on Inter modal integration including Footpath for pedestrians	82.23
12	Rolling Stock	1,200.00
13	Total Cost at July, 2023 price levels (Excluding Land, R&R, PPP, IDC, General Charges, Contingencies, Central & State Taxes)	5,745.30
14	General Charges @ 5% on all items except land	287.27
15	Contingencies @ 3 % on all items except land	172.36
16	Total Cost at July, 2023 price levels incl. General Charges and Contingencies (Excluding Land, R&R, PPP, IDC, Central & State Taxes)	6,204.93
17	Escalation at 5 % pa on all items except contingencies	813.06
18	Total Cost incl. General Charges, Contingencies, Escalation, (excluding Land, R&R, PPP, IDC, Central & State Taxes)	7,017.99
19	Central GST & Basic Customs duty	624.10
20	Escalation at 5% pa on Central Taxes including Basic Customs Duty	84.12
21	Total Cost incl. General Charges, Contingencies, escalation, Central Taxes (excluding Land, R&R, PPP, IDC, State Taxes)	7,726.20
22	State GST including escalation @ 5% pa	615.64
23	Interest during Construction (IDC) including Front End Fee	312.71
25	Land including escalation @ 5% pa	3,414.20
26	PPP component (Lifts and Escalators installations) incl. Central and State Taxes, escalation etc	131.34
27	Total Completion Cost	12,200.10

17.5. OPERATION AND MAINTENANCE COST

The Operation and Maintenance cost for Thane Metro Ring Corridor is worked under three major heads:

- Staff cost
- Maintenance cost which includes expenditure towards upkeep and maintenance of the system and consumables and
- Energy cost

17.5.1. Staff Cost

The O&M staff is assumed to be provided @ 35 persons per kilometre and the annual cost this account is estimated considering average staff salary of Rs. 14.6 Lakhs per annum in the year 2029 considering pay-revision. The escalation factor used for staff costs is 9% per annum to provide for growth in salaries. The estimated staff cost is **Rs.143.84 Cr.** for Thane Metro for the inception year i.e. 2029

17.5.2. Maintenance Expenses

Maintenance expenses are taken @ Rs. 1.68 Crores/km in the year 2023. Maintenance cost for Thane Metro would be **Rs. 72.15 Crore** in the inception year i.e. 2029 considering escalation @ 5% p.a. for every year of operation.

17.5.3. Energy Charges

The energy consumption to meet the traction and non-traction power requirement is based on traffic demand for different horizon years. The cost of electricity is a significant part of O&M charges, constituting about 30% of total annual working cost. The traction power tariff is taken @ Rs. 5.8 per kWh & Rs. 270 per kVA per month in the year 2018, which is escalated @ 5% every year of operation. Annual energy consumption charges have been estimated as **Rs. 121.67 crore** in year 2029, **Rs. 184.77 crore** in 2035, **Rs. 352.99 crore** in 2045 and **Rs. 481.58 crore** in 2050 for Thane Metro

17.5.4. Additional Investment

To cater to increased traffic demand, additional investment will have to be made for purchase of additional coaches. The additional investment in the year 2035 works out to **Rs. 368.61 Crores** for purchase of 30 additional coaches.

An investment of **Rs. 525.67 Crores** would be required for purchase of 39 additional coaches in the year 2045 and **Rs 401.80 crores** for 27 additional coaches in the year 2050 for Thane Metro. These additional investments have been worked out considering an escalation factor of 2% per annum.

17.5.5. Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipments due to wear and tear. With the nature of equipment proposed to be provided for the corridor, it is expected that about 25% of the equipment comprising Electrical, Rolling stock and 50% of Signalling & Telecom would require replacement/ rehabilitation after 20 years.

The replacement cost for Thane Metro works out to be **Rs. 1945.99 Crore** in the year 2045. The replacement cost has been worked out considering an escalation factor of 5% per annum.

The year wise total Operation and Maintenance cost for the corridor of Thane Metro is indicated in **Table 17.7**

TABLE 17.7: O&M COST WITH ESCALATION

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M cost	Addition/ Replace - ment Cost (Cr.)	Remarks
	Esc @9%	Esc @5%	Esc @5%			
2029	143.84	72.15	121.67	337.66		
2030	156.79	75.76	130.31	362.86		
2031	170.90	79.55	139.45	389.90		
2032	186.28	83.53	149.23	419.04		
2033	203.05	87.71	159.54	450.30		
2034	221.32	92.10	170.54	483.96		
2035	241.24	96.71	184.77	522.72	368.61	Addition of 30 coaches

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M cost	Addition/ Replacement Cost (Cr.)	Remarks
	Esc @9%	Esc @5%	Esc @5%			
2036	262.95	101.55	196.47	560.97		
2037	286.62	106.63	208.96	602.21		
2038	312.42	111.96	222.14	646.52		
2039	340.54	117.56	236.17	694.27		
2040	371.19	123.44	251.06	745.69		
2041	404.60	129.61	266.85	801.06		
2042	441.01	136.09	283.55	860.65		
2043	480.70	142.89	301.33	924.92		
2044	523.96	150.03	320.08	994.07		Addition 39 coaches=525.67 Cr. Replacement of 25% of Elec. & 50% S&T assets = Rs. 1945.99 Cr Total= Rs. 2471.66 Cr.
2045	571.12	157.53	352.99	1,081.64	2471.66	
2046	622.52	165.41	379.13	1167.06		
2047	678.55	173.68	407.10	1259.33		
2048	739.62	182.36	436.81	1358.79		
2049	806.19	191.48	468.48	1466.15		
2050	878.75	201.05	504.28	1584.08	401.80	Addition of 27 coaches
2051	957.83	211.10	505.66	1674.60		
2052	1044.03	221.66	530.95	1796.64		
2053	1138.00	232.74	557.49	1928.23		
2054	1240.42	244.38	585.37	2070.16		

Chapter – 18

TRANSIT ORIENTED DEVELOPMENT

18. TRANSIT ORIENTED DEVELOPMENT

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1

NATIONAL TRANSIT ORIENTED DEVELOPMENT POLICY

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. TOD integrates land use and transport planning and aims to develop planned sustainable urban growth centres, having walkable and liveable communes with high density mixed land-use. Citizens have access to open green and public spaces and at the same time transit facilities are efficiently utilized.

TOD focuses on creation of high density mixed land use development in the influence zone of transit stations, i.e. within the walking distance of (500-800 m) of transit station or along the corridor in case the station spacing is about 1 km. TOD advocates pedestrian trips to access various facilities such as shopping, entertainment and work.

TOD increases the accessibility of the transit stations by creating pedestrian and Non-Motorised Transport (NMT) friendly infrastructure that benefits large number of people, thereby increasing the ridership of the transit facility and improving the economic and financial viability of the system. Since the transit corridor has mixed land-use, where the transit stations are either origin (housing) or destination (work), the corridor experiencing peak hour traffic in both directions would optimize the use of the transit system.

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OBJECTIVES OF TOD

The objectives of TOD include:

- To promote the use of public transport by developing high density zones in the influence area, which would increase the share of transit and walk trips.
- To provide all the basic needs of work/ job, shopping, public amenities, entertainment in the influence zone with mixed land-use development
- To establish a dense road network within the development area for safe

and easy movement and connectivity of NMT and pedestrians between various uses as well as to transit stations.

- To achieve reduction in the private vehicle ownership, traffic and associated parking demand.
- To provide all kinds of recreational/entertainment/ open spaces, required for a good quality of life in the influence area.
- To prevent urban sprawl by accommodating the growing population in a compact area with access to the transit corridor, this would also consolidate investments and bring down the infrastructure cost for development.
- To reduce carbon footprints by shifting towards environmentally friendly travel options for the line haul as well as for access and egress trips.

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3

TOD

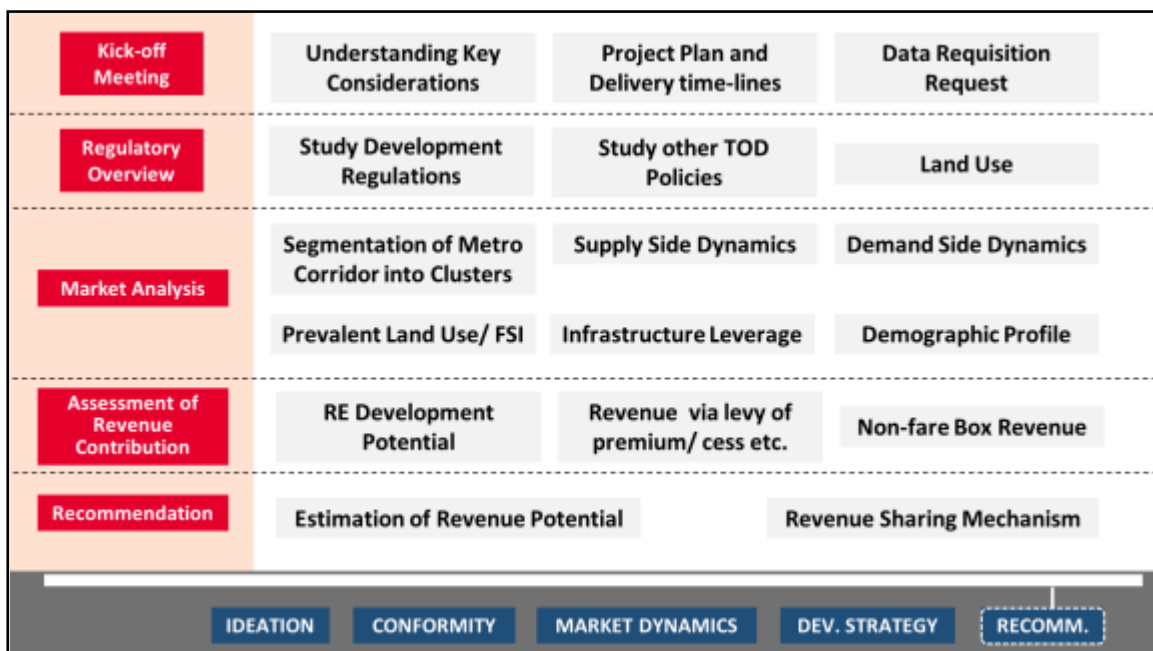
STUDY METHODOLOGY

- The study begins by discussions with the client to understand the key considerations such as metro line alignment, land use in the corridor alignment. This include details on existing and proposed land-use, planned and under construction infrastructure projects, development control regulations etc.
- This is followed by site reconnaissance to understand the corridor alignment, activities and exiting land use in the catchment of the corridor, major transport intersections, real estate micro market prevalence etc.
- The study has been supported by segmentation of metro corridors into clusters, real estate market research in each cluster, study of TOD policies in other cities etc.
- The study includes on-ground research, interactions with local body to understand regulatory aspect and review of development control regulations (DCR). The study has been further strengthened by secondary research that include review of available literature and database.
- Recommendations include revenue estimates to SPV from Thane Metro TOD development and other non-fare box revenue streams.

- Demand assessment along the TOD corridor for potential asset classes has been carried out to identify the potential along the corridor and determine the revenue estimation through sale of premium FSI (basis the supply demand dynamics).
- Revenues from other sources of non-fare box revenue streams have been estimated on the basis of case studies, benchmarks and primary data collection. The other sources of non-fare box revenue taken in the study are as under:
 - Advertisement in stations and trains
 - Leasing of retail space inside stations
 - Semi-naming rights of stations

The TOD study methodology flowchart is shown in **Figure 18.1**.

FIGURE 18.1: TOD STUDY METHODOLOGY



The land management and urban development initiatives within municipal jurisdiction are handled by Thane Municipal Corporation (TMC). As per Maharashtra Regional and Town Planning Act, 1966, TMC has formulated Development Control.

18.4.1. Land Use Classification

The city of Thane has been divided into five (5) land-use zones such as Residential, Commercial, Industrial, Green and Special Reservations (**TABLE 18.1**).

TABLE 18.1: LAND USE CLASSIFICATION

Land Use	Sub Zone	Permissible Usages
Residential	(R1) Purely Residential	• Residential Building • Customary Home Occupation • Medical and Dental Practitioners dispensaries or Pathological or diagnostic clinics permitted on the ground floor/stilt or first floor • Nursing Homes, polyclinics maternity homes and medical practitioners. • Professional Offices and studies of a resident of the premises and incidental to such residential use • Educational Building excluding building of trade schools but including student hostels in independent buildings, religious buildings, community halls, welfare centers and gymnasias. • Public Libraries • Club Houses or Gymkhana • Bus shelters, bus stations, bus depot, railway stations, taxi stands and heliports on independent plots • Radio Broadcasting and Television studios • Police Stations, telephone exchanges, government sub-offices, municipal sub-offices, consulate offices.
	(R2) Residential with shop line at ground floor	• All uses permitted in Purely residential zone (R1) • Stores and Shops for retail business, including department stores • Personal services establishments • Hair dressing saloons and beauty parlors • Frozen food stores • Shoe repair and sports shops • Professional offices • Tailoring, embroidery and button hole making shops • Cleaning and Pressing establishments for cloths. • Shops for goldsmiths, lock smiths, watches and clocks repair, musical instruments and their repairs • Coffee grinding establishment with electric motive power. • Restaurant, eating houses, cafeteria, ice cream parlors and milk bars, bakeries • Trade and other similar schools • Coal or Fire wood shops • Local Sub-offices of any public utility

Land Use	Sub Zone	Permissible Usages
		• Data Processing Units • Repairing garages, motor driving schools, travel agencies, ticket booking and selling agencies
Commercial	(C1) Commercial Zone	• Any uses permitted in R2 Zone • Auto Part stores and show rooms for motor vehicles and machinery • Sale of used or second-hand goods for merchandise • Club houses or other recreational activities conducted as business • Storage of furniture and household goods • Retailing of building materials, open and enclosed • Pasteurizing and milk processing plants • Business offices including trade exchanges.
	(C2) Commercial Zone	• All uses permitted in C1 Zone • Wholesale establishments • Printing, book binding, engraving, block making • Public Utility buildings • Headquarters of commercial organizations
Industrial	Industrial Zone	• Uses permissible in industrial zone shall be as per the industrial location policy of the Govt. • Information Technology Establishment shall be permitted in Industrial Zone and Service industrial estates on all plots fronting on roads having width 12 m or more. • Uses permissible in Non-viable plots in industrial Zone are as follows • Petrol Pumps or service stations • Parking Lots • Electric Sub station • Offices for public utility or organization • Banks including safe vaults, telephone exchanges, police stations, govt and semi-govt offices, municipal offices, fire stations. • Hotel with not more than 50 rooms • Convenience shops, departmental stores • Restaurants • Warehouses
Green	(G1, 2 & 3) Green Zone	• Agriculture, horticulture and animal husbandry • Gardens and poultry farms • Forestry • Golf Clubs and Links • Public Parks, Private parks, playfields, stadia, gymkhanas, swimming pools • Amusement Park

Land Use	Sub Zone	Permissible Usages
		• Race tracks and shooting ranges • Fish Curing on open land/fish farming • Public Utility establishment • Cemeteries and crematoria • Slaughter house

18.4.2. Floor Space Index

TABLE 18.2: PERMISSIBLE FSI IN THANE

Land Use	Permissible FSI
Residential	In R-1 zone, (a) for plots fronting on roads below 9 m. width, permissible FSI will be 1.5 only, (b) for plot fronting on road width of 9 m. above (existing or proposed) additional 0.5 FSI shall be allowed for commercial use only subject to condition that, margin and parking space as required under these regulations are provided and separate access for residential and commercial users are provided.
Other Buildings	Maximum floor space index shall be 1.33
Educational Buildings	The maximum F.S.I shall be 1.00
Institutional Buildings	The maximum F.S.I. shall be 1.00
Public Entertainment Hall/Mangal Karyalaya Building	The maximum F.S.I. shall be 1.00
Commercial	The maximum F.S.I. shall be 1.00. For the purpose of F.S.I. net area of land excluding open space and area covered by internal roads shall only be considered.
Industrial	The maximum F.S.I. shall be 1.00

18.4.3. Benchmark Study of TOD Policy

Since TOD Policy specifically for Thane city is not available, therefore the benchmark study analysis of TOD policies of Mumbai and Nagpur cities have been carried out.

A. Draft Transit Oriented Development Policy for Mumbai Region

➤ Key Objectives of TOD (Draft Proposal Stage)

A TOD Framework for the Mumbai city can be developed to ensure a clear priority towards land use and transport integration can be realized at all scales from vision to implementation.

- Aim of the project is to enhance safe access to the Metro Station, supporting transit supportive development in its vicinity. This would improve development potential of the area.
- Stations within walking distance avoid second mode of transport
- Parking is a specific domain and has to be comprehensively addressed in terms of on-street parking, off-street parking and parking within TOD areas
- Promote affordable housing stock around station areas
- Create Poly-centric growth nodes around public transit stations
- Reduce use of cars, promote sustainable development, decongest roads & promote efficient travel.

➤ Influence Zone of The TOD Corridor

TOD Zones have been identified around all Suburban Rail stations, and around the metro line 01, 02, 03 & 04, as well as the monorail stations. These TOD zones have been classified into a hierarchy on the importance based on a Passenger Volume Survey and Interchanges. Accordingly, growth bands within 1.0 km influence zones on either side of the 3 Suburban Rail lines (the Western, Central & Harbour Railway lines), and 0.5 km influence zones along metro rail (TABLE 18.3).

TABLE 18.3: INFLUENCE ZONES IN MUMBAI TOD CORRIDOR

Hierarchy and Influence Buffer	Railway Line	TOD Node
Order 01: 1 Km influence Zone	Suburban Railway	Dadar, Andheri, Kurla, CST, Borivala, Bandra, Mumbai Central, Ghatkopar
Order 02: 0.5 Km Influence Zone	Metro Rail	D.N. Nagar, Marol
Order 03: 0.3 Km influence buffer	Metro Rail	All Metro Stations except D.N. Nagar and Marol.
	Mono Rail	All Monorail Stations.

- Order 1 stations are proposed to have a larger area of influence of 1 km radius. This distance can be easily covered using Intermediate Public Transport or cycles

- Order 2 stations have a lower intensity than Order 1 stations and are proposed to have an influence radius of 500 m from the railway station. This distance can be covered by walk
- Order 3 stations have the least intensity and an influence area with a 300 m radius.

➤ **Key Features of Proposed Mumbai TOD Guidelines**

- Reduction of road traffic by intensifying urban development along railway corridors
- Development of selective commercial pockets with higher FAR (Floor Area Ratio) for commercial developments by carefully considering the overcrowding and congestion levels.
- Incentivizing higher FAR in 500 m x 500 m area around each station in the new transit systems urban renewal scheme.
- Construction of commercial developments and multi-storeyed parking structures at potential bus depots to generate revenues for upgrading bus infrastructures and for compensating the losses of BEST (Brihanmumbai Electric Supply and Transport).
- In the TOD areas where FSI is 5.0 to 6.5 and higher, parking provision is half of that provided in other zones for Residential, Commercial, Retail, Hotels and Industrial land uses.
- Any alignment modifications introduced in Metro/Mono/Elevated Corridors/Corridors of Mass Rapid Transport System, including BRTS, by the Appropriate Authority and sanctioned by Government shall stand automatically amended on the Development Plan as modified.
- Furthermore, any new "Transport Corridor" such as Metro/Mono/Elevated Corridors/Corridors of Mass Rapid Transit System, including BRTS, proposed by Appropriate Authority and sanctioned by Government, shall stand automatically added on to Development Plan.

B. TRANSIT ORIENTED DEVELOPMENT POLICY IN NAGPUR

TOD policy in Nagpur has been notified as per notification no. **TPS-2414/477/CR-248 (Part 1)/2014/UD-9 dated 14th March 2018 – Urban Development Department, Government of Maharashtra**. The notification

enumerates the definitions and usages (w.r.t. Maximum Permissible FSI, Premium etc.) for the Nagpur Metro Rail Corridor (NMRC).

- **Nagpur Metro Rail Corridor (NMRC)** - It is defined as the area falling within 500 mt distance on either side of the Nagpur Metro Rail measured from its center line and includes the area falling within 500 mt distance from the longitudinal end of the last Metro Railway Station.
- **Base permissible FSI**- It is the FSI permissible as per the provisions of the Principal DCR, excluding the TDR that can be received.
- **Maximum Permissible FSI**- The maximum permissible total FSI in NMRC shall be 4.00 including the base permissible FSI, subject to condition that, the additional FSI over and above the base permissible FSI shall be allowed within the overall limit of maximum permissible FSI, as mentioned in the **TABLE 18.4**.

TABLE 18.4: PERMISSIBLE FSI IN NAGPUR TOD CORRIDOR

Sr. No.	Minimum Road Width	Plot Area	Maximum Permissible FSI
1	9.00 mt.	Below 1,000 sq.mt.	2.00
2	9.00 mt.	1,000 sq .mt. or above	3.00
3	12.00 mt.	2,000 sq.mt. or above	3.50
4	15.00 mt.	2,000 sq.mt. or above	4.00

The maximum permissible FSI shall be determined by satisfaction of both the criteria viz. Minimum Road width as well as plot area simultaneously. However, in case both these criteria are not satisfied, the maximum permissible FSI shall be minimum of that permissible against each of these two criteria as illustrated in **Table 18.5**.

TABLE 18.5: PLOT AREA AND ROAD WIDTH IN NAGPUR TOD CORRIDOR

Plot Area	Road Width			
	Less than 9 m	9 m & above	12 m & above	15 m & above
Below 1,000 sq.mt.	Principle DCR	2	2	2
1,000 sq .mt. up to 2,000 sq.mt.	Principle DCR	3	3.5	3.5
Above 2,000 sq.mt.	Principle DCR	3	3.5	4.0

Premium for Additional FSI

Additional FSI over and above base permissible FSI of respective land use zones as per principle DCR, may be permitted on payment of premium as may be decided by the Govt. from time to time.

The minimum tenement density per hectare of the gross plot area is as given below.

- Minimum number of tenements= gross plot area X maximum proposed FSI for residential use X 200 tenements per Hectare

In case tenement density proposed is less than that stipulated, the premium to be paid in that event the additional premium shall be paid as may be decided by the Govt. from time to time and such premium shall be chargeable on the total additional FSI to be availed beyond base permissible FSI.

C. TOD POLICY ADOPTED FOR THANE METRO

At present, there is no TOD policy notified for Thane Metro. The TOD policy for Mumbai Region (discussed in point A above) is also in draft stage. Recently for Pune Metro and Mumbai Metro line 7, TOD policies have been notified in similar lines with Nagpur Metro. Therefore TOD policy for Thane Metro has also been taken in lines with Nagpur Metro. As per the policy, TOD corridor of Thane Metro has been taken as 500 m on either sides of Metro corridor.

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REAL

ESTATE ANALYSIS ALONG TOD CORRIDOR

Thane city has witnessed rapid demographic and real estate market growth in last decade. Thane Municipal Corporation (TMC) is the Urban Local Body (ULB) and governs 128 sq.km of area under it's jurisdiction. Thane was an industrial town during 1960-70 and the major industrial estate like Wagle, Kalwa, Kolshet and Balkum were developed during this period. Large manufacturing and industrial units in Thane gradually gave way to commercial development and additionally, evolution of Thane as a residential hub stimulated development of support social infrastructure. The city emerged as one of the preferred locations for corporate entities. Moreover, proximity to Mumbai and infrastructure developments resulting in rapid access to the real estate micro-markets also enhanced the location attractiveness of the micro markets.

18.5.1. Segmentation of Thane Metro Corridor

The real estate dynamics along Thane Metro Corridor has been analyzed by segregating the corridor into 8 small clusters, which are further detailed out in the subsequent sections. The cluster map is shown in **Figure 18.2**. The clusters are segregated broadly based on the following factors:

- Geographical Extent
- Location Characteristics – Nature of economic activity, nature of residing population
- Prevalent real estate scenario – Organized / Unorganized real estate activity, prevalent pricing

A detailed analysis of these clusters has been carried out with respect to the following:

- Economic activity in the cluster
- Physical and Social Infrastructure
- Key drivers for real activity
- Supply-Demand dynamics along various asset classes like residential, office and retail
- Future outlook of the real estate growth in the cluster

Real Estate Market overview for residential, commercial and retail are presented in

FIGURE 18.3, FIGURE 18.4 and FIGURE 18.5.

FIGURE 18.2: MAP OF CLUSTERS ALONG METRO CORRIDOR

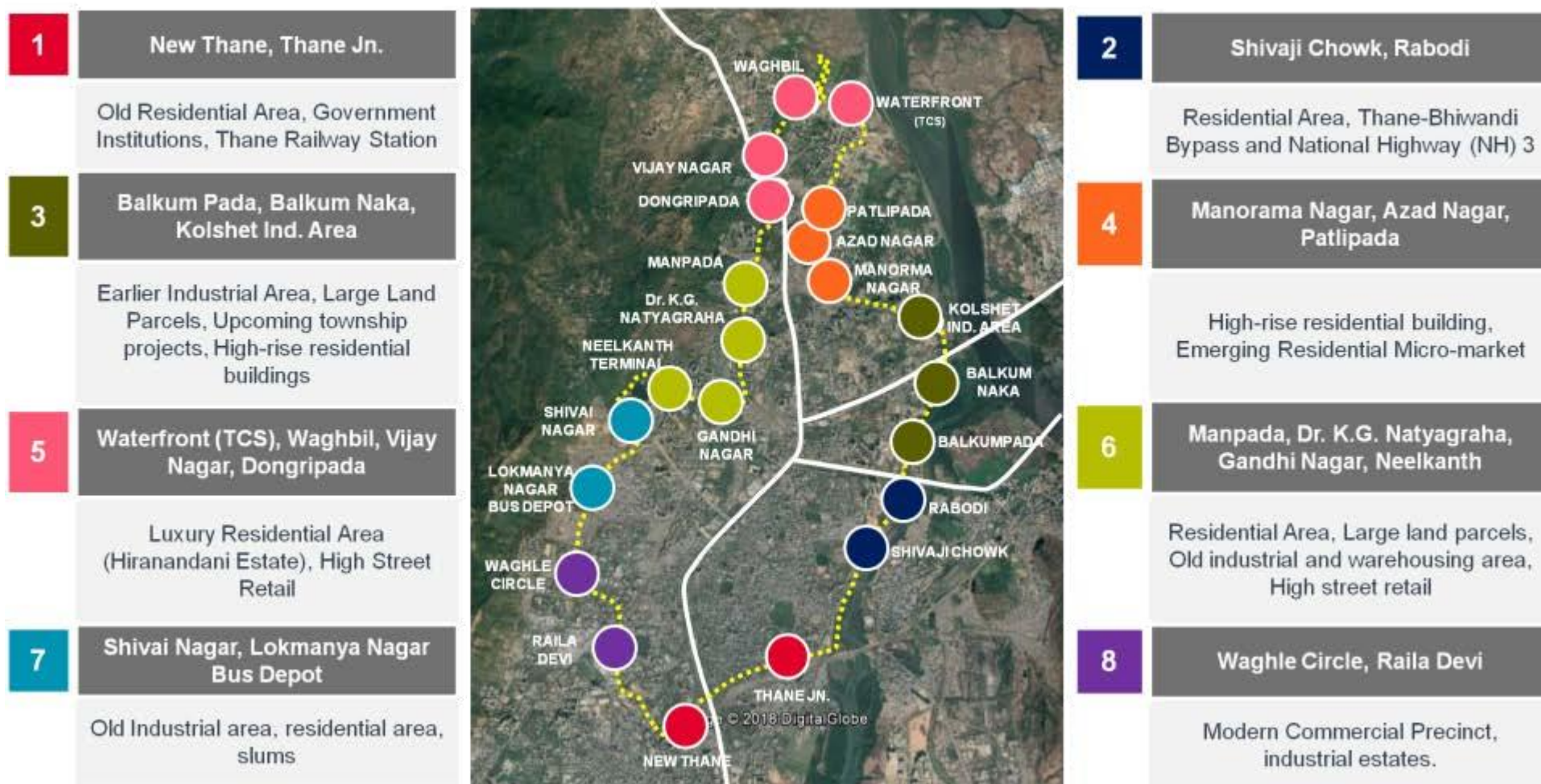


FIGURE 18.3: RESIDENTIAL MARKET OVERVIEW OF THANE

No.	Name of the project	Developer	Status	Total Units	Available Units
1	Hiranandani Skylark Enclave	Hiranandani Developers	Under Construction	278	261
2	Acme Ozone	Acme Housing	Under Construction	506	338
3	Cosmos Habitat	Cosmos Developers	Under Construction	102	90
4	Dosti West County	Dosti Realty	Under Construction	1,060	851
5	Piramal Vaikunth	Piramal Realty	Under Construction	1,314	1,050
6	Wadhwa Elite	Wadhwa Group	Under Construction	457	287
7	Tata Serein	Tata Housing	Under Construction	658	497
8	Lodha Amara	Lodha Group	Under Construction	4,537	2,916
9	Kalpataru Immensa	Kalpataru Developers	Under Construction	1,579	1,441



FIGURE 18.4: COMMERCIAL MARKET OVERVIEW OF THANE

No.	Building Name	Developer	Location	Area (GLA) Sq. Ft.	Year of completion	Rentals INR per Sq. Ft. per month	Vacancy Sq. Ft.
1	Thane One	DIL Ltd	Ghodbunder Road	200,000	2016	55	64,500
2	Lodha Supremus 2	Lodha Group	Thane	600,000	2016	60	560,000
3	Ashar IT Park - 2	Ashar Group	Thane	210,000	2014	60	60,000
4	Lodha Supremus Thane	Lodha Group	Thane	150,000	2013	50	12,000
5	Neptune Element	Neptune Group	Thane	289,000	2012	-	-
6	Kalpataru Prime	Kalpataru Constructions	Thane	330,000	2012	50	23,000
7	Dosti Pinnacle	Dosti Group	Thane	350,000	2011	50	40,000
8	G. Corp. Tech Park	G. Corp. Properties	Ghodbunder Road	760,000	2010	-	-
9	Nitco Business Park	Nitco	Thane	200,000	2010	50	10,500
10	Lodha I-THINK (2 Wings)	Lodha Group	Ghodbunder Road	867,267	2010	50	50,000
11	Ackruti SMC	Ackruti City Ltd	Thane	170,000	2009	50	45,000
12	MBC Infotech Park	-	Ghodbunder Road	157,710	2009	50	5,000
13	Ashar IT Park - 1	Ashar Group	Thane	720,000	2009	60	131,500
14	Lexington	Hiranandani Builders	Thane	132,000	2005	-	-



FIGURE 18.5: RETAIL MARKET OVERVIEW OF THANE

No.	Mall Name	Developer	Major Brands	Location	Area (GLA) Sq. Ft.	Vacancy Sq. Ft.
1	High Street Mall	Siddhi Group	Big Bazar, Cinemastar,	Kapurbawdi Junction	580,000	406,000
2	Lake City Mall	Siddhi Group	Woodland	Kapurbawdi Junction	90,000	50,400
3	Korum Mall	Kalpataru Ltd	AND, Bose, Vero Moda	Eastern Express Highway	500,000	35,000
4	R Mall	Runwal Developers	Westside, Brand Factory, Croma, Maxx	Ghodbunder Road	300,000	45,000
5	Big Shopping Center	Big India Malls Pvt Ltd	Decathlon, Puma, Adidas, Big Bazar	Ghodbunder Road	237,000	18,960
6	Viviana	Sheth Developers	Marks & Spencers, Zara, GAS, Forever 21, Vero Moda	Eastern Express Highway	940,000	-
7	Cine Wonder	Kanakia Spaces	Blackberrys, Reliance Digital, Pizza Hut, Café Coffee Day	Ghodbunder Road	100,000	-
8	Eternity Mall	Kanakia Spaces	Cinemax	Teen Hath Naka	500,000	-
9	Lodha Boulevard	Lodha Group	McDonald's, The Road House	Eastern Express Highway	68,000	-



The snapshot of real estate scenario across various clusters along the corridor is presented in **Table 18.6**.

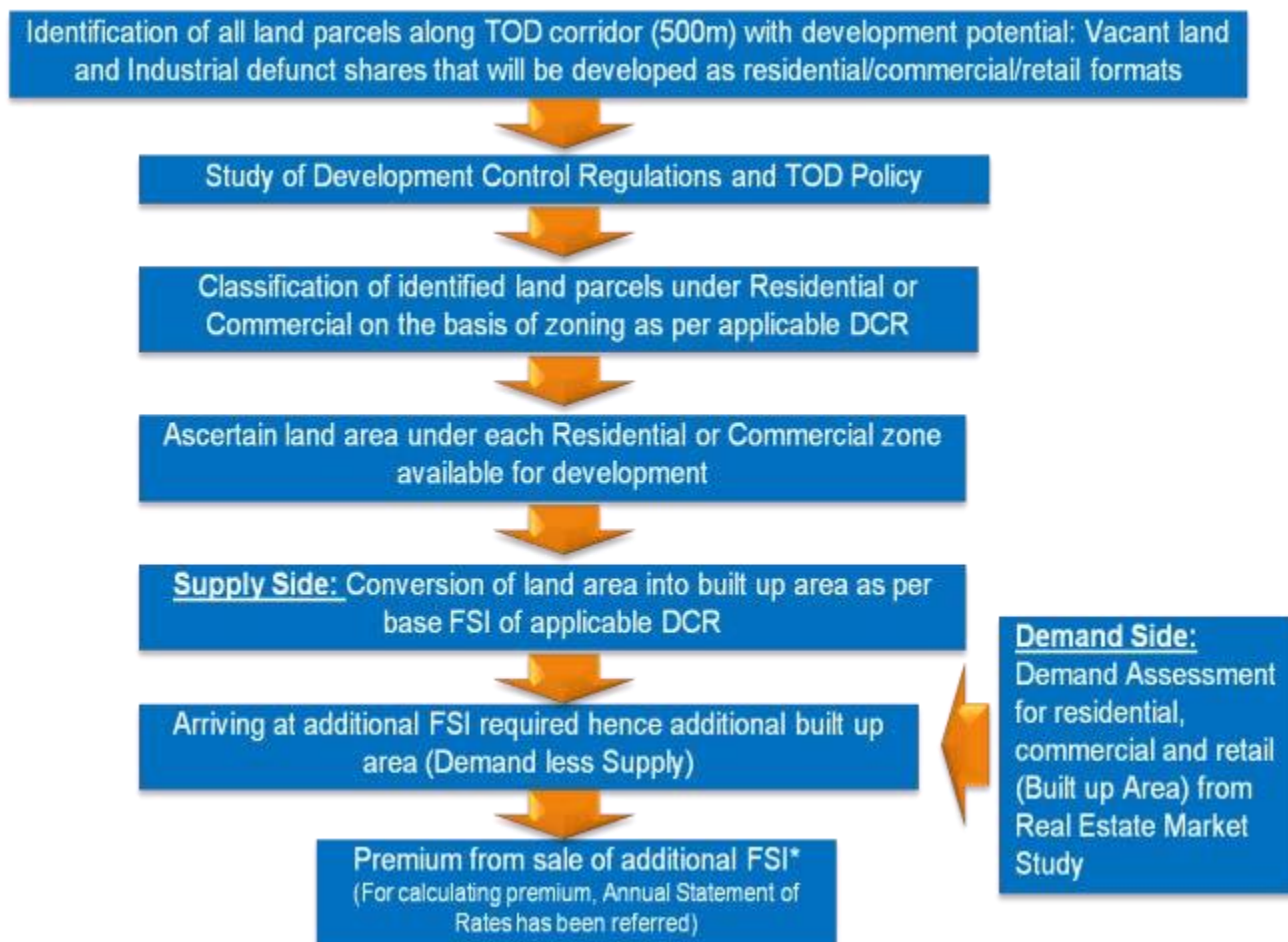
TABLE 18.6: SNAPSHOT OF REAL ESTATE SCENARIO ACROSS VARIOUS CLUSTERS ALONG THE CORRIDOR

CLUSTER	STATIONS IN THE CLUSTER	LAND USE	KEY DEMAND DRIVERS	FUTURE OUTLOOK FOR REAL ESTATE GROWTH		
				RESIDENTIAL	OFFICE	RETAIL
1	Thane Station, New Thane	Mixed, Residential, Retail	- Connectivity to Suburban Railway Network - Accessibility and Connectivity to other modes of transport such as city buses and state transport buses	LOW	LOW	MEDIUM
2	Shivaji Chowk, Rabodi, BalkumPada	Mixed, Residential, Institutional, Retail	- Proximity to National Highway 3 - Established Social Infrastructure	MEDIUM	LOW	MEDIUM
3	Balkum Naka, Kolshet	Industrial, Residential	- Large Defunct Industrial Land Parcels - Upcoming residential township projects	HIGH	MEDIUM	MEDIUM
4	Manorama Nagar, Azad Nagar, Patlipada	Residential, Retail	- Emerging Residential Micro-market - Large land parcels - Established Social Infrastructure - Proximity to Ghodbunder Road	HIGH	MEDIUM	HIGH
5	Waterfront, Waghbil, Vijay Nagar, Dongripada	Residential, Commercial	- Emerging Residential micro-market - Small scale retail outlets - Commercial Development	HIGH	MEDIUM	HIGH
6	Manpada, K.G Natyagruh, Gandhi Nagar, Neelkanth	Industrial (Warehousing), Residential, Retail	- Established Social infrastructure - Large land parcels - Proximity to Ghodbunder Road	HIGH	MEDIUM	MEDIUM
7	Sivai Nagar, Lokmanya Nagar	Industrial, Residential, Commercial, Retail	- Desirable location for Commercial and residential development - Established social infrastructure	HIGH	HIGH	MEDIUM
8	Wagle Circle, Raila Devi	Commercial, Industrial, Residential	- Established Commercial and MSME industrial micro-market - Proximity to LBS Marg	MEDIUM	HIGH	HIGH

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The methodology followed for the assessment of revenue from premium on additional FSI is presented in **Figure 18.6**.

FIGURE 18.6: METHODOLOGY FOR ESTIMATION OF ADDITIONAL FSI



Vacant land parcels have been identified on best effort basis through primary site visit along the corridor alignment and google imagery. **Table 18.7** indicates the supply side dynamics for vacant and defunct industrial plots along the influence zone of the metro corridor. The permissible FSI area of each identified land parcel as per the base FSI has been determined. The areas of the plots within 500 m from both sides of the corridor have been determined.

In addition to these, some land parcels which come under public utilities and green zones as per the Development Plan have been presented in **Table 18.8**. These land parcels have not been considered in the assessment of built up area.

TABLE 18.7: AREA AND FSI DETAILS OF IDENTIFIED LAND PARCELS ALONG TOD CORRIDOR

Plot No	Area (sq.mt)	Nearest proposed Metro Station	Land Use as per DP	Cluster	Approx. Approach Road width (m)	Applicable FSI as per DCR	RG Reservation	Net Plot Area (sq.m.)	Permissible FSI area (sq.m.)	Permissible FSI area (sq.ft.)
V1	14,797	Waghbil	Residential	5	30	1	15%	12,577	12,577	135,384
V2	14,343	Waghbil	Residential	5	30	1	15%	12,192	12,192	131,230
V6	5,934	Waterfront	Residential	5	40	1	15%	5,044	5,044	54,293
V7	7,308	Patlipada	Residential	4	20	1	15%	6,212	6,212	66,864
V8	19,983	Patlipada	Residential	4	20	1	15%	16,986	16,986	182,832
V9	14,961	Patlipada	Residential	4	20	1	15%	12,717	12,717	136,884
V10	3,099	Patlipada	Residential	4	20	1	15%	2,634	2,634	28,354
V11	42,709	Patlipada	Residential	4	20	1	15%	36,303	36,303	390,762
V12	7,245	Patlipada	Residential	4	20	1	15%	6,158	6,158	66,287
V14	7,749	Azad Nagar	Residential	4	42	1	15%	6,587	6,587	70,899
V15	15,763	Azad Nagar	Residential	4	12	1	15%	13,399	13,399	144,222
V16	10,422	Azad Nagar	Residential	4	21	1	15%	8,859	8,859	95,355
V17	14,626	Azad Nagar	Residential	4	12	1	15%	12,432	12,432	133,819
V18	3,764	Azad Nagar	Residential	4	21	1	15%	3,199	3,199	34,438
V19	3,283	Manorama Nagar	Residential	4	21	1	15%	2,791	2,791	30,037
V20	8,323	Manorama Nagar	Residential	4	18	1	15%	7,075	7,075	76,150
V21	24,671	Manorama Nagar	Residential	4	18	1	15%	20,970	20,970	225,725
V22	9,002	Manorama Nagar	Residential	4	9	1	15%	7,652	7,652	82,363
V23	12,449	Manorama Nagar	Industrial	3	33	1	10%	11,204	11,204	120,601
V24	8,431	Manorama Nagar	Industrial	3	33	1	10%	7,588	7,588	81,676
V25	3,686	Manorama Nagar	Residential	4	33	1	15%	3,133	3,133	33,725
V26	130,649	Manorama Nagar	Residential	3	24	1	15%	111,052	111,052	1,195,360
V27	78,745	Kolshet Industrial Area	Residential	3	24	1	15%	66,933	66,933	720,470
V28	22,705	Kolshet Industrial Area	Residential	3	18	1	15%	19,299	19,299	207,737
V30	44,496	BalkumPada	Residential	6&7	20	1	15%	37,822	37,822	407,112
V31	179,124	Gandhi Nagar	Industrial converted to Residential	6&7	32	1	15%	152,256	152,256	1,638,880
V33	12,254	Dr. K.G Natyagraha	Residential	5	30	1	15%	10,416	10,416	112,117

TABLE 18.8: IDENTIFIED LAND PARCELS UNDER PUBLIC UTILITIES AND GREEN ZONE

Plot No	Area (sq.mt)	Nearest proposed Metro Station	Land Use as per DP	Cluster	Approx. Approach Road width (m)
V3	1,726	Waghbil	Public Utilities	5	30
V4	15,429	Waghbil	Public Utilities	5	30
V5	85,413	Waterfront	Green Zone - G1	5	15
V13	13,037	Azad Nagar	Park - RG	4	42
V29	34,351	Rabodi	Public & Semi Public	2	12
V32	33,171	Waterfront	Public Utilities	5	15
V34	25,825	Waterfront	Public Utilities	5	36

All the identified land parcels come under residential and industrial landuse as per the development plan. The clusterwise permissible FSI area details for the asset classes of residential and industrial/commercial landuses have been presented in **Table 18.9**.

TABLE 18.9: CLUSTER WISE PERMISSIBLE FSI AREA DETAILS

Asset Class		Cluster 3	Cluster 4	Cluster 5	Cluster 6 & 7	Total
Residential	Permissible FSI area (sq.ft.)	2,123,567	1,798,717	433,023	407,112	4,762,419
	Average unit size (sq.ft.)	1,200				
	Average no of units	1,770	1,499	361	339	3,969
Industrial/ Commercial (Can be developed into Commercial IT- ITEs)	Permissible FSI area (sq.ft.)	202,277			1,638,880	1,841,157

The cluster wise identified land parcels have been shown in **Figure 18.7 to 18.13**.

FIGURE 18.7: IDENTIFIED LAND PARCELS IN CLUSTER 1

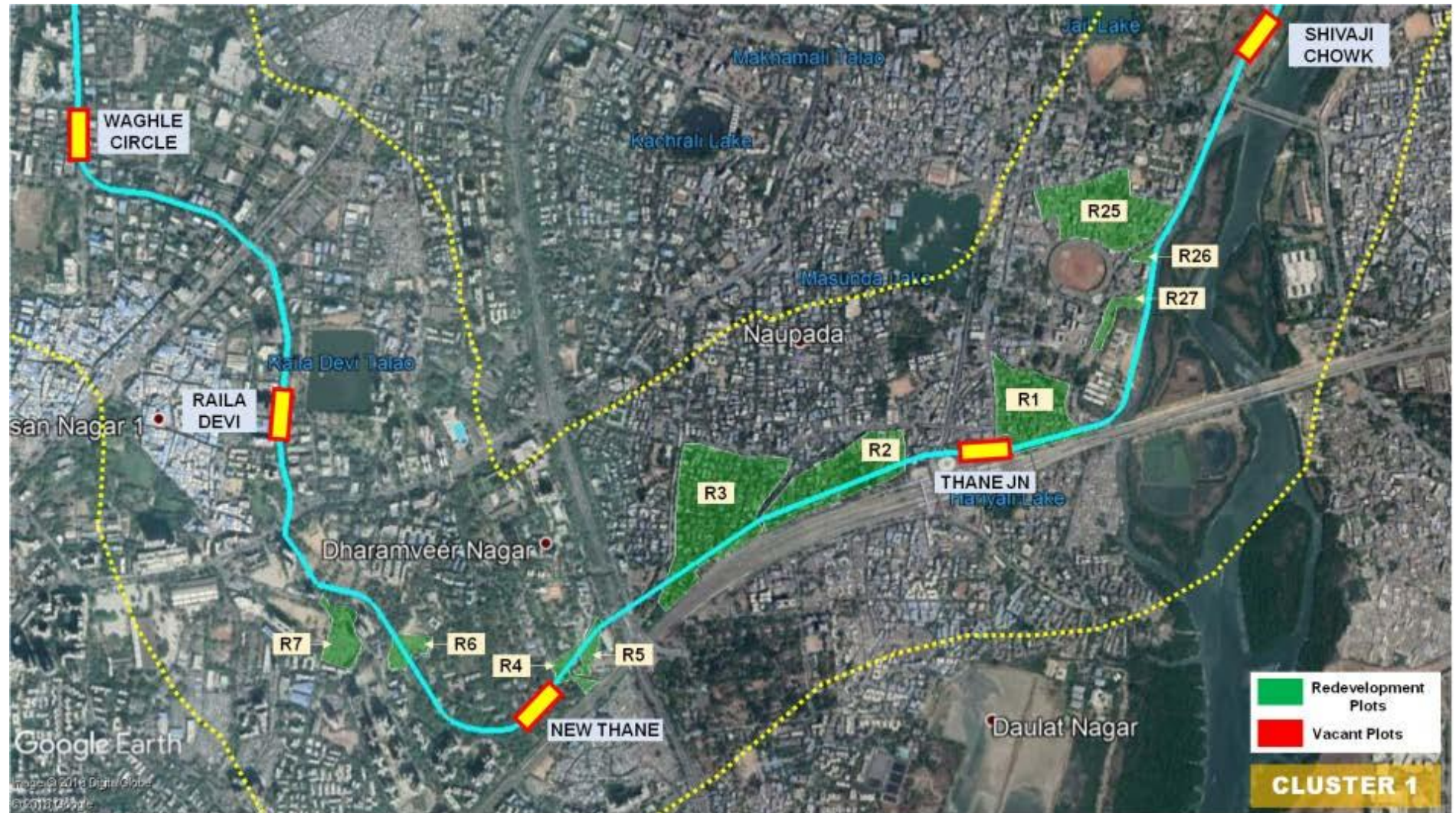


FIGURE 18.8: IDENTIFIED LAND PARCELS IN CLUSTER 2

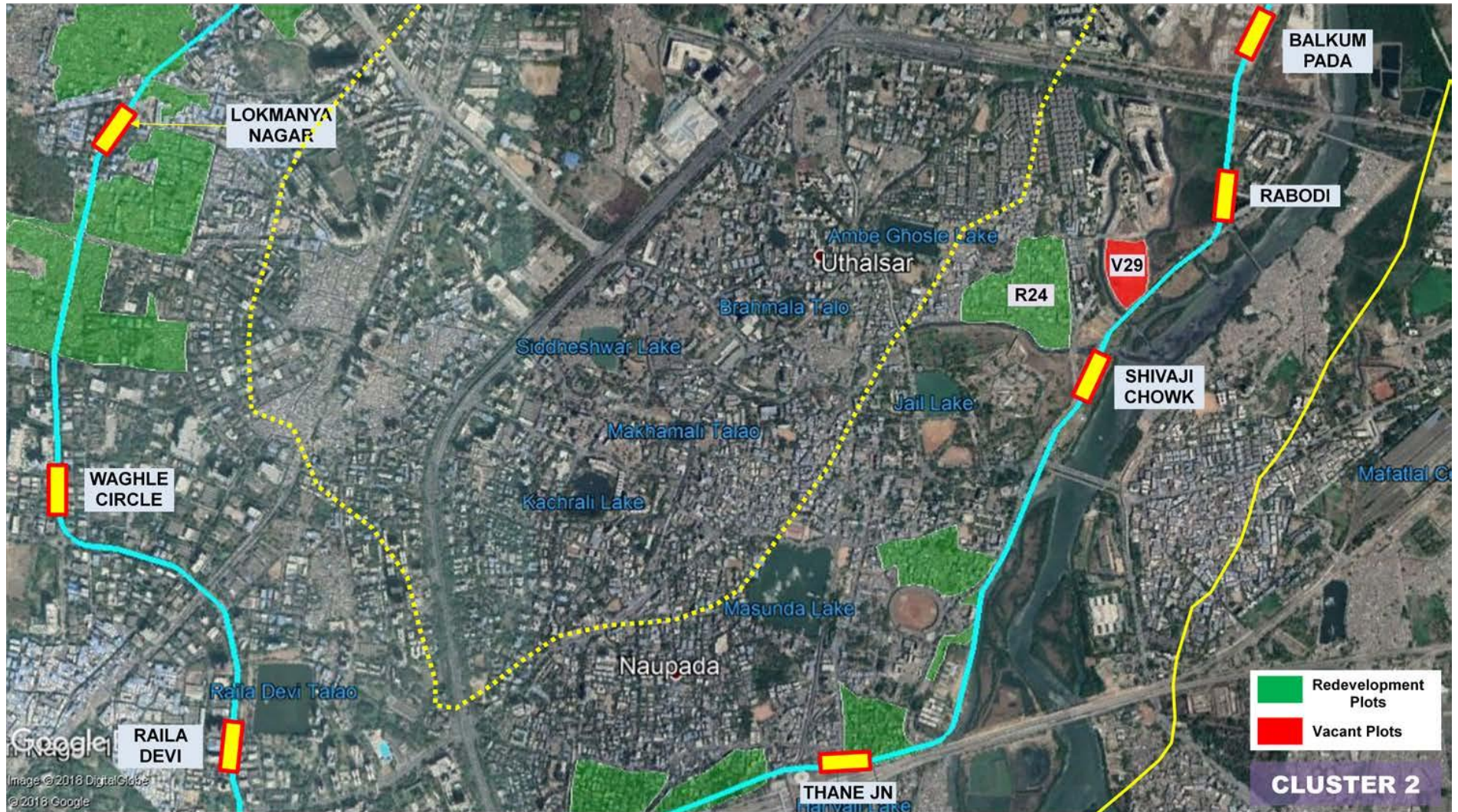


FIGURE 18.9: IDENTIFIED LAND PARCELS IN CLUSTER 3



FIGURE 18.10: IDENTIFIED LAND PARCELS IN CLUSTER 4

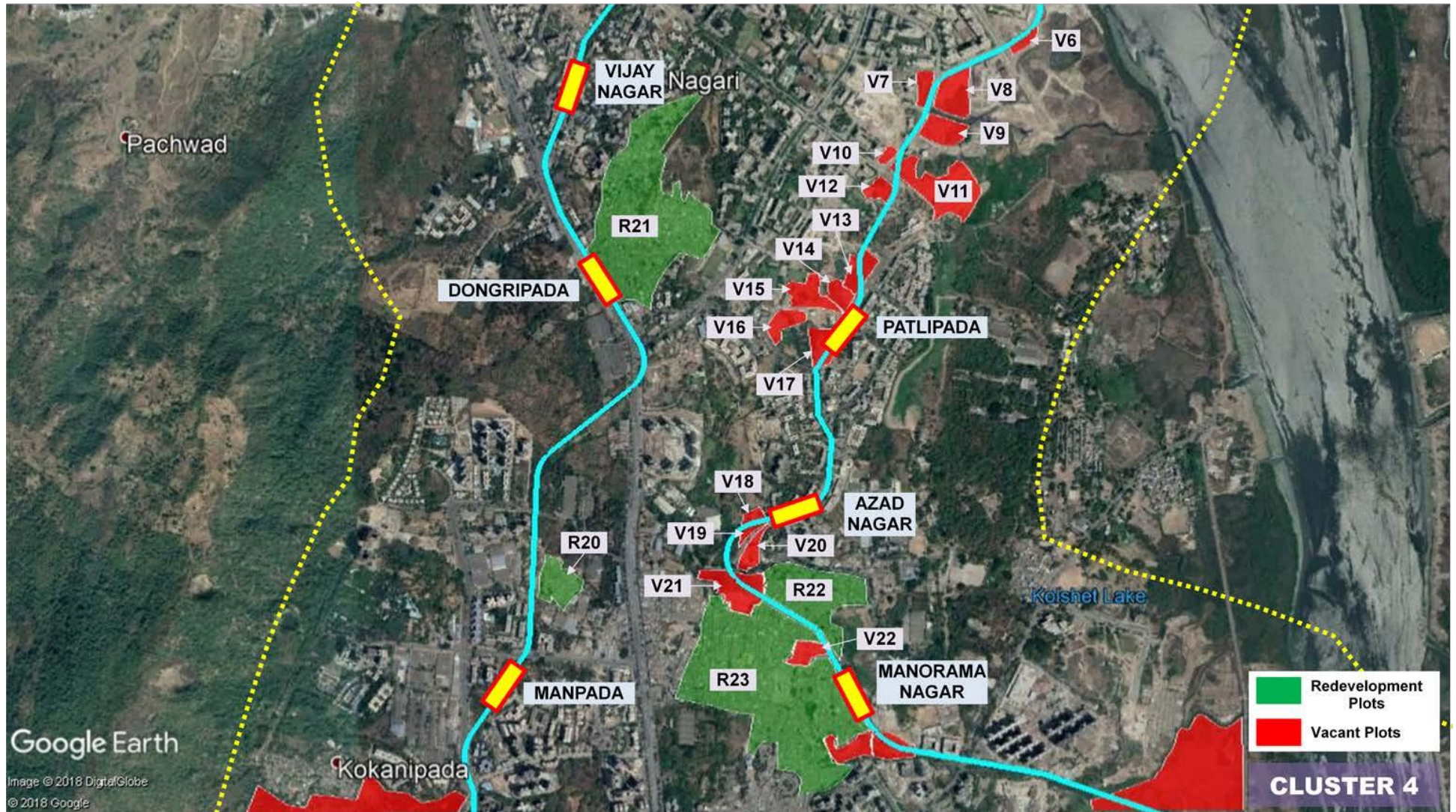


FIGURE 18.11: IDENTIFIED LAND PARCELS IN CLUSTER 5



FIGURE 18.12: IDENTIFIED LAND PARCELS IN CLUSTER 6 & 7

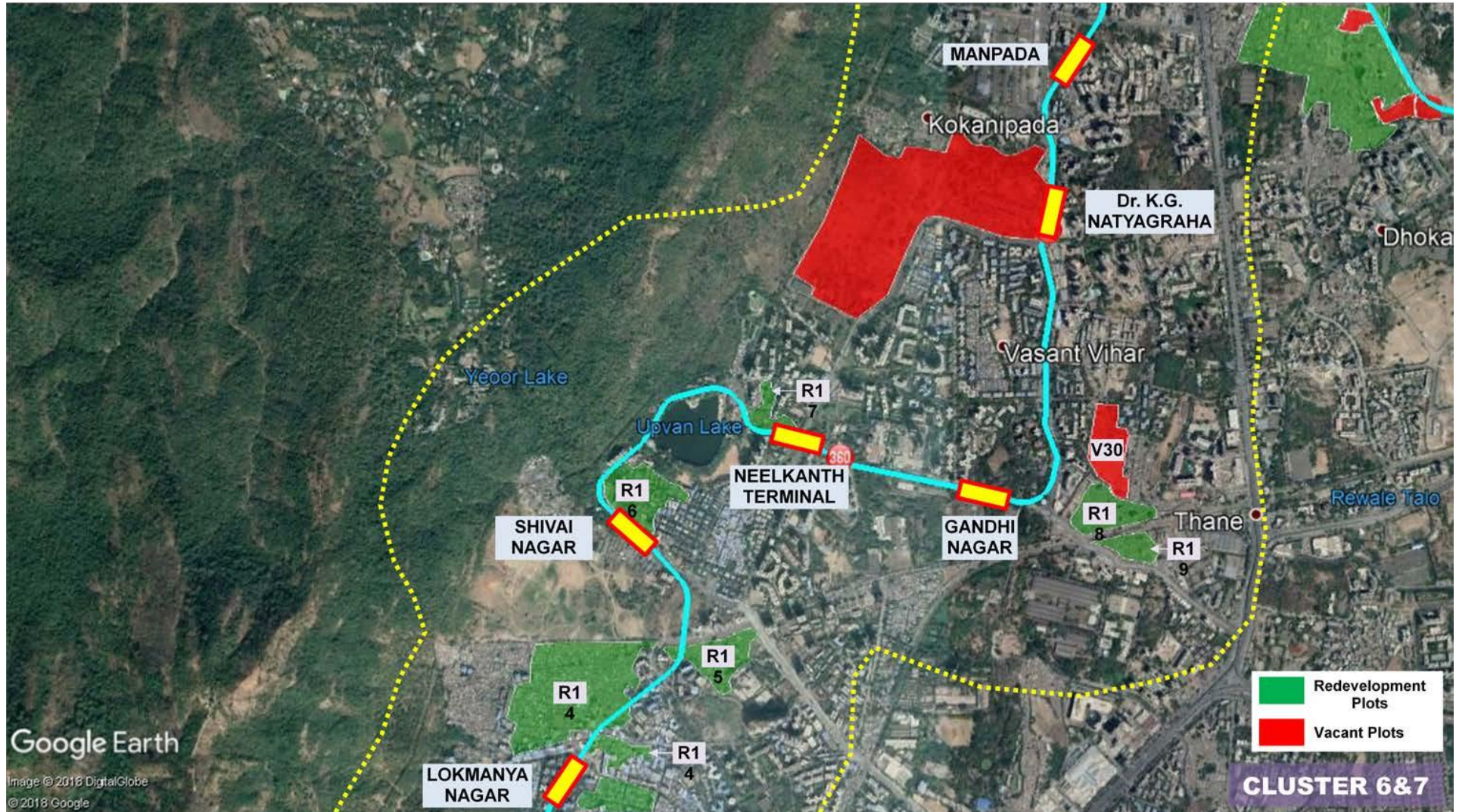
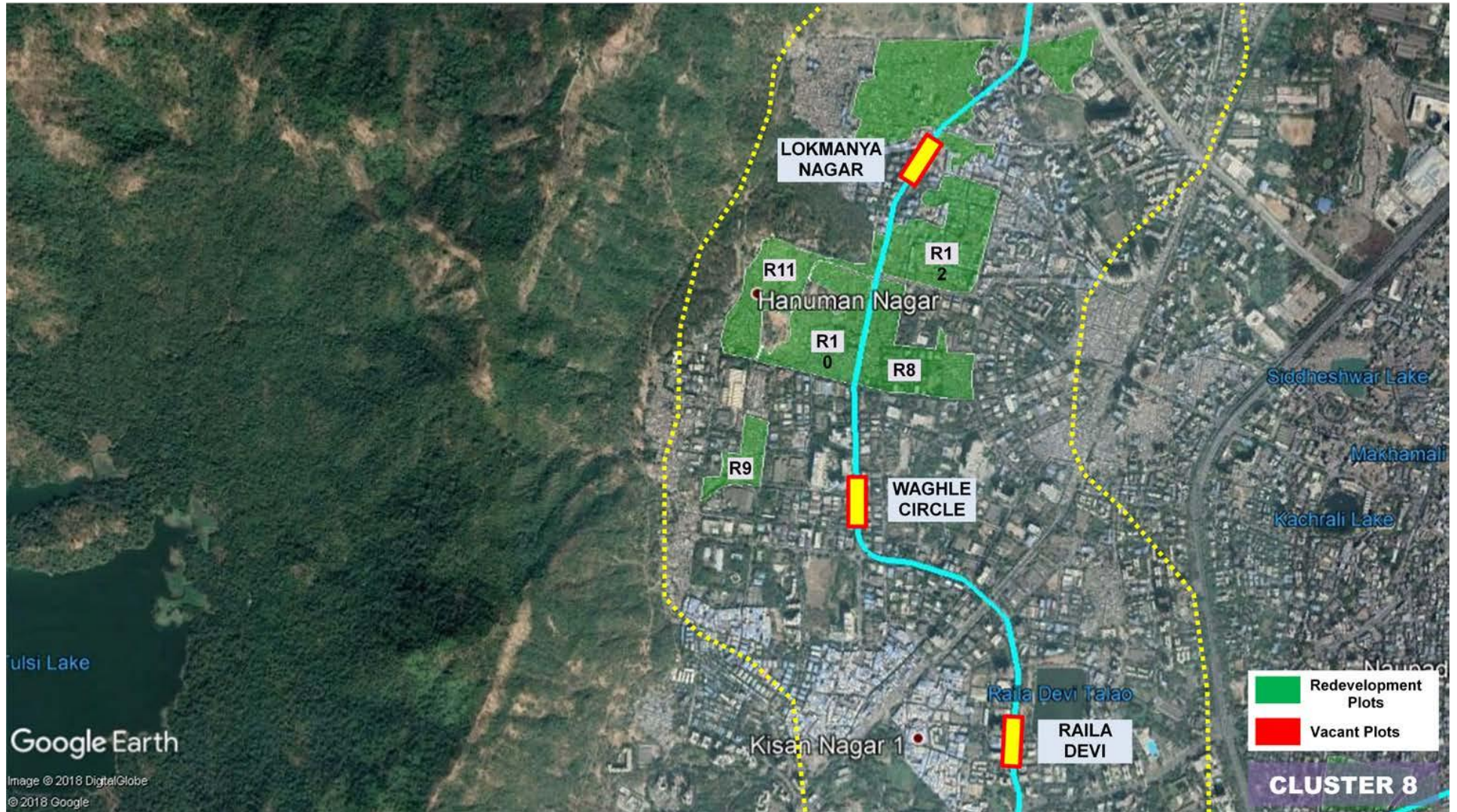


FIGURE 18.13: IDENTIFIED LAND PARCELS IN CLUSTER 8



DEMAND SIDE POTENTIAL

18.7.1. Demand Estimation for Residential Segment

Demand estimation for residential segment has been worked out in four steps as explained below:

- **Step I: Population Projection**

From the Indicus Analytics data for Thane district, decadal growth rate has been used for future projections of Thane population. Average Household (HH) size has been calculated by dividing the total population by number of households. The HH size has been used to calculate the number of HH's for projected population.

- **Step II: Estimating number of HH on the basis of total household earnings**

From Indicus Analytics data, the number of households segregated by household earnings has been used to calculate the estimated number of HH in each HH earning bracket.

- **Step III: Estimating potential demand of residential apartments**

As per 2011 census, 26% of total Thane district population resides in rented houses. The percentage share of the rented households is applied on the earning wise households to estimate the housing demand. Households with earnings over INR 5 Lakh bracket are considered to be the potential demand for residential apartments. Demand for next 30 years has been calculated.

- **Step IV: Demand along the TOD corridor**

Thane, at present has approx. 22,000 unsold residential units, which are deducted from the calculated cumulative demand for next 30 years to arrive at the actual demand numbers for the city. Based on Thane real estate market understanding and the existing supply demand dynamics along the TOD corridor, it has been considered that 60-80% of the demand shall come along the metro corridor spread across various clusters.

Key target segment for housing in Thane

- Residential demand in Thane is largely end-user driven and typically generated by the following target segments
 - Rented households living in Thane looking to invest in own homes

- Investors living in Thane investing in homes for rental income
- While the above segments are primary demand drivers for housing in Thane, secondary demand drivers for housing comprise of speculative investors and end-user generated as a result of nuclearization of families.

Table 18.10 presents the distribution of households by annual income.

TABLE 18.10: DISTRIBUTION OF HOUSEHOLDS BY ANNUAL INCOME

Annual Income of Households (INR/annum)	% Share of Population	Housing Affordability	Source
<Rs. 75,000	17%		Annual Income of Households - Indicus Market Skyline of India 2013-14
Rs. 75,000 - Rs.150,000	17%	Upto 7.5 Lakhs	Housing Affordability based on Housing Loan Eligibility
Rs.150,001 - Rs.300,000	19%	INR 7.6 to 15 Lakhs	
Rs.300,001 - Rs.500,000	14%	INR 16 to 25 Lakhs	
Rs.500,001 - Rs.1,000,000	14%	INR 26 to 50 Lakhs	
1,000,001 - Rs.2,000,000	10%	INR 51 Lakhs to 1 Cr	
2,000,001 - Rs.5,000,000	6%	INR 1 to 2.5 Crore	

The demand for housing in Thane in terms of no. of units for different income households is presented in **Table 18.11**.

TABLE 18.11: HOUSING DEMAND IN THANE

Housing Demand in Thane- No. of Units (in Thousands)							
Annual Income of Households (INR/annum)	2018	2024	2029	2034	2039	2044	2049
500,001 - 1,000,000	82.1	99.5	115.2	125.1	140.4	153.2	168.1
1,000,001 - Rs.2,000,000	59.5	72.1	83.4	90.6	101.7	110.9	121.7
2,000,001 - Rs.5,000,000	36.3	44	51	55.3	62.1	67.8	74.4
5,000,001 - 10,000,000	6.4	7.7	8.9	9.7	10.9	11.9	13
>10,000,000	0.5	0.6	0.7	0.7	0.8	0.9	1

As discussed earlier, the primary target segments for housing in Thane are those who reside in Rented households (which comprise of end-users segment), and investors who invest in homes for rental income. Eventually the occupiers of homes in both the above segments are the rented households. Hence, the **Table 18.12** calculates the demand for housing from the rented households based in Thane. Proportion of rented households in Thane is 26% (as per census 2011).

TABLE 18.12: HOUSING DEMAND IN THANE FROM RENTED HOUSEHOLDS

Housing Demand in Thane- No. of Units (in Thousands)							
Annual Income of Households (INR/annum)	2018	2024	2029	2034	2039	2044	2049
Rs.500,001 - Rs.1,000,000	21.4	25.9	30	32.5	36.5	39.8	43.7
1,000,001 - Rs.2,000,000	15.5	18.7	21.7	23.6	26.4	28.8	31.6
2,000,001 - Rs.5,000,000	9.4	11.4	13.2	14.4	16.1	17.6	19.3
Rs. 5,000,001 - Rs.10,000,000	1.7	2	2.3	2.5	2.8	3.1	3.4
>Rs.10,000,000	0.1	0.2	0.2	0.2	0.2	0.2	0.3
Cumulative Demand for Housing Units in Over INR 5 Lakh Price Segment	48	58.2	67.4	73.2	82,131	89,614	98,315
Incremental Demand for Housing Units in Over 5 Lakh Price Segment		1,838	1,816	1,752	1,809	1,775	1,710
Supply (Unsold Inventory)	22,000 (Q1 2018)						

The current residential market demand dynamics in Thane indicate:

- Absorption of ~650 – 700 residential units across various configurations and sizes per month.
- Also proposed infrastructure initiatives which include the Metro line 4 (Wadala – Kasarvadavali) and the upcoming Thane-Bhiwandi-Kalyan metro is expected to further impact the real estate activity in Thane

Considering the growth in real estate activity in Thane and current absorption, we anticipate about 2-2.5 years for the unsold inventory to be completely absorbed. Hence demand for residential segment in initial years is very low. However, post the absorption of the unsold inventory we foresee a demand for residential segment (approx. 28,250 units) in Thane (next 30 years demand).

- Considering the present supply dynamics (upcoming projects), we have considered ~ 70-80% (19,500 – 22,500 units) share of the residential demand to come along the TOD corridor
- The available vacant land parcels along the TOD corridor has a potential to develop approx. 3,900 units. (~4.76 mn. Sq.ft.)
- The additional demand along the TOD corridor comes out to be ~17,250 units = ~20.68 mn. Sq. ft. It can be developed through purchase of premium FSI from the authority at the rate of 60% of the ready reckoner rates.

18.7.2. Demand Estimation for Commercial Segment

Demand estimation for commercial segment has been worked out in five steps as explained below:

- **Step I: Grade A Commercial Absorption Trend**

For last seven years, 2009-2015 Y-o-Y Grade A commercial absorption (sq. ft.) rate for each of the micro market in Mumbai has been studied and arrived at average absorption (sq. ft.) for each of the micro-market in Mumbai.

- **Step II: Projected absorption for Mumbai**

On the basis of absorption CAGR of 2.36% for last seven years, accelerated growth rate of 5% has been considered till 2019 and 3% there on for the overall absorption in Mumbai micro-market. Share of absorption for each of the micro-market of Mumbai is divided into two components - (i) 2016-19 and (ii) 2019 onwards. The projected Grade A supply in each micro-market for next three years i.e. 2016-2019.

- **Step III: Projected absorption for Thane (2016-19)**

The absorption (sq. ft.) for 2016-19 has been estimated on the basis of average historic absorption (sq. ft.) trend considering the vacancy levels trend in micro-market. Along with this average absorption (sq. ft.) rate, based on historic trend it is observed that there is a lump in absorption when the supply hits the market due to pre-commitments. Considering this the projected supply is estimated to witness approx. 60% absorption by the time it hits in the micro-market.

- **Step IV: Projected absorption 2019 onwards**

The absorption (sq. ft.) 2019 onwards has been estimated on the basis of average absorption (sq. ft.) for Thane micro-market from 2009-2019.

- **Step V: Share of TOD corridor**

Share of TOD corridor is taken post 2019 considering time taken for project conceptualization, initiation, development and marketing. Share of 33% has been considered for subject site.

Demand for office Space in Thane has been assessed based on the past office space absorption trends in Thane over a 9 year period from year 2009 to year 2017 (**Table 18.13**). The past 9 years considers various real estate cycles that a metropolitan city would witness ranging from peak demand to slowdown in the market.

Further the demand projections are done for Mumbai market as a whole and thus the share of demand of Thane in Mumbai Market over next 30 years timeframe. It

is estimated that Thane will have nominal share (7%) as seen historically (Thane-Belapur Road being the larger share due to lower rental values and larger supply).

The office space absorption in Thane and TOD corridor for the next 30 years has been projected in **Table 18.14**. The summary of estimated demand along TOD corridor is presented in **Table 18.15**.

TABLE 18.13: OFFICE SPACE ABSORPTION TRENDS IN MILLION SQ. FT.

Trends in absorption of office space in Million Sq. Ft.										
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average
Mumbai	3	3.65	4.3	5.38	4.39	3.21	3.22	2.71	2.43	3.59
Thane	0.26	0.67	0.11	0.31	0.51	0.38	0.38	0.41	0.02	0.34
% share of Thane	9%	18%	3%	6%	12%	12%	12%	15%	1%	10%

TABLE 18.14: OFFICE SPACE ABSORPTION IN THANE & TOD CORRIDOR (MN SQ. FT.)

Year	2018	2024	2029	2034	2039	2044	2048
Mumbai	2.48	2.8	3.09	3.41	3.76	4.15	4.5
Thane share @ 7%	0.14	0.2	0.22	0.24	0.26	0.29	0.31
Share of TOD Corridor in Thane (67%)	0.097	0.13	0.144	0.159	0.176	0.194	0.21

TABLE 18.15: SUMMARY OF ESTIMATED DEMAND ALONG TOD CORRIDOR

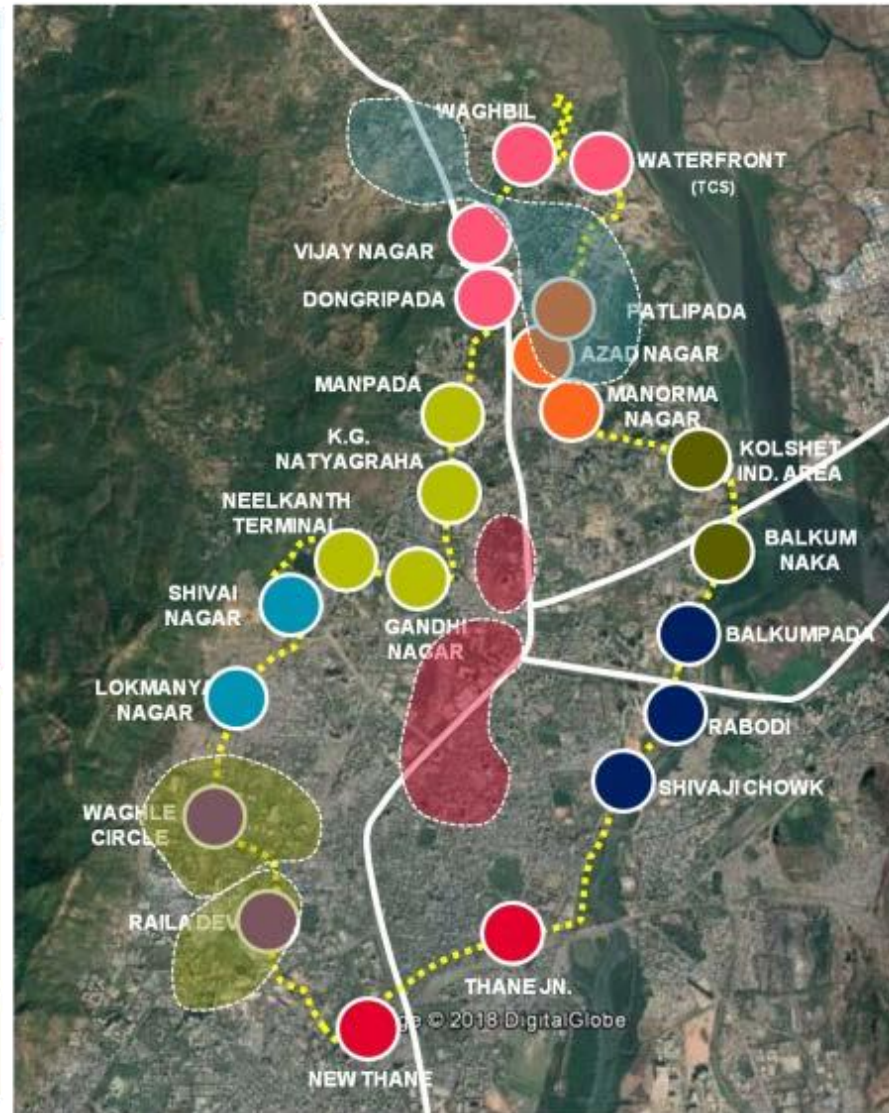
Past Absorbed Trends in Thane 9 Year Period (Year 2009-2017)	3.051 mn.sq.ft.
Estimated Future Absorption for office Space in Thane: 30 Year Period (Year 2018-2048)	7.31 mn. sq.ft.
Estimated Future Absorption for office Space in TOD corridor: 30 Year Period (Year 2018-2048)	4.87 mn. sq.ft.
Estimated Future Demand for office Space in in TOD corridor (considering 23% vacancy): 30 Year Period (Year 2018-2048)	6.33 mn. sq.ft.

The future potential demand along the TOD corridor is estimated to be 4.87 Mn. sq. ft., whereas the vacant land parcels along the corridor indicate a potential supply of commercial development to be 1.84 Mn. sq. ft.

Hence the additional demand can be catered to by purchase of additional FSI from the authority. The commercial micro-market within TOD station clusters is presented in **Figure 18.14**.

FIGURE 18.14: COMMERCIAL MICRO-MARKET WITHIN TOD STATION CLUSTERS

Key Areas	Godhbunder Road, Pokhran Road, Hiranandani Estates
Major Projects	G Corp Tech Park, MBC Infotech Park, Lexington (Hiranandani)
Quoted Rental	INR 50 per sq. ft. per month
Key Areas	Kapurbawdi
Major Projects	Thane One, Lodha i-Think
Quoted Rental Range	INR 50 - 55 per sq. ft. per month
Key Areas	Wagle Estate, Modella
Major Projects	Lodha Supremus, Ashar IT Park 2, Lodha Supremus 2, Neptune Element, Kalpataru Prime, Dosti Pinnacle, Nitco Business Park,
Quoted Rental Range	INR 50 – 60 per sq. ft. per month



Out of the total demand projected in the Thane TOD corridor, below mentioned is the percentage share distribution across two micro markets:

- Ghodbunder Road and Pokhran Road- new developments – 70% (Cluster 5, 6 & 7)
- Waghle Circle and Raila Devi- redevelopment of industrial to commercial - 30% (Cluster 8)

18.7.3. Demand Estimation for Retail Segment

Demand estimation for retail segment has been worked out in seven steps as explained below:

- **Step I: Estimate Total Household Expenditure**

From the Indicus Analytics data for Thane city, we have considered the expenditure of households with annual earnings greater than five lakhs. This expenditure includes food and related items, FMCG, Personal/ durable goods, clothing and footwear, misc. goods & services (travel, doctor fees etc.). This expenditure is escalated considering the inflation rate and population growth at city level. Thus we arrive at year-on-year per capita annual expenditure for households with annual earnings greater than five lakh.

- **Step II: Estimate Total Household Expenditure on Retail**

The expenditure on Retail is considered for items that includes 1) Food & Related items 2) FMCG 3) Personal/ Durable Goods 4) Clothing & Footwear. Retail expenditure constitute 30% of total expenditure

- **Step III: Lease Rentals for the Retail**

Considered the weighted average rentals for the retail establishments in the city considering the major malls, the annual escalation of 5% is taken for this rent.

- **Step IV: Retail Rent Expenditure**

The retailers on an average spends about ~12% on the rent of the total earnings of establishment. This is considered to convert the household earnings to the retailer space required at the city level

- **Step V: Built-up Area required for retail**

Built-up Area (BUA) sq. ft. for retail is calculated by = (Total expenditure in INR for households with earnings greater than INR five lakh) * Annual Expenditure Escalation * Retail Rent Expenditure)/(Lease rent in INR per sq. ft. per month * 12 * Annual Lease Rental Escalation

- **Step VI: Built-up Area required for organised retail**

The total retail space requirement is mix of unorganised, organised retail and online shopping. based on secondary reports, organised retail constitute of 10% share at India level in 2016 and same has been considered for Thane. Organised or modern chain stores, all owned or franchised by a central entity, or a single store that is larger. Organised retail constitute of formats such as malls, high streets, shopping plazas, hypermarkets. Thus we arrive at organised retail demand in Thane in next 10 years.

Table 18.16 and 18.17 presents the estimation of demand for retail segment along TOD corridor in Thane.

TABLE 18.16: ESTIMATION OF RETAIL DEMAND ALONG TOD CORRIDOR

Year		2018	2024	2029	2034	2035	2036	2037
Population in households earning >Rs.500,000 (INR Lakhs)		7.72	9.35	10.83	11.76	12.04	12.33	12.62
Per Capita expenditure (INR Lakhs)	3.34							
Increase in expenditure- Inflation rate adjusted (%) (INR Lakhs)		4.26	5.71	7.29	9.31	9.77	10.26	10.77
Total expenditure for Households earning >Rs.500,000 (INR Lakh Crores)		0.33	0.53	0.79	1.09	1.18	1.26	1.36
Retail expenditure share at 30% for total expenditure (INR Lakh Crores)		0.1	0.16	0.24	0.33	0.35	0.38	0.41

TABLE 18.17: ESTIMATED DEMAND FOR RETAIL ALONG TOD CORRIDOR

Year		2018	2024	2029	2034	2035	2036	2037
Retail Rent Expenditure (Sq. Ft.) at 12%		37.97	46.01	53.25	57.84	59.23	60.64	62.05
Share of Modern Retail (Organized) (Sq. Ft.)		3.8	4.6	5.32	5.78	5.92	6.06	6.21
Incremental demand (sq. ft.)		13,719	14,548	14,222	13,951	14,050	14,140	13,719
Existing Organized Supply (lakhs sq. ft.)	33.15							
Additional demand for organized retail in Thane (lakhs sq. ft.)		-29.35	-28.55	-27.83	-27.37	-27.23	-27.09	-26.94

The demand estimation indicates oversupply in Thane market from Retail development perspective. It is estimated that even newer supply comes up in the corridor, it will be part of large residential development as support retail and may not avail the additional FSI. Hence retail segment is not considered as potential segment for revenue generation from additional FSI.

ESTIMATION OF REVENUE FROM VALUE CAPTURE FINANCE**18.8.1. Premium on Additional FSI**

The additional demand along the TOD corridor is spread across cluster 3, 4, 5, 6 and 7 with available vacant land parcels. For computing premium on additional FSI, rates have been charged as 30% of ASR Land rates as follows:

* ASR Land Rates are land rates for the 'Receiving Plot', as mentioned in the Annual Statement of Rates, prepared by the Inspector General of Registration & Controller of Stamps, Maharashtra State for the year of utilization of additional FSI.

The Annual Statement of Rates (ASR) for different areas along TOD corridor are given in **Table 18.18**.

TABLE 18.18: ANNUAL STATEMENT OF RATES

Nearest Metro Station	Proposed Location of Vacant Land Parcel (Area As Per Reckoner Rate)	Land Rate (INR/Sq.M.)
Waghbil	Waghbil	9,700
Waterfront	Hiranandani Township	47,700
Patlipada	Patlipada	44,000
Azad Nagar	Azad Nagar	8,500
Manorama Nagar	Manorama Nagar	8,500
Kolshet Industrial Area	Kolshet Industrial Area	42,433
Balkum Pada	Balkum Pada	30,367
Gandhi Nagar	Gandhi Nagar	56,200
Dr. K. G. Natyagraha	Dr. K. G. Natyagraha	42,200

For the purpose of Revenue Estimation from sale of additional FSI, we have divided Ready Reckoner Rates in 4 Groups as follows:

- Group 1 – 0 – 10,000
- Group 2 – 20,000 – 40,000
- Group 3 – 40,000 - 50,000
- Group 4 – 50,000 – 60,000

Assuming the average Ready Reckoner Rate in Each Group and 2% escalation in Rate every year (2018 – 2049) the Ready Reckoner Rates in Year 2024 are as follows:

	Group 1 (0-10,000)	Group 2 (20,000-40,000)	Group 3 (40,000-50,000)	Group 4 (50,000-60,000)
Ready Reckoner Rate 2024 (Rs/Sq.M.)	9,843	34,198	49,413	63,290

The revenue estimation from sale of additional FSI of residential and commercial is presented in **Table 18.19**.

TABLE 18.19: REVENUE FROM SALE OF ADDITIONAL FSI TO SPV

Year	Revenue from sale of Additional FSI (Residential) (INR Crore)	Revenue from sale of Additional FSI (Commercial) (INR Crore)	Total Revenue from sale of Additional FSI (INR Crore)	50% Share to SPV (INR Crore)
2025	166.5	12.1	178.6	89.3
2026	169.8	12.4	182.2	91.1
2027	173.2	12.6	185.8	92.9
2028	161.9	12.9	174.7	87.4
2029	165.1	13.1	178.2	89.1
2030	140.4	13.4	153.8	76.9
2031	143.2	13.6	156.9	78.4
2032	146.1	13.9	160.0	80.0
2033	149.0	14.2	163.2	81.6
2034	152.0	14.5	166.5	83.2
2035	147.8		147.8	73.9
2036	150.7		150.7	75.4
2037	153.7		153.7	76.9
2038	156.8		156.8	78.4
2039	159.9		159.9	80.0
2040	163.1		163.1	81.6
2041	166.4		166.4	83.2
2042	169.7		169.7	84.9
2043	173.1		173.1	86.6
2044	176.6		176.6	88.3
2045	180.1		180.1	90.1
2046	183.7		183.7	91.9
2047	187.4		187.4	93.7
2048	191.1		191.1	95.6
2049	195.0		195.0	97.5
	4,123	133	4,255	2,128

18.8.2. Additional 1% Surcharge on Property Transactions

Government of Maharashtra vide Notification in Govt. Gazette dated 21.08.2015 amended in Maharashtra Municipal Corporation Act 2015, to levy 1% additional surcharge on property transactions in accordance with section 149(B) of the act. Government of Maharashtra has already started recovering 1% additional Surcharge on property transactions since October 2016 in Nagpur. The additional 1% collection from hike in surcharge will be transferred to Maha-Metro's account.

Thane District is divided in 12 zones/ ward office for collection of surcharge on property transactions and registration charges of properties. At present, the surcharge on property transactions is charged at 6% of the agreement value and registration is charged at 1% of market value or INR 30,000 whichever is less.

The annual collection of surcharge on property transactions in Thane Municipal Area (share of TMC) for the past four years from 2014-15 to 2017-18 has been collected from Thane Municipal Corporation (data also available on TMC website) (**Table 18.20**). As per the sources from TMC, out of the total 6% surcharge on property transactions, 1% surcharge goes to Thane Municipal Corporation.

TABLE 18.20: SURCHARGE ON PROPERTY TRANSACTIONS IN THANE MUNICIPAL AREA

Sr. No.	Year	1% Surcharge on Property Transactions in Thane Municipal Area available to Municipal Corporation (Rs in Cr)
1	2014-15	134
2	2015-16	106
3	2016-17	119
4	2017-18	64

Based on the past growth trends of surcharge collection, the average growth rate comes out to be negative. The figure of 2017-18 is abnormal thus it has not been considered in the projection. Considering that the surcharge collection will increase in coming years, it has been assumed that expected surcharge on property transactions in Thane Municipal area may be expected to grow at a Y-o-Y growth rate of 2%. In similar lines with Nagpur Metro, 1% additional surcharge on property transactions may be collected as a revenue to SPV. The estimated revenue to SPV from 1% additional surcharge on property transactions is presented in **Table 18.21**.

TABLE 18.21: REVENUE FROM ADDITIONAL SURCHARGE ON PROPERTY TRANSACTIONS

S. No.	Year	1% Surcharge on Property Transactions to TMC at Y-o-Y 2% CAGR (INR Cr)	Revenue from additional 1% Surcharge on Property Transactions to SPV (INR Cr)
1	2015	134	
2	2016	106	
3	2017	119	
4	2018	121	
5	2019	124	
6	2020	126	
7	2021	128	
8	2022	131	
9	2023	134	
10	2024	136	

S. No.	Year	1% Surcharge on Property Transactions to TMC at Y-o-Y 2% CAGR (INR Cr)	Revenue from additional 1% Surcharge on Property Transactions to SPV (INR Cr)
11	2025	139	139
12	2026	142	142
13	2027	145	145
14	2028	148	148
15	2029	151	151
16	2030	154	154
17	2031	157	157
18	2032	160	160
19	2033	163	163
20	2034	166	166
21	2035	170	170
22	2036	173	173
23	2037	176	176
24	2038	180	180
25	2039	184	184
26	2040	187	187
27	2041	191	191
28	2042	195	195
29	2043	199	199
30	2044	203	203
31	2045	207	207
32	2046	211	211
33	2047	215	215
34	2048	219	219
35	2049	224	224
		Total	4455.0

18.8.3. Revenue from increase in Development Charge

As per section 124B of Maharashtra Regional and Town Planning Act, 1966, development charges are to be levied & collected by the nodal authority at rates specified in column (4) of the second schedule.

As per point (c) of column 3 of the second Schedule, projects involving development of land for residential or institutional use, also involving building or construction operations shall imply development charge fee as follows:

- For land component – 0.5% of rates of developed land as mentioned in the Stamp Duty Reckoner
- For the built up component – 2.0% of the rates of developed land mentioned in the Stamp Duty Reckoner

The annual collection of development charge in Thane Municipal Area for the past four years from 2014-15 to 2017-18 has been collected from Thane Municipal Corporation (data also available on TMC website) (**TABLE 18.22**).

TABLE 18.22: SURCHARGE ON PROPERTY TRANSACTIONS IN THANE MUNICIPAL AREA

Sr. No.	Year	Development Charge Collection in Thane Municipal Area (Rs in Cr)
1	2014-15	50.02
2	2015-16	168.6
3	2016-17	198.15
4	2017-18	150

Based on the past growth trends of development collection, the average growth rate comes out to be very high. Considering that the development charge collection will increase at low pace in coming years, it has been assumed that expected development charge in Thane Municipal area may be expected to grow at a Y-o-Y growth rate of 2%.

As per the clause 2-1A of the section 124B of the MRTP act, for consideration of a Vital Urban Transport Project, the development charges levied and collected under the provision of the sub-section (2) shall be increased by one hundred percent. This report considers the additional 100% only as the revenue to be accrued towards SPV. The estimated revenue to SPV from 100% increase in development charge is presented in **Table 18.23**.

TABLE 18.23: REVENUE FROM DEVELOPMENT CHARGE TO SPV

S. No.	Year	Development Charge collection by Authority at Y-o-Y 2% CAGR (INR Cr)	100% increase in Development Charge (Revenue to SPV) (INR Cr)
1	2015	50.02	
2	2016	168.6	
3	2017	198.15	
4	2018	150	
5	2019	153	
6	2020	156	
7	2021	159	
8	2022	162	
9	2023	166	
10	2024	169	
11	2025	172	172
12	2026	176	176
13	2027	179	179
14	2028	183	183
15	2029	187	187

S. No.	Year	Development Charge collection by Authority at Y-o-Y 2% CAGR (INR Cr)	100% increase in Development Charge (Revenue to SPV) (INR Cr)
16	2030	190	190
17	2031	194	194
18	2032	198	198
19	2033	202	202
20	2034	206	206
21	2035	210	210
22	2036	214	214
23	2037	219	219
24	2038	223	223
25	2039	227	227
26	2040	232	232
27	2041	237	237
28	2042	241	241
29	2043	246	246
30	2044	251	251
31	2045	256	256
32	2046	261	261
33	2047	266	266
34	2048	272	272
35	2049	277	277
		Total	5,519

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ESTIMATION OF REVENUE FROM OTHER SOURCES

18.9.1. Revenue from Advertisement and Leasing of Commercial Space in Stations

Figure 18.15 and 18.16 present the study of success stories from abroad which points to several innovative and systematic approaches to advertising

FIGURE 18.15: CASE STUDIES OF NON FARE BOX REVENUE FROM ADVERTISEMENT WORLDWIDE

London Underground



- They outsourced the entire advertising planning and strategy to Viacom Outdoor for a period of **8.5 years** which includes station advertising and underground advertising.
- **Investment by agency to the tune of 50 million pounds**, will include digital advertising, digital panels, digital cross-track projections

Corporate branding in Dubai & London



- Emirates Cable Car was a deal in which Emirates pays **36 million pound for 10 years**. This deal was made at the inception of the cable-car launch by London Network Rail
- Dubai Metro has offered 23 out of 47 stations for corporate branding. Government is offering 23 out of 47 stations for corporate branding.

Source: Economist, news, industry highlights

Madrid Vodafone Deal



- Madrid Metro has entered into an agreement with Vodafone to rename one of its lines as "Line-2 Vodafone"
- Station will be named Vodafone-Sol
- **3 million Euros for a period of 3 years**
- Vodafone will be allowed to use its insignia on Madrid's official metro map, platforms and trains.



Dubai Metro

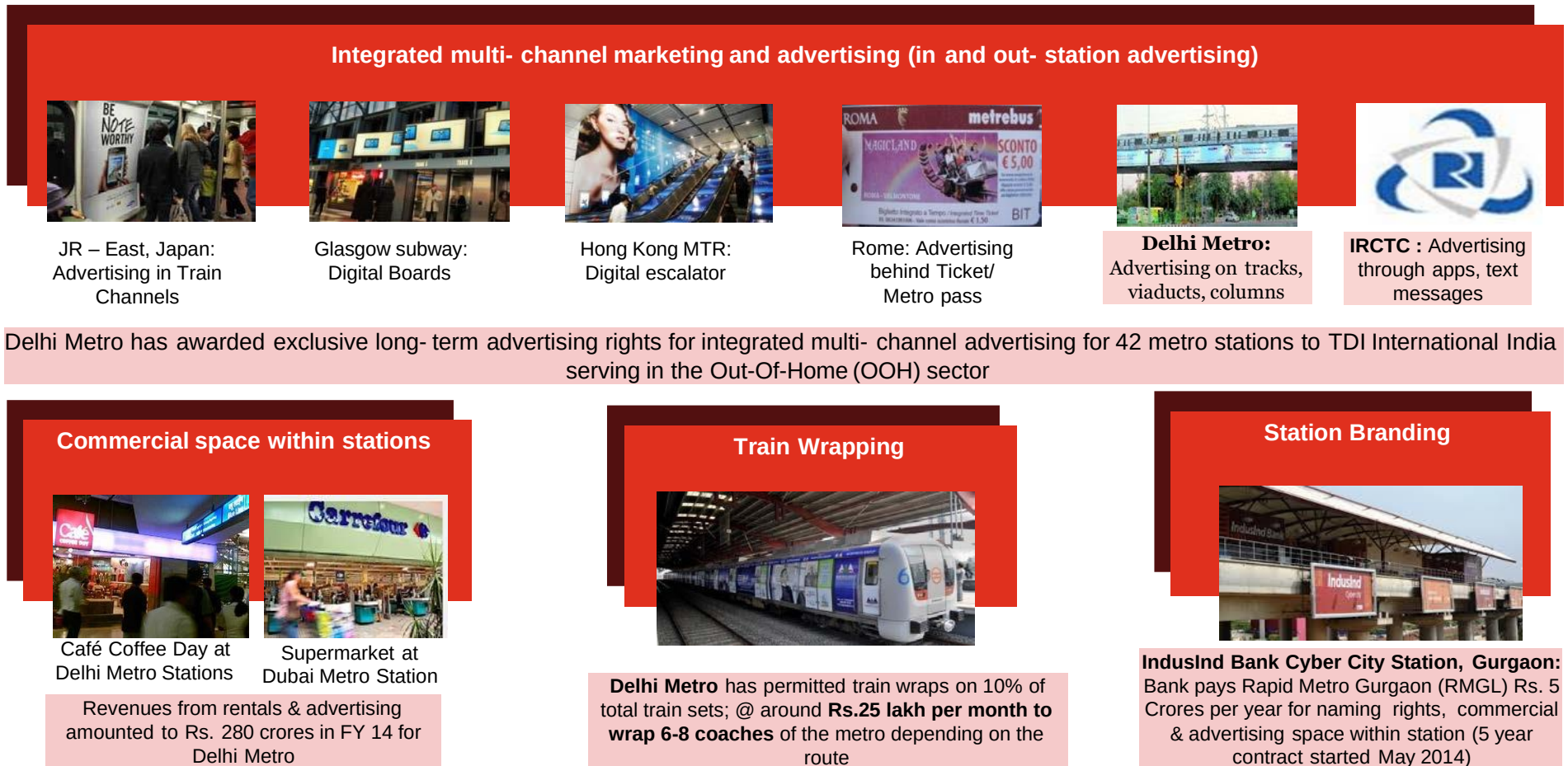
US\$250 mn (Rs. 1,550 crore) over 10 years.
Total 10 stations.
Additional stations being commercialized



London Emirates Cable Car

GBP 36mn (Rs. 335 Crore) over 10 years
Emirates Cable Car (started June 2012)

FIGURE 18.16: CASE STUDIES OF NON FARE BOX REVENUE FROM ADVERTISEMENT WORLDWIDE



Metros earn a substantial part of their non fare box revenue from advertising. Internal station space, external and internal train space and metro pillars are leased out to media agencies for using the space for advertising. Static panels, cut-outs, train wraps, smart card advertising, bill boards, posters, internal train wraps, metro pillar cut-outs, OOH, in train and station audio and video advertising are some of the main sources for revenue. Delhi Metro, Mumbai Metro, Kochi Metro, Kolkata Metro, Gurgaon Metro, Hyderabad Metro, Chennai Metro, Bangalore metro all have a substantial part of their non fare box revenue earned from advertisement. **Generally advertising revenue is observed to be in the range of 7-15% of fare box revenue for most of the above metros depending on the city.**

The year wise revenue details from advertisement and commercial spaces in stations of Delhi Metro are as under:

TABLE 18.24: ADVERTISEMENT REVENUE OF DELHI METRO

Non Fare Box Revenue Heads	Total Revenue (INR Crore)				
	2011-12	2012-13	2013-14	2014-15	2015-16
Fare Box Revenue	1016.3	1223	1364.83	1505.75	1650
Advertisement Revenue	78	81	75.16	77.07	102.05
% share of Advt. Revenue	8%	7%	6%	5%	6%
Average Share	6%				

TABLE 18.25: REVENUE FROM COMMERCIAL SPACE LEASE OF DELHI METRO

Non Fare Box Revenue Heads	Total Revenue (INR Crore)				
	2011-12	2012-13	2013-14	2014-15	2015-16
Fare Box Revenue	1016.3	1223	1364.83	1505.75	1650
Revenue from commercial spaces inside stations	17	22	23.73	29.79	42.59
% share	2%	2%	2%	2%	3%
Average share	2%				

From the tables, it can be seen that the average share of advertisement revenue of Delhi Metro is 6% of fare box revenue and the average share of commercial space lease revenue is 2% of fare box revenue. Considering the share of non fare box revenue of Delhi Metro, the non fare box revenue share from advertisement for Thane Metro may be considered at 5-6% in the initial years of operation and 8% post stabilization of metro operations. Similarly the revenue share from leasing of commercial space inside stations may be considered at 2% in the initial years of operation and 3% post stabilization of metro operations.

The year wise revenue from advertisement and leasing of commercial space inside stations for Thane Metro is presented in **Table 18.26**.

TABLE 18.26: REVENUE FROM ADVERTISEMENT & COMMERCIAL SPACE OF THANE METRO

Year	Fare Box Revenue of Thane Metro (INR Cr)	% Share of Advt. Revenue	Revenue from Advertisement (INR Cr)	% Share of Commercial Space Lease Revenue	Revenue from Leasing of Commercial Space in Stations (INR Cr)
2025	845	5	42.2	2	16.9
2026	931	5	46.5	2	18.6
2027	1026	6	61.6	2	20.5
2028	1127	6	67.6	2	22.5
2029	1235	6	74.1	2	24.7
2030	1358	8	108.6	3	40.7
2031	1493	8	119.5	3	44.8
2032	1642	8	131.4	3	49.3
2033	1812	8	144.9	3	54.4
2034	1990	8	159.2	3	59.7
2035	2259	8	180.7	3	67.8
2036	2415	8	193.2	3	72.5
2037	2586	8	206.9	3	77.6
2038	2767	8	221.3	3	83.0
2039	2964	8	237.1	3	88.9
2040	3165	8	253.2	3	95.0
2041	3389	8	271.1	3	101.7
2042	3627	8	290.2	3	108.8
2043	3881	8	310.5	3	116.4
2044	4151	8	332.0	3	124.5
2045	5110	8	408.8	3	153.3
2046	5544	8	443.5	3	166.3
2047	6026	8	482.1	3	180.8
2048	6547	8	523.8	3	196.4
2049	7101	8	568.1	3	213.0
			5878.3		2198.1

18.9.2. Revenue from Semi-Naming Rights (CO-Branding) of Stations

Co-Branding by Suffixing/Prefixing of Brand Name with the Metro Station name may be allowed for selected metro stations. Co-branding rights may be awarded to the eligible/competent parties through tendering process. The Scope under this type of advertisement may be to Suffix the Brand name with the Metro Station name along with colouring of the station in brand colour. The contract may be awarded generally for tenure of 10 years which may be further extendable by 5

years on mutually agreeable terms and conditions. The bidders quote the lump sum rate/annum for the total scope offered at the station.

The case study of Delhi Metro for the semi-naming rights of stations is presented below:

Particulars		Unit
Revenue from semi naming rights	2	INR cr/station/year
Total no. of stations with semi naming rights	43	no. of stations
Total revenue	86	INR cr/year

The similar rates of semi-naming rights i.e. Rs. 2 Crore per station per year has been considered for Thane Metro. Out of total 22 stations, it has been assumed that lesser number of stations will be given for semi-naming rights in the initial years of metro operation and all the stations will be given post stabilization of metro operation. The year wise revenue from semi-naming rights of station for Thane Metro is presented in **Table 18.27**.

TABLE 18.27: REVENUE FROM SEMI-NAMING RIGHTS OF STATIONS

Year	No of stations given for semi naming rights	Revenue estimate (INR/cr.) per station per year	Total Revenue from semi-naming rights (INR Cr.)
2025	6	2	12
2026	8	2.1	16.8
2027	10	2.2	22.1
2028	12	2.3	27.8
2029	14	2.4	34.0
2030	16	2.6	40.8
2031	20	2.7	53.6
2032	22	2.8	61.9
2033	22	3.0	65.0
2034	22	3.1	68.3
2035	22	3.3	71.7
2036	22	3.4	75.3
2037	22	3.6	79.0
2038	22	3.8	83.0
2039	22	4.0	87.1
2040	22	4.2	91.5
2041	22	4.4	96.0
2042	22	4.6	100.8
2043	22	4.8	105.9
2044	22	5.1	111.2
2045	22	5.3	116.7

Year	No of stations given for semi naming rights	Revenue estimate (INR/cr.) per station per year	Total Revenue from semi-naming rights (INR Cr.)
2046	22	5.6	122.6
2047	22	5.9	128.7
2048	22	6.1	135.1
2049	22	6.5	141.9
		Total	1948.9

CHAPTER - 19

FINANCIAL ANALYSIS

19. FINANCIAL ANALYSIS & NON FARE BOX REVENUE ASSESSMENT

19.1. INPUT FOR THE ANALYSIS

19.1.1. Input for Analysis

The financial analysis has been carried out for the Thane metro corridor. Accordingly, the capital costs and O&M costs for the corridor has been added to arrive at the total capital and O&M costs for proposed Thane MRTS.

19.1.2. Capital Cost

The Construction cost of the metro corridor at July, 2023 prices is estimated at Rs. **6032.57** Crore. The total cost of project including land & R&R cost is estimated at Rs. **8915.35** Crore. The capital cost components at July, 2023 are given in **Table 19.1**.

TABLE 19.1: CAPITAL COSTS (RS. IN CRORE)

S.No	Cost Component	Total
1	Construction Cost without land & R&R	6032.57
2	Land Cost including R&R Costs	3170.05
	· Private land	2643.40
	· Govt land	526.65
3	Construction Cost including land & R&R	9202.62
	Taxes	1166.62
	· Central Taxes	624.10
	· State Taxes	542.52
4	Total Cost with Land & Taxes & R&R	10369.24
5	Total Cost with land and Central Taxes only	9826.72

19.1.3. Completion Cost

Escalation rate has been assumed @ 5%. It has been calculated on the basis of growth in Whole Sale Price index for last 12 years (**Table 19.2**).

TABLE 19.2: ESTIMATION OF ESCALATION RATE

Financial Year	WPI Index
2016-17	183.2
2015-16	176.67

Financial Year	WPI Index
2014-15	181.19
2013-14	177.64
2012-13	167.62
2011-12	156.13
2010-11	143.32
2009-10	130.81
2008-09	126.02
2007-08	116.63
2006-07	111.35
2005-06	104.47
Growth over 12 years	1.0479 ~1.05

Source: Govt. of India, Ministry of Commerce & Industry

With escalation factor of 5% p.a., Land cost has been escalated to estimate land rates applicable at the time of transfer. The details of completion cost under different scenarios are as per **Table 19.3**.

TABLE 19.3: DETAILS OF COMPLETION COSTS (RS IN CRORE)

Completion Cost	Amount
Cost without taxes, Land & R&R	6,846
Cost with Central Taxes and without Land & R&R	7,554
Cost with all taxes and Land & R&R (without PPP component & IDC)	11,584

19.1.4. Phasing of Construction

Considering the lengths of MRTS network, it is expected that the construction of Thane metro will take 5-6 years but the operation can start after 5 years. **Table 19.4** gives the % distribution of costs during the construction period based on typical construction schedule. This has been finalized in discussion with Maha Metro.

TABLE 19.4: % DISTRIBUTION OF COSTS DURING CONSTRUCTION

Year	% Distribution of Cost
2024-2025	10%
2025-2026	25%
2026-2027	30%
2027-2028	20%
2028-2029	15%

19.1.5. Requirement of Funds

The year wise requirement of funds under different scenarios has been given in **Table 19.5** (Without any Taxes), in **Table 19.6** (With Central Taxes only) and

Table 19.7 (With Central and State Taxes). The cost of land is divided into two initial years during which it is expected that the land acquisition work would be over and related payments would be released.

TABLE 19.5: YEAR WISE FUND REQUIREMENTS WITHOUT TAXES (Rs. IN CRORE)

Year	Completion Cost	Land & R&R Cost	Completion Costs (inc Land & R&R)
2024-2025	618	974	1592
2025-2026	1623	1365	2988
2026-2027	2045	1075	3120
2027-2028	1432		1432
2028-2029	1128		1128
TOTAL	6846	3414	10260

TABLE 19.6: YEAR WISE FUND REQUIREMENTS WITH CENTRAL TAXES WITHOUT LAND & R&R (Rs. IN CRORE)

Year	Completion Cost	Central Taxes	Total Completion Cost
2024-2025	618	64	682
2025-2026	1623	168	1791
2026-2027	2045	211	2256
2027-2028	1432	148	1580
2028-2029	1128	117	1245
TOTAL	6846	708	7554

TABLE 19.7: YEAR WISE FUND REQUIREMENTS WITH ALL TAXES (Rs. IN CRORE)

Year	Completion Cost	Land & R&R Cost	Central Taxes	State Taxes	Total Completion Cost
2024-2025	618	974	64	56	1712
2025-2026	1623	1365	168	146	3302
2026-2027	2045	1075	211	184	3515
2027-2028	1432		148	129	1709
2028-2029	1128		117	101	1346
TOTAL	6846	3414	708	616	11584

19.1.6. Operation & Maintenance Costs Estimates

- **Basis of O&M Cost Estimates**

The O&M Cost has three major components which include:

- Manpower Cost
- Energy Cost
- Maintenance Cost

Staff Cost

The O&M staff is assumed to be provided @ 35 persons per kilometer and the annual cost this account is estimated considering average staff salary of Rs. 14.60 Lakhs per annum in the year 2029 considering pay-revision. The escalation factor used for staff costs is 9% per annum to provide for growth in salaries. The estimated staff cost is **Rs. 143.84 Cr.** for Thane Metro for the inception year i.e. 2027.

Maintenance Expenses

Maintenance expenses are taken @ Rs. 1.68 Crores/km in the year 2021. Maintenance cost for Thane Metro would be **Rs. 72.15 Crore** in the inception year i.e. 2029 considering escalation @ 5% p.a. for every year of operation.

Energy Charges

The energy consumption to meet the traction and non-traction power requirement is based on traffic demand for different horizon years. The cost of electricity is a significant part of O&M charges, constituting about 30% of total annual working cost. The traction power tariff is taken @ Rs. 5.80 per kwh & Rs 270 per kva per month in the year 2018, which is escalated @ 5% every year of operation. Annual energy consumption charges have been estimated as **Rs. 121.67 crore** in year 2029, **Rs. 184.77 crore** in 2035, **Rs. 352.99 crore** in 2045 and **Rs. 481.58 crore** in 2050 for Thane Metro.

Additional Investment

To cater to increased traffic demand, additional investment will have to be made for purchase of additional coaches, installation of balance AFC, Lifts& Escalators. The additional investment in the year 2035 works out to **Rs. 368.61 Crores** for purchase of 30 additional coaches. An investment of **Rs. 525.67Crores** would be required for purchase of 39 additional coaches in the year 2045and **Rs 401.80 crores** for 27 additional coaches in the year 2050 for Thane Metro. These additional investments have been worked out considering an escalation factor of 2% per annum for rolling stock.

Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipments due to wear and tear. With the nature of equipment proposed to be provided for the corridor, it is expected that about 25% of the equipment comprising Electrical, Rolling stock and 50% of Signalling & Telecom would require replacement/ rehabilitation after 20 years. The replacement cost for Thane Metro works out to be **Rs. 1945.99 Crore** in the year 2045. The replacement cost has been worked out considering an escalation factor of 5% per annum. The Replacement Cost in terms be considered as Depreciation Cost. The year wise total Operation and Maintenance cost for the corridor of Thane Metro is indicated in **Table 19.8**.

TABLE 19.8: OPERATION AND MAINTENANCE COSTS (RS IN CRORE)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M cost	Addition/ Replace - ment Cost (Cr.)	Remarks
	Esc @9%	Esc @5%	Esc @5%			
2029	143.84	72.15	121.67	337.66		
2030	156.79	75.76	130.31	362.86		
2031	170.90	79.55	139.45	389.90		
2032	186.28	83.53	149.23	419.04		
2033	203.05	87.71	159.54	450.30		
2034	221.32	92.10	170.54	483.96		
2035	241.24	96.71	184.77	522.72	368.61	Addition of 45 coaches
2036	262.95	101.55	196.47	560.97		
2037	286.62	106.63	208.96	602.21		
2038	312.42	111.96	222.14	646.52		
2039	340.54	117.56	236.17	694.27		
2040	371.19	123.44	251.06	745.69		
2041	404.60	129.61	266.85	801.06		
2042	441.01	136.09	283.55	860.65		
2043	480.70	142.89	301.33	924.92		
2044	523.96	150.03	320.08	994.07		
2045	571.12	157.53	352.99	1,081.64	2471.55	Addition of 39 coaches
2046	622.52	165.41	379.13	1167.06		525.67
2047	678.55	173.68	407.10	1259.33		Replacement of 25% of
2048	739.62	182.36	436.81	1358.79		Electrical & 50% of S&T
						assets = 1945.88
						Total = 2471.55

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M cost	Addition/ Replace - ment Cost (Cr.)	Remarks
	Esc @9%	Esc @5%	Esc @5%			
2049	806.19	191.48	468.48	1466.15		
2050	878.75	201.05	504.28	1584.08	401.80	Addition of 27 coaches
2051	957.84	211.10	479.11	1648.05		
2052	1044.05	221.66	514.49	1780.20		
2053	1138.00	232.74	557.49	1928.23		
2054	1240.42	244.38	585.37	2070.16		

19.2. MEANS OF FINANCE

The Revenue for Thane metro will mainly consists of fare box collection and revenue from other non-fare box sources such as property development, advertisement, parking, taxes etc. Estimation of revenue from fare box and non-fare box source has been made.

19.2.1 Fare Box Revenue

➤ Projected Traffic Demand

The ridership on the proposed Thane metro system has been estimated at 6.47 Lakh passenger trips per day in the year 2029. The ridership figures for key horizon years are given in **Table 19-9**.

TABLE 19.9: EXPECTED METRO RIDERSHIP IN HORIZON YEARS

Year	Passenger Trips per day (Lakh)
2029	6.47
2035	7.61
2045	8.72

➤ Trip Length Distribution

Average trip length on the Thane metro corridor is 7.07 km in 2045. The trip length distribution is given in **Table 19.10**.

TABLE 19.10: TRIP LENGTH DISTRIBUTION

MRTS FARE SLAB (KMS)	2029	2035	2045
	% Distribution in Horizon Years		
0 to 2	16.87%	17.16%	16.53%
2 to 5	27.53%	25.44%	25.63%
5 to 12	42.40%	37.84%	42.52%
12 to 16	12.18%	15.04%	14.34%

MRTS FARE SLAB (KMS)	2029	2035	2045
	% Distribution in Horizon Years		
16 to 21	0.83%	4.09%	1.75%
21 to 32	0.15%	0.38%	0.24%
>32	0.00%	0.00%	0.00%
Average Trip Length (Km)	6.63	7.24	7.07

➤ Fare Structure

DMRC revised its fare structure in 2017 with revision @ 7% per year as proposed by DMRC Fare Fixation Committee 2016. DMRC fare in 2017-18 and Thane metro fare for first year of operation in the year 2024-25 on the same basis is given in (Table 19.11).

TABLE 19.11: FARE STRUCTURE - THANE METRO BASED ON REVISED DMRC FARE

Fare slabs	DMRC Fare in 2017-18	MAHA Metro Fare in 2029
0-2	10	19
2-5	20	40
5-12	30	59
12-21	40	78
21-32	50	98
>32	60	119

DMRC revised its fares in 2017 after a gap of 8 years. The increase in fares is almost 7% per annum. Considering the fact that DMRC has been operating MRTS systems since 2002 and the current fares reflect the better picture of fares in relation to operational cost. It is, therefore, suggested that MAHA metro may consider adopting the revised fare structure of DMRC for Thane Metro. **Table 19.12** the year wise fare structure for Thane Metro in horizon years.

TABLE 19.12: FARE STRUCTURE FOR THANE METRO BASED ON REVISED DMRC FARES

YEAR		0-2	2-5	5-12	12-21	21-32	>32
2029	2030	19	40	59	78	98	119
2030	2031	20	43	63	83	105	127
2031	2032	21	46	67	89	112	136
2032	2033	22	49	72	95	120	146
2033	2034	24	52	77	102	128	156
2034	2035	26	56	82	109	137	167
2035	2036	28	60	88	117	147	179
2036	2037	30	64	94	125	157	192
2037	2038	32	68	101	134	168	205

YEAR		0-2	2-5	5-12	12-21	21-32	>32
2038	2039	34	73	108	143	180	219
2039	2040	36	78	116	153	193	234
2040	2041	39	83	124	164	207	250
2041	2042	42	89	133	175	221	268
2042	2043	45	95	142	187	236	287
2043	2044	48	102	152	200	253	307
2044	2045	51	109	163	214	271	328
2045	2046	55	117	174	229	290	351
2046	2047	59	125	186	245	310	376
2047	2048	63	134	199	262	332	402
2048	2049	67	143	213	280	355	430
2049	2050	72	153	228	300	380	460
2050	2051	77	164	244	321	407	492
2051	2052	82	175	261	343	435	526
2052	2053	88	187	279	367	465	563
2053	2054	94	200	299	393	498	602

19.2.2 Non Fare Box Revenue

The sources of non fare box revenue identified in the study are divided into two heads:

1. Value Capture Finance (VCF) tools
 2. Other sources like Advertisement etc.
- a) The three sources as a part of VCF have been used for assessment of revenue in Thane Metro in similar lines with Thane Metro:
- Levying premium on additional Floor Space Index (FSI)
 - Levying 1% additional surcharge on property transactions
 - 100% increase in Development Charge

The assessment of revenue from VCF tools has been detailed in Chapter 18.

- b) The other sources of Non-fare box revenue may be considered for Thane Metro as under:

i. Advertisements:

- **Inside Station Advertisement:** All section/Lines of Metro may be awarded for advertisement purposes. Scope of the inside station advertisement may be display static advertisement on fixed advertisement boards/panels as well as through digital displays, putting up promotional canopies etc. Area of advertisement space may be fixed based on type of station i.e. elevated or underground station, size of station, footfall of station etc.
- **Outdoor Advertisement:** Commercial Advertisement may be allowed by putting Advertisement boards on Metro Civil Structure/Ancillary Buildings/Via Duct/FOBs/Pillars. Scope of the Outdoor advertisement may be to put up static advertisement display at the Metro Pillars/FOBs/Metro Viaduct/Ancillary Building/Lift Lobby etc. Area of advertisement space may be decided based on type, size of station and footfall of station etc. and as per policy of Urban Local Body.
- **Advertisement on Trains:** The Metro company may be allowed Commercial Advertisement on Metro Rail Trains; inside on prefabricated advertisement spaces and outside by wrapping of trains. Bidder may wrap 10% of available cars subject to maximum of 20% trains available in the line as well as may do advertisement on pre-designated spaces inside the Metro Trains.
- **Co-Branding:** Co-Branding by Suffixing/Prefixing of Brand Name with the Metro Station name may be allowed for selected metro stations. Co-branding rights may be awarded to the eligible/competent parties through tendering process. The Scope under this type of advertisement may be to Suffix the Brand name with the Metro Station name whereas for Stations. Colouring of the station in brand colour as well as inside and outside Advertisement rights for the station may also be permitted. The contract may be awarded generally for tenure of 10 years which may be further extendable by 5 years on mutually agreeable terms and conditions. The bidders quote the lump sum rate/annum for the total scope offered at the station.

ii. Shops:

- **Built-up Shops:** Built up shops on the selected Metro Stations may be available on license basis. These types of Shops may have an inbuilt structure and located within the Metro Stations. The Shops awarded to the eligible/competent parties through tendering process. The shops which fail to attract any bid through tendering process may be made available through Walk-in-basis Scheme (First come first serve basis) wherein the bidders may take the shops at reserve price.

- **Kiosks:** - Leasing of small bare spaces to operate small kiosks for commuters facilitations may be allowed on the metro stations.
- **Water Vending Kiosk:** - Small bare spaces may be allotted to install Water Vending Kiosks as commuter facilitation.
- **ATMs** - Bare spaces may be leased to Banks to install and operate their ATMs/e-lobby at Metro Stations as commuter facility.

The assessment of revenue from other non fare box sources has been detailed in Chapter 18.

Year wise revenue from all the sources of non fare box revenue under the heads of premium on additional FSI, Cess on stamp duty, development charge, Advertisement, Leasing of commercial space in stations and semi-naming rights of stations is shown In **TABLE 19-13**.

19.2.3 Urban Transport Fund

The non fare box revenue from VCF tools will go to Urban Transport Fund from where it will be distributed to different agencies including SPV implementing Thane MRTS project. As per the prevalent rules and regulations in the state, following revenue share will be given to MRTS SPV

- Premium on additional FSI-50%
- Additional surcharge on property transactions-100%
- Development Charge- 100%

However, the revenue from other sources namely advertisement, leasing of commercial space at stations and naming of metro stations will be go directly to MRTS SPV.

TABLE 19-13: ESTIMATION OF NON FARE BOX REVENUE (2029-2054)

Year	Total Revenue (Rs. In Crore)								
	TOD (VCF)				Other Sources				Grand Total
	50% of Premium on Additional FSI	1 % Additional Surcharge on Property Transactions	Development Charge	Total	Advt.	Leasing of Commercial Space in Stations	Semi-Naming Rights of Stations	Total	
2029	89.1	151	187	427.1	74.1	24.7	34	132.8	559.9
2030	91.1	154	190	435.1	108.6	40.7	41	190.3	625.4
2031	92.9	157	194	443.9	119.5	44.8	54	218.3	662.2
2032	87.4	160	198	445.4	131.4	49.3	62	242.7	688.1
2033	89.1	163	202	454.1	144.9	54.4	65	264.3	718.4
2034	76.9	166	206	448.9	159.2	59.7	68	286.9	735.8
2035	78.4	170	210	458.4	180.7	67.8	72	320.5	778.9
2036	80	173	214	467.0	193.2	72.5	75	340.7	807.7
2037	81.6	176	219	476.6	206.9	77.6	79	363.5	840.1
2038	83.2	180	223	486.2	221.3	83	83	387.3	873.5
2039	73.9	184	227	484.9	237.1	88.9	87	413	897.9
2040	75.4	187	232	494.4	253.2	95	91	439.2	933.6
2041	76.9	191	237	504.9	271.1	101.7	96	468.8	973.7
2042	78.4	195	241	514.4	290.2	108.8	101	500	1014.4
2043	80	199	246	525.0	310.5	116.4	106	532.9	1057.9
2044	81.6	203	251	535.6	332	124.5	111	567.5	1103.1
2045	83.2	207	256	546.2	408.8	153.3	117	679.1	1225.3
2046	84.9	211	261	556.9	443.5	166.3	123	732.8	1289.7
2047	86.6	215	266	567.6	482.1	180.8	129	791.9	1359.5
2048	88.3	219	272	579.3	523.8	196.4	135	855.2	1434.5
2049	90.1	224	277	591.1	568.1	213	142	923.1	1514.2
2050	91.9	228	283	602.9	616.6	231.2	149	996.8	1599.7
2051	93.7	233	289	615.7	670.2	251.3	156	1077.5	1693.2
2052	95.5	237.8	294	627.5	610.71	229.22	163.03	1002.95	1630.4
2053	97.3	242.6	299	639.4	632.82	237.52	167.93	1038.26	1677.7
2054	99.1	247.5	305	651.4	657.93	246.98	173.10	1078.01	1729.4
TOTAL	2226.6	5073.8	6279.4	13579.4	8848.5	3315.8	2680.1	14844.3	28424.2

19.2.4 Total Revenue

The total annual revenue through the fare box and non fare box sources for the study corridor is given in **Table 19.14**.

TABLE 19.14: TOTAL REVENUE COLLECTION (RS. IN CRORE) - DMRC REVISED FARES

Source of Revenue	2029	2035	2045
Fare Box Revenue	1171	2206	5114
Non Fare Box Revenue	560	779	1225
Total Revenue	1731	2985	6339

19.3. OPERATIONAL VIABILITY/FINANCIAL INTERNAL RATE OF RETURN (FIRR)

The FIRR for the project with capital costs including all taxes and revenue from fare box and non-fare box sources works out to be **15.06%** with DMRC revised fares and is presented in **Table 19.16**. As with DMRC revised fares, the project has better financial viability, it is suggested that MAHA metro may adopt fare structure based on revised fares of DMRC.

19.4. SENSITIVITY ANALYSIS

The FIRR of the project is sensitive to revenues, and capital costs. The sensitivity of the project FIRR for DMRC revised fares Scenario with respect to above factors is given in **Table 19.15**.

It can be seen that the project FIRR is more sensitive to ridership variations than to variations in costs.

TABLE 19.15: PROJECT FIRR SENSITIVITY W.R.T COST AND RIDERSHIP

Parameter	+5%	+10%	-5%	-10%
Capital Cost	14.06	12.99	15.70	16.53
Ridership	15.47	16.24	14.60	13.90

TABLE 19.16: THANE MRTS FIRR BASED ON DMRC REVISED FARES (Rs. IN CRORE)

Year	Project Completion Costs				Project Revenues							Project O&M Costs		Operational Surplus
	Completion Cost	Land Cost	All taxes	Total Project Completion Cost	Fare Box Revenue	Revenue from Adv & PD	Premium on Additional FSI	1 % Additional Surcharge on Property Transactions	Development Charge	Total	Gross Revenue	O&M Cost	Additional/ Replacement Cost	
2024-2025	636	975	120	1730	0.00	0.00					0			-1730
2025-2026	1666	1365	314	3345	0.00	0.00					0			-3345
2026-2027	2097	1075	396	3567	0.00	0.00					0			-3567
2027-2028	1466		277	1743	0.00	0.00								-1743
2028-2029	1153		218	1371	0	0								-1371
2029-2030					1171	133	89	151	187	427	1730	338	0	1393
2030-2031					1252	190	91	154	190	435	1878	363	0	1515
2031-2032					1353	218	93	157	194	444	2015	390	0	1677
2032-2033					1455	243	87	160	198	445	2143	419	0	1780
2033-2034					1571	264	89	163	202	454	2289	450	0	1900
2034-2035					1690	287	77	166	206	449	2426	484	0	2007
2035-2036					2206	321	78	170	210	458	2985	523	0	2534
2036-2037					2372	341	80	173	214	467	3180	561	0	2696
2037-2038					2550	364	82	176	219	477	3390	602	369	2499
2038-2039					2745	387	83	180	223	486	3619	647	0	3058
2039-2040					2954	413	74	184	227	485	3852	694	0	3250
2040-2041					3163	439	75	187	232	494	4096	746	0	3450
2041-2042					3407	469	77	191	237	505	4381	801	0	3687
2042-2043					3652	500	78	195	241	514	4666	861	0	3921
2043-2044					3930	533	80	199	246	525	4988	925	0	4187
2044-2045					4203	568	82	203	251	536	5306	994	0	4446
2045-2046					5114	679	83	207	256	546	6339	1082	0	5415
2046-2047					5500	733	85	211	261	557	6789	1167	0	5795
2047-2048					5906	792	87	215	266	568	7266	1259	2472	3712
2048-2049					6312	855	88	219	272	579	7747	1359	0	6579
2049-2050					6774	923	90	224	277	591	8289	1456	0	7029
2050-2051					7273	997	92	228	283	603	8873	1561	0	7514
2051-2052					7825	1078	94	233	289	616	9518	1675	0	8062
2052-2053					8358	1003	96	238	294	627	9989	1797	402	8025
2053-2054					8957	1038	97	243	299	639	10635	1928	0	8960
TOTAL	7018	3414	1324	11756	101696	13766	2127	4826	5975	12928	128390	2308		93335
													IRR	0.1506
													%	15.06

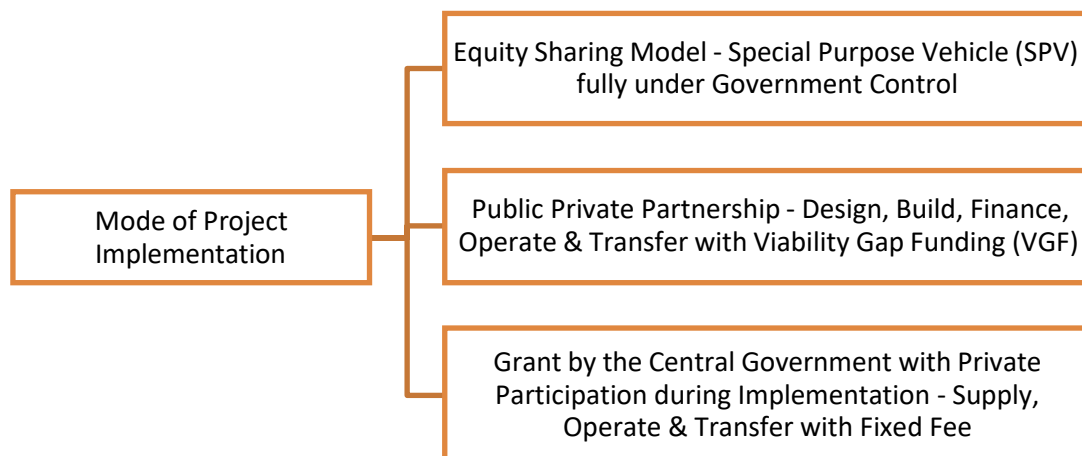
19.5. ALTERNATE MEANS OF FINANCING

The financing option for metro implementation depends upon selection of the dedicated agency created to implement the project. As per Metro Rail Policy '2017, the prominent models are:

- Equity Sharing Model- Special Purpose Vehicle (SPV) fully under Government Control
- Public Private Partnership (PPP)
- Grant by the Central Government

Figure19.1 presents the implementation models graphically.

FIGURE19.1: MODEL OF IMPLEMENTATION OF MRTS PROJECTS



19.5.1 Equity Sharing Model (SPV Model)

Under this model, a Special Purpose Vehicle (SPV) is set up as a joint venture between Central Government and State Government for the implementation of the project and for its subsequent Operation & Maintenance. Under this arrangement Government of India and State Government make equal equity contribution and run SPV as a commercial enterprise. As per the prevalent practice, Central Government contribute 20% of the project cost as their equity contribution. An equal amount can be contributed by State Government aggregating the total equity to 40%. Remaining 60% is arranged as soft loan from funding agencies. Delhi Metro Rail Corporation, Bangalore Metro Rail Corporation, Chennai Metro Rail Corporation & Kolkata Metro Rail Corporation are some of the examples of success of such a SPV. Under implementation Thane metro has also been planned on Equity Sharing Model only.

19.5.2 Public Private Partnership

As per Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail.

The fundamental principle underlying Public Private Partnerships (PPP's) as a development option for any infrastructure project is to combine the strengths of the private sector with those of the public sector in order to overcome challenges faced during construction & operation and to achieve better outcomes. The private sector can be expected to contribute to efficiency gains in the development of land, construction, operations and maintenance through the use of technology, better management and construction practices. In addition, the private sector should be expected to bring economies of scale from large projects and by involving a larger number of private partners.

However, the success of PPP will depend critically on designing PPP structures that make an appropriate allocation of risks, responsibilities, rewards and penalties, and create the incentives for value creation. Indeed, this risk allocation is the defining feature of the PPP strategy. The golden principle is that risks should be allocated to the entity best equipped to manage each risk. The expectation is that such an allocation of risks will not only produce the best possible program and project outcomes but also optimize costs. This should lead to good quality outcomes at optimum prices.

19.5.3 Grant by Central Government

Under this option Central Government would fund 10% of the project completion cost excluding private investment Land, R&R and state taxes. Remaining costs are to be borne by state with Private sector participation. These models have been explored for implementation of Thane Metro Rail.

19.5.4 Case Studies of Private Sector Participation in MRTS in Indian Cities

Metro systems being planned in the cities of India have majorly adopted equity sharing model. Some of the cities have gone for private sector participation also. **Exhibit 19.1** to **Exhibit 19.4** give the examples of PPP in construction and operation of MRT system. Some of the metro companies have involved private sector in O&M also. **Exhibit 19.5** to **Exhibit 19.7** gives the examples of PPP in some of the O&M

activities. The involvement of private sector in O&M activities in case of Thane Metro, can be finalized at the time of operation.

EXHIBIT 19.1: DELHI AIRPORT LINE UNDER PPP MODEL

DMRC has implemented a High Speed Airport Link from New Delhi Railway Station to IGI Airport and further extension to Sector-21, Dwarka covering a distance of 22.7 KM with private sector participation. The project with an estimated cost of Rs. 3869 Crore has been implemented under a unique model of PPP where in the DMRC has undertaken the civil works with the funds being contributed by GoI, GNCTD, Delhi International Airport Limited and DDA (54%) and the cost of systems and Rolling Stock (46%) is being met by the private operator who will operate the system for 30 years, after which the system will revert back to DMRC. The approved funding pattern of the line is depicted in **Figure 19.2**. **There have been some issues with the concessionaire and DMRC is now operating the system.**

FIGURE 19.2 APPROVED FUNDING PATTERN OF DELHI AIRPORT LINE

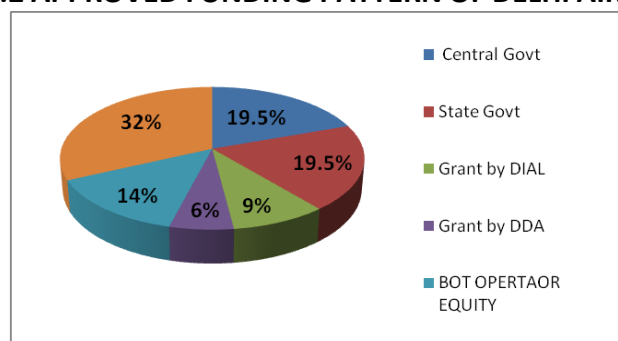


EXHIBIT 19.2: HYDERABAD METRO UNDER PPP MODEL

Hyderabad Metro is the first PPP Metro Rail Project that has been sanctioned by Government of India. GoAP has undertaken the Hyderabad Metro Rail Project under Viability Gap Funding (VGF) scheme of GoI. The MRTS network include three high density traffic corridor with total length of about 71 km. The Project is being executed by L&T on design, build, and finance, operate and transfer (DBFOT) basis. GoAP will spend another 1,980 Crore towards land acquisition, R&R package, shifting of utilities and GoI will support the project with grant of 1,458 Crore as VGF. **Figure 19.3** gives the funding plan of Hyderabad metro.

FIGURE 19.3 FUNDING PATTERN OF HYDERABAD METRO

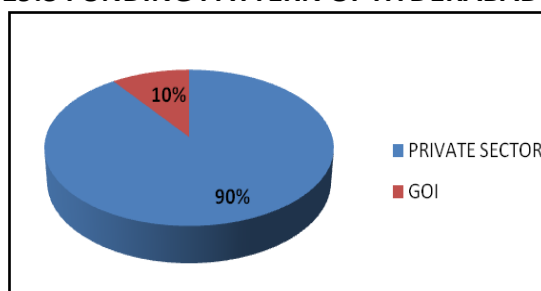


EXHIBIT19.3: GURGAON METRO UNDER PPP MODEL

Gurgaon's Rapid Metro project is India's first fully privately financed metro. With the project cost of Rs 1100 Crore, it has a network of 5.1 km connecting Cyber City, NH-8 & Sikanderpur Station (DMRC) in Phase I. The planned route for Rapid Metro acts as a feeder to the MRC's Jahangirpuri-Central Secretariat-HUDA City Centre (Yellow Line). A special purpose vehicle (SPV), Rapid Metro Rail Gurgaon Limited (RMGL) was formed to construct, operate and maintain the metro.

EXHIBIT19.4: MUMBAI METRO LINE 1 & 2 UNDER PPP MODEL

In contrast to the SPV model adopted for construction of metro rail system in the city of Delhi, Bangalore, Chennai & Kolkata, the Maharashtra government has opted Build Own, Operate & Transfer (BOOT) model in the city of Mumbai.

So far, 2 lines covering a distance of 44 KMs (Line 1 of 11.07 KMs from Versova – Andheri - Ghatkopar with a total cost of Rs. 2356 Crore and Line 2 of 32 KMs from Charkop – Bandra – Mankurd with an estimated cost of Rs. 8250 Crore) have been awarded to private operator for construction and operation by giving Viability Gap Funding by GoI & Maharashtra State Government to the extent of Rs. 650 Crore and Rs. 1532 Crore for Line 1 & Line 2 respectively.

*Mumbai Metro One Private Limited is a Joint Venture Company formed by Reliance Energy Limited, a Reliance ADA Group Company, Veolia Transport, France and Mumbai Metropolitan Region Development Authority (MMRDA) incorporated under the Companies Act, 1956 to implement this project. **Figure 19.4** gives the funding pattern of Mumbai Metro Line 1. Line 1 is now operational. There are some issues with the concessionaire and the implementation mechanism for Line 2 is being revisited.*

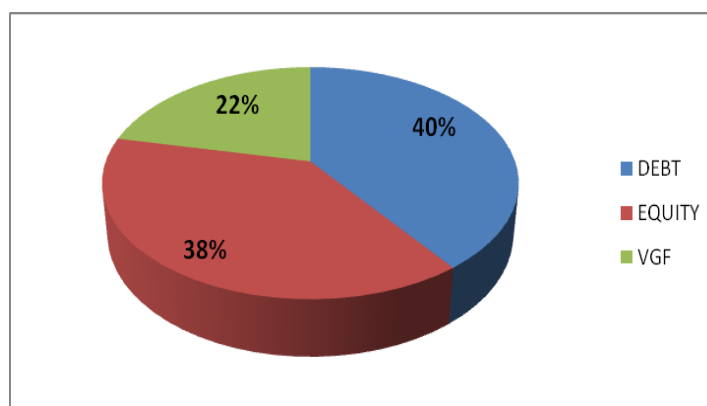
FIGURE 19.4 FUNDING PATTERN OF MUMBAI METRO LINE 1

EXHIBIT 19.5: PPP IN O&M ACTIVITIES IN BANGALORE METRO

Bangalore Metro Rail Corporation Ltd (BMRCL) has signed a memorandum of understanding (MoU) with the Embassy Group to build the Kadubeesanahalli Metro station. Embassy Group will pay Rs 100 Crore to BMRCL in installments. The group is the first corporate to sign the agreement under the public-private partnership scheme. The station, to be located just outside the Embassy Tech Village on the Outer Ring Road, will be on the recently approved 17-km North-South Metro corridor linking Silk Board Junction with Krishnarajapuram.

The construction will be done in accordance with the façade designs and specifications approved by BMRCL. The period of concession and permission granted to Embassy Group will be for 30 years starting from the date of commencement of commercial operations and could be extended further on mutual terms. The agreement mandates that the group will maintain Kadubeesanahalli Metro station, including housekeeping and maintenance, along with all the equipment, according to specifications laid down by the corporation.

The partnership also means the group will be entitled to utilize the pre-determined spaces for advertisements. Embassy can also use the leasable retail space measuring approximately 3,000 sq. ft at the Metro station. Embassy will also have the advantage of leveraging the linear zone of 250 metres around the Kadubeesanahalli Metro

EXHIBIT 19.6: PPP IN O&M ACTIVITIES IN LUCKNOW METRO - AFC

LMRC has tied up with M/s HDFC Bank for Fare Collection System and Provision of Allied Banking Application for Phase I (21 stations of North South Corridor of the project). The Bank was offered two options for partnership

Option 1 – Annual royalty payable by bidder to LMRC (including provisions of TVMs and RCTMs)

Option 2 – Annual royalty payable by bidder to LMRC (excluding provisions of TVMs and RCTMs)

The Royalty Shall increase by 20% on completion of every 3 years on a compounding basis.

M/s HDFC Bank opted for Option 2 i.e. Annual Royalty payable by Bidder to LMRC (excluding provisions of TVMs and RCTMs). HDFC Bank pays Rs. 1000 as Annual Royalty under option 2 to LMRC. While opting for option 2, following cost is being incurred by HDFC Bank in discharging the obligation.

Annual Manpower Cost (including dress) – Rs. 101.17 Lakh

Annual Cash Management Charges – Rs. 53.4 Lakh

Annual Maintenance Charges – Rs. 3.00 Lakh

Total - Rs. 157.54 Lakh

The above cost will be increased by approx. 9% annually considering the inflation and other cost.

EXHIBIT 19.7: PPP IN O&M ACTIVITIES IN KOCHI METRO - AFC

Kochi Metro Rail Limited (KMRL) has signed a public-private partnership (PPP) pact with Axis Bank for the automated fare collection (AFC) system. Under the agreement, investment for the entire funding required for the AFC system will be undertaken by Axis Bank, which will also maintain it for 10 years. The bank will pay a royalty of Rs 209 Crore over the next 10 years for the right to be KMRL's partner in this endeavor. In return, Axis Bank will get the right to issue co-branded cards, which will function as a smart card as well as a ticket, to the users of the metro. In addition to this, 0.2 per cent of Axis Bank's gross revenue, from the utilization of this card outside KMRL's ecosystem in various mercantile outlets and internet transactions, will also accrue to KMRL over the next 10 years.

The AFC system is a critical core component of any metro system. It includes complex hardware and software installed at entry points of metro stations as well as buses and boats. It uses radio frequency identification devices (RFID) to collect fares from the users. In such a system, the metro ticket can be in the form of a co-branded card or an NFC-enabled smart phone or a 'patch' on a mobile device or any other surface with NFC stickers or QR code, or even as a paper-coupon. The smart card can be linked with any bank account of the user, in any bank.

KMRL is planning a 'click and collect' system whereby the commuter will be able to order goods and services using this card, which can be delivered at all metro stations. It is also planning to start a drive for including a variety of local and national goods and services that can be accessed using the KMRL-Axis Bank co-branded card. In addition to the co-branded card, the bank will also develop a mobile app, which can be used for ticketing as well as e-commerce. This initiative is unique in that it is for the first time that 'open-loop' smart cards are being

19.5.5 Equity Sharing Model (SPV Model) for Thane Metro

Under this model, a Special Purpose Vehicle (SPV) will be set up as a joint venture between Central Government and Government of Maharashtra for the implementation of the project and for its subsequent Operation & Maintenance. As per the prevalent practice, Central Government contribute 20% of the project cost excluding land and state taxes as its equity contribution. An equal amount will be contributed by State Government aggregating the total equity to 40%. In addition to equity, Govt of Maharashtra will also fund the cost of land and state taxes. During Stake holder consultations, it was agreed that local bodies in the city would contribute towards funding of the metro in the city by giving land for the project free of cost. Remaining amount shall be arranged as soft loan from funding agencies.

Soft loan (ODA Loan) from three funding agencies namely ADB and KFW has been considered. **Table 19.17** gives the loan conditions of these agencies.

TABLE 19.17: LOAN CONDITIONS OF FUNDING AGENCIES

S.N	Agency	Loan period	Moratorium period	Interest rate	Commitment fee
1	KFW	20	5	1.25%+6 monthly Euribor	Nil
2	ADB	20	5	0.6%+6 monthly Euribor	

In case of KFW and ADB, the loan interest rate has fixed and floating components, Euribor rate is floating component in the interest rate. A positive Euribor rate gets added to the interest rate to determine final loan interest rate whereas negative Euribor has no effect on fixed rate of interest.

The funding pattern developed under this model is placed in **Table 19.18**, and **Table 19.19**.

TABLE 19.18: FUNDING PATTERN UNDER EQUITY SHARING MODEL (PROJECT COST WITH CENTRAL TAXES) – CONSIDERING KFW LOAN

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1151.13	15.30%
Equity by Govt. of Maharashtra	1151.13	15.30%
SD for CT by Govt. of Maharashtra	354.11	4.70%
SD for CT by GoI	354.11	4.70%
Soft Loan from bilateral/multilateral funding agencies	4515.72	60.00%
Total Cost excluding Land, R&R and PPP	7526.20	100.00%
Contribution by Local Bodies as Grant	200.00	
SD for land and R&R by Govt. of Maharashtra	3414.20	
State Taxes towards Completion Cost	615.64	-
IDC by GoM	312.71	
Total Cost including Land, R&R, State Taxes and IDC	12068.76	
PPP Component	131.34	
Total Completion Cost	12200.10	

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

TABLE 19.19: FUNDING PATTERN UNDER EQUITY SHARING MODEL (PROJECT COST WITH CENTRAL TAXES) - CONSIDERING ADB LOAN

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1151.13	15.30%
Equity by Govt. of Maharashtra	1151.13	15.30%
SD for CT by Govt. of Maharashtra	354.11	4.70%
SD for CT by GoI	354.11	4.70%
Soft Loan from bilateral/multilateral funding agencies	4515.72	60.00%
Total Cost excluding Land, R&R and PPP	7526.20	100.00%
Contribution by Local Bodies as Grant	200.00	
SD for land and R&R by Govt. of Maharashtra	3414.20	
State Taxes towards Completion Cost	615.64	-
IDC by GoM	573.31	
Total Cost including Land, R&R, State Taxes and IDC	12329.35	
PPP Component	131.34	
Total Completion Cost	12460.69	-

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

19.5.6 Public Private Partnership in Thane Metro

In this model, the private firm may be responsible for designing, building, operating and maintaining of the entire project. Government of Maharashtra will bear the cost towards land including R&R and state taxes irrespective of the model of PPP. The metro rail being a social sector project not many private parties are available to bid for such a project. Besides quite expectedly the private operator may demand assured rate of return in the range of 16% to 18% or a comfort of guaranteed ridership.

The operation period by a private entity is considered as 30 years, Debt: Equity ratio for all financing by private entity is considered as 70:30, with long term cost of debt as 12% p.a. The Private Partner will develop the infrastructure with its own funds and funds raised from lenders at its risk (that is, it will provide all or the majority of the financing). Private Partner is also responsible for operating (supply and running of rolling stock) and managing the infrastructure life cycle (assuming life-cycle cost risks) for a specified number of years. To carry out these tasks, the Private Partner, will usually create an SPV.

The bid parameter in such projects is either Premium (as percentage of revenues) if the funds coming from users are sufficient to cover O&M expenses and long-term maintenance with a surplus that can then be used as a source to repay the financing of the construction of the asset, and where no Bidder is offering a Premium, bidding

parameter is the Grant required (as per VGF scheme of Government of India which is at present is maximum of 20% of the project cost). The Grant/ Premium is computed for a target pre-tax equity IRR of private entity as 18%. Based on above, the funding pattern without additional income from PD is provided in **Table 19.21**.

TABLE 19.20: FUNDING PATTERN UNDER PPP – BOT WITH VGF

Particulars	Amount in Rs. Crores	% of Contribution
VGF by GoI	1505.24	20.00%
VGF by GoM	1505.24	20.00%
Equity by Concessionaire	2257.86	30.00%
Concessionaire's Debt @ 12% p.a.	2257.86	30.00%
Total Cost Excluding Land, R&R and PPP	7526.20	100.00%
Land by GoM	3414.20	
State Taxes by GoM	615.64	
IDC by GoM	1146.62	
Total Cost including Land, R&R, State Taxes and IDC	12702.66	
PPP Component	131.34	

VGF: Viability Gap funding, IDC: Interest During Construction

19.5.7 Grant by the Central Government – Supply of System and O&M by Private Participation

Under this model, Government of Maharashtra will bear the cost towards land including R&R and state taxes. Central Government shall provide a grant of 10% and post-construction of civil assets by State Government, the Private Partner installs the system (signaling and electrical assets), procures rolling stock and operates and maintains all these assets. The State Government collects all the revenue and pays the Private Partner a monthly/ annual payment for operations and maintenance of the system. The remuneration given could comprise of a fixed fee and a variable component, which would depend on the quality of service provided and the fixed fees computed for a target pre-tax equity IRR of private entity as 18% which will be financed through the revenue generated in the project. For our analysis, a fixed fee escalated at long-term WPI i.e. 4% p.a. is considered. Based on above, the funding pattern is provided in **Table 19.22**.

TABLE 19.22: FUNDING PATTERN UNDER GRANT BY CENTRAL GOVERNMENT MODEL

Particulars	Amount (Rs in Cr)	% of Contribution
Capital Contribution by GOI	752.61	10.0%
Capital Contribution by GoM	4515.71	60.0%
Equity by Concessionaire	677.38	9.0%
Concessionaire's Debt @ 12% p.a.	1580.50	21.0%
Total	7526.20	100.0%

Particulars	Amount (Rs in Cr)	% of Contribution
Land by GoM	3414.20	
Taxes by GoM	1323.86	
IDC	521.15	
Total Cost	12785.41	

IDC: Interest During Construction

The total fund contribution of Gol & Govt of Maharashtra under various alternatives is tabulated in **Table 19.23**.

It can be seen from the table that the contribution of Governments under SPV model is same as that of VGF model. However, under the VGF model, the entire revenues for the Concession Period are accruing to the Private Partner with no return on Government's contribution. Accordingly, it is proposed that Thane Metro project may be implemented on SPV Model with soft loans from bilateral-multilateral agencies.

CHAPTER - 20

ECONOMIC ANALYSIS

20. ECONOMIC ANALYSIS

20.1. APPROACH AND METHODOLOGY FOR ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV.

20.1.1 Evaluation Assumptions

Project horizon comprises of the construction and operation period of the rail based transit project. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR. The key assumptions used in the evaluation are listed in **Table 20.1**.

TABLE 20-1: KEY EVALUATION ASSUMPTIONS

Parameter	Assumption
Price Level	July, 2023
Construction period	2024-2029
First year of operation of MRTS	2029
Daily to annual factor	340

20.1.2 Development of 'With' and 'Without' Scenarios

The ‘Without Project Scenario’ is essentially the present condition but it includes existing and committed transport infrastructure proposals that will be constructed in the near future. The ‘Without Project Scenario’ includes the existing road network and improvements that are likely to be implemented

within the next few years, except for the mass transit system corridors being considered in this study.

The Without Project Scenario provides a baseline for comparing travel benefits in both 'with and without project scenarios' for Metro System. Accordingly, transport demand analysis for metro system in both scenarios has been carried out. The mode-wise passenger trips for the horizon years have been worked out and shown in **Table 20.2**.

The introduction of mass rapid transit system in the Study Area will help in reducing vehicular traffic on the road thereby contributing to relieving traffic congestion along proposed corridors, reduction in accidents and larger environmental savings.

TABLE 20-2: ESTIMATED DEMAND & MODAL SHARE IN "WITH" AND "WITHOUT SCENARIO"

Mode	Daily Trips without Mass Transport System			Daily Trips with All Mass Transport System		
	2029	2035	2045	2029	2035	2045
Train	14.50	19.13	22.24	11.35	15.01	17.53
Bus	4.45	5.54	6.43	3.49	4.35	5.07
Car	2.31	3.28	3.87	1.81	2.58	3.05
Two Wheeler	2.36	3.28	3.87	1.85	2.58	3.05
Auto	2.41	3.39	4.00	1.89	2.66	3.15
Taxi	0.48	0.67	0.78	0.37	0.53	0.62
MRTS	0.00	0.00	0.00	5.77	7.61	8.72
TOTAL	26.51	35.30	41.19	26.51	35.30	41.19

Source: Thane CMP 2018

20.2 ESTIMATION OF ECONOMIC COST OF MRTS

The economic costs of the capital works and annual operation and maintenance costs have been calculated from the financial cost estimates by excluding:

- Price contingencies/price escalations
- Import duties and taxes
- Sunk costs
- Interest payment, principal payment and interest during construction

The economic costs (**Table 20.3**) have been derived from financial costs using following shadow price factor for each component to take care of the distortions brought by above factors.

TABLE 20-3: FACTORS USED FOR CONVERTING PROJECT COSTS TO ECONOMIC COSTS

S. No	Item	Factor
1	Capital Cost	0.83
2	Operations & Maintenance Cost	0.87

Table 20.4 and **Table 20.5** gives the capital and O&M costs of the MRTS in financial and economic terms at July'23 price levels respectively.

TABLE 20-4: FINANCIAL COSTS OF METRO - CAPITAL O&M (RS. IN CRORE)

Cost Component	Metro
Construction Cost Including Land and R&R	9203
Taxes @18% FOR GST	1324
O&M Costs	
2029	338
2035	523
2045	1082

TABLE 20-5: ECONOMIC COSTS OF METRO- CAPITAL AND O&M (RS IN CRORE)

Cost Component	Metro
Construction Cost Including land and R&R	7638
O&M Costs	
2029	294
2035	455
2045	941

20.3 ECONOMIC BENEFITS OF MRTS

Thane Metro will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. **Table 20.6** gives reduced passenger trips due to Thane metro.

TABLE 20-6: REDUCED PASSENGER TRIPS DUE TO THANE MRTS

S. No.	Mode	Reduced pass Trips Due to Thane Metro		
		2029	2035	2045
1	Bus	0.97	1.20	1.36
2	Car	0.50	0.71	0.82
3	2W	0.51	0.71	0.82
4	Auto	0.52	0.73	0.85
5	Taxi	0.10	0.14	0.17
6	Train	3.15	4.13	4.71
7	MRTS	5.77	7.61	8.72

Shifting of passenger trips from road to metro would lead to reduction in number of mini buses, IPT, usage of private vehicles, air pollution and increase in the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general. The benefit stream includes:

- Savings in Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing modes in case MRTS project is not taken up.
- Savings in operating costs of different modes due to de-congestion including those that would continue to use the existing transport network even after the MRTS is introduced.
- Savings in time of commuters using the MRTS over the existing transport modes because of faster speed of MRTS.
- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.
- Savings on account of prevention of accidents and pollution with introduction of MRTS.
- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case MRTS is not introduced.

The Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area
- Improving the image of the city

20.3.1 Input Parameters

Inputs used for Economic analysis have been collected from primary and secondary data sources. Vehicle Operating cost (VOC) and Value of Travel Time (VOT) are the two important parameters of Economic Analysis.

Vehicle Operating Cost (VOC): VOC is a function of speed, road roughness, carriageway, width/capacity, rise and fall per unit. The VOC unit cost have been taken from the “Manual on Economic Evaluation of Highway Projects in India, 2009” by the Indian Road Congress (IRC). The VOC has been adjusted for Thane according to the traffic, road conditions in the city as recommended in the manual. **Table 20.7** gives the mode wise VOC to estimate benefits accruing to the society from the project.

TABLE 20-7: MODE WISE VOC FOR THANE

Mode	VOC* Rs /Km
Bus	38.32
Car	10.14
2W	3.09
Auto	5.07
Shared Auto	6.12

**Source IRC SP 30 (2009) Values brought to 2023 level using factor of 5%*

Value of Travel Time (VOT): VOT is another important parameter of Economic Analysis. It refers to the cost of time spent on transport. It includes costs of both work and non-work trips. Mode wise value of time has also been taken from IRC SP-30 (2009) Values brought to 2018 level using factor of 5%. The value of travel time for MRTS passengers has been taken as that of deluxe bus. **Table 20.8** gives the mode wise VOT to estimate benefits accruing to the society from the project.

TABLE 20-8: MODE WISE VOT FOR THANE MRTS

Mode	Value of Travel Time**Passenger/ Hour
BUS	83.00
CAR	105.00
SC/MC	45.00
AUTO	89.00
SHARED AUTO	65.00

**Source IRC SP 30 (2009) Values brought to 2023 level using factor of 5%*

Other operational parameters required to assess the savings in VOC and VOT, accidents, pollution for the system in year 2045 is presented in **Table 20.9**.

TABLE 20-9: MODE WISE OPERATIONAL PARAMETERS –METRO

Mode	Average Lead KM	Veh- KM/ Day	Average Speed (Km/Hr)* (With MRTS)			Average Speed (Km/Hr)* (Without MRTS)			Occupancy
			2029	2035	2045	2029	2035	2045	
Bus	12.2	150	14.7	11.6	10.8	12.8	10.1	9.4	19
Car	12.2	24	20.1	18.5	16.6	17.5	16.1	14.4	2.4
Two Wheeler	11.9	24	24.4	21.3	17.8	21.2	18.5	15.5	1.4
Auto	9.2	92	19.3	18.3	16.9	16.8	15.9	14.7	2.6
Taxi	20.5	160	19.6	17.6	15.3	17.0	15.3	13.3	2.8
TRAIN			32.0	32.0	32.0	32.0	32.0	32.0	

Source: Thane CMP- 2018

Other benefits that will accrue to the society include reduction in emission, savings due to reduction in accidents. The input for the benefit estimation from these parameters includes the emission factors by vehicle category as given by CPCB (**Table 20.10**).

TABLE 20-10: MODE WISE EMISSION FACTORS (GRAM/KM)

Vehicle Type/ Pollutant	CO	HC	NOX	PM	CO2
2-wheeler	1.4	0.7	0.3	0.05	28.58
Auto	2.45	0.75	0.12	0.08	77.89
Cars (incl. cabs)	1.39	0.15	0.12	0.02	139.52
Bus (incl. BRT)	3.72	0.16	6.53	0.24	787.72
Treatment Cost (Rs. /ton)	1,00,000	1,00,000	1,00,000	1,00,000	500

Source: Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017

20.3.2 Estimation of Project Benefits

The methodology adopted to quantify benefits that will accrue to the society owing to implementation of the metro project include:

- **Travel time savings-** travel time savings will accrue on two accounts:
 - Travel time savings for passenger trips that are shifted to MRTS from other modes due to higher speed of MRTS project as compared to 'without' project scenario.
 - Travel time savings for trips remaining on road due to reduction in congestion due to shift on metro leading to fewer vehicles on roads.

- Passenger time savings = time savings of modal shift passenger + time savings of passenger travelling on other mode.
- Time savings of modal shift passengers = (time spent by modal shift passengers on metro rail project - time spent by modal shift diverted passenger on alternate transport mode in do nothing/alternative scenario) x value of passenger time.
- Time savings of passengers travelling on other modes = (time spent by passengers travelling on other mode in with project scenario - time spent by passengers travelling on other mode in do nothing/alternative scenario) x value of passenger time.
- **Savings in Vehicle Operating Cost-** Shifting of passenger trips from road to MRTS will result in lesser vehicles on roads resulting in saving in VOC. Savings in VOC will also accrue on two accounts:
 - VOC savings of mode wise vehicle trips which have shifted from road to MRTS.
 - VOC savings due to reduced congestion on roads of vehicles trips remaining on road.
 - The VOC savings are calculated by multiplying the unit VOC cost with the number of vehicle trips and with the average lead distance for the particular vehicle category. $\text{VOC savings} = \text{VOC [Rs. /km]} \times \text{Average Lead [km]} \times \text{no. of vehicle trips}$
 - The VOC savings are calculated for the vehicle types and then added. The difference of cost in “with” and “without” project is taken to estimate savings in Vehicle Operating Cost.
- **Accident reduction-** These savings are also based on reduction in no of vehicles on roads due to shift of passengers of different modes on MRTS.

Reduction in fatal and injury accidents due less no of vehicles on roads.

- Savings in damage cost to vehicles involved in accidents.
- Based on trends of last 3-year data of vehicles and relationship with fatal and damage accidents data, the reduction in no of accidents is estimated for reduced no of vehicles on roads due to modal shift of passengers. reduced number of fatal and damage accidents are then multiplied by the cost of accident to arrive at savings due to metro.

- Savings from pollution reduction - the reduction in no of vehicles on roads due to shift of passengers of different modes on MRTS will reduce the air pollution.
- Absence of vehicles on road due to modal shift passengers on MRTS will save pollution from modes that would have continued on road in "without MRTS scenario"
- Savings from pollution are estimated by using the following method
- Vehicle km saved = [no. of trips shift to metro from other mode] x [average lead of the mode]
- Total volume of pollutant = [volume of pollutant released per km] x [daily vehicle km saved]
- Annual treatment cost = [volume of pollutant] x [treatment cost/ton]
- savings in road infrastructure maintenance
- with less no of vehicles on roads, expenditure on road maintenance is expected to go down. in the absence of data, a lump-sum expenditure of Rs. 50 cr/ year has been assumed.

Following the above methodology socio-economic benefits of Thane metro have been estimated in monetary terms. following factors have been used for converting project benefits to economic costs (**Table 20.11**).

TABLE 20-11: FACTORS FOR CONVERTING PROJECT BENEFITS IN ECONOMIC COSTS

S. No	Item	Factor
1	Savings in Capital & Operating Cost of Buses	0.83
2	Savings in Capital & Operating cost of Private Vehicles	0.9
3	Savings in Passenger Time	1.0
4	Savings in VOC	0.9
5	Savings in Accident Costs	0.9
6	Savings in Pollution Costs	1.0
7	Infrastructure Maintenance Cost Savings	0.87

With input from above tables, the accrued economic benefits for Thane metro in the horizon year 2051-2052 has been summarized in **Table 20.12**.

TABLE 20-12: ECONOMIC RETURN PARAMETERS OF THANE METRO

S.NO	BENEFITS	MRTS	
		Amount	% Share
1	Travel Time Savings	12805	81
2	Savings in Vehicle Operating Cost	3008	18
3	Savings from Accident, Pollution & Road maintenance Reduction	63	1
	Total	15876	100

It is clear from the Table that benefits are mainly come from saving of Travel Time by MRTS (81%), and VOC savings (18%), and benefit from emission reduction, accident reduction and road maintenance cost (together 1%).

EIRR for 30 years for deriving the values of economic indicators (EIRR, ENPV), cost and benefit stream for the system has been constructed in terms of money value. The toolkit on finance and financial analysis 2013 by MOHUA, suggests that ENPV to be calculated on social cost of capital or government security rate. Accordingly, ENPV for the system have been calculated on both the rates. Metro Rail Policy, 2017 prescribes 14% as acceptable EIRR rate for metro project, same has been considered as the social cost of capital. The government security rate in July, 2023 is 8.00%. Accordingly, ENPV for the system has been calculated based on these rates. The summary of the ENPV and EIRR is presented in **Table 20.13**. The cost and benefit streams for metro system is presented in **Table 20.15**.

TABLE 20-13: ECONOMIC RETURN PARAMETERS OF THANEMETRO

S.NO	PARAMETER	Metro
1	EIRR	23.80%
2	ENPV - Social cost of capital @14% -Government Security Rate @ 8.00%	11749 Crore 38052 Crore

20.3.3 Outcome on Economic Viability

The project has EIRR more than 14%, indicating that the benefits to the society are more than the social cost of capital of 14%. It also meets the acceptable norm of MoHUA. Thus the project is economically viable and should be implemented.

20.3.4 Sensitivity Analysis

The sensitivity analysis has been carried out to see the impact of change in critical parameters in the range of 5% to 15% on EIRR and is presented in **Table 20.14**.

TABLE 20-14: SENSITIVITY ANALYSIS

S.No.	Factor	Range in percentage		
		5%	10%	15%
1	Cost overruns due to delay or other factors	22.52	21.16	20.46
2	Increase in Maintenance Cost	22.97	22.52	22.16
3	Reduction in Ridership	21.87	21.11	20.34
4	Reduction in benefits	21.76	20.87	19.94
5	Combination of reduction in benefits and increase in cost	21.01	19.45	17.94

TABLE 20-15: ECONOMIC COST AND BENEFIT STREAM FOR METRO SYSTEM (IN CRORE)

Year	Capital Cost without land, R&R and IDC - 83%	O & M - 87%	Addition cost +Replacement Cost- 83%	Total Cost	Travel Time Savings (VOT Savings)- 100%	Savings in Vehicle Operating Cost (VOC)- 90%	Accident Reduction Benefits - 90%	Pollution Reduction Benefits- 100%	Reduced Road Infrastructure Costs -87%	Total Savings /Benefits	Net Benefits (Rs. in Crore)
24-25	1,436			1,436							(1,436)
25-26	2,776			2,776							(2,776)
26-27	2,961			2,961							(2,961)
27-28	1,447			1,447							(1,447)
28-29	1,138	-		1,138							(1,138)
29-30		294		294	(1,003)	988	7.8	32	7.2	32	(262)
30-31		316		316	(1,017)	1,053	8.3	32	7.7	84	(232)
31-32		339	-	339	(1,032)	1,122	8.9	32	8.1	140	(200)
32-33		365	-	365	6,147	1,067	8.6	29	8.5	7,260	6,896
33-34		392	-	392	6,228	1,135	8.8	30	(259.4)	7,142	6,750
34-35		421	-	421	6,425	1,207	9.1	30	(5.2)	7,667	7,246
35-36		455	-	455	6,510	1,285	9.3	31	(5.4)	7,829	7,374
36-37		488	-	488	6,595	1,367	9.5	31	(5.7)	7,997	7,509
37-38		524	306	830	6,682	1,454	9.8	32	(5.9)	8,171	7,341

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F Year	Capital Cost without land, R&R and IDC - 83%	O & M - 87%	Addition cost +Replacement Cost- 83%	Total Cost	Travel Time Savings (VOT Savings)- 100%	Savings in Vehicle Operating Cost (VOC)- 90%	Accident Reduction Benefits - 90%	Pollution Reduction Benefits- 100%	Reduced Road Infrastructure Costs -87%	Total Savings /Benefits	Net Benefits (Rs. in Crore)
38-39		562	-	562	6,769	1,547	10.1	32	(6.3)	8,352	7,790
39-40		604	-	604	6,858	1,646	10.4	32	(6.6)	8,540	7,936
40-41		649	-	649	6,948	1,751	10.7	33	(7.0)	8,736	8,087
41-42		697	-	697	7,039	1,863	11.0	33	(7.3)	8,939	8,243
42-43		749	-	749	8,518	1,566	9.8	27	113.8	10,234	9,485
43-44		805	-	805	8,617	1,663	10.4	27	3.2	10,321	9,516
44-45		865	-	865	8,717	1,767	11.1	27	3.4	10,525	9,660
45-46		941	-	941	9,023	1,877	11.8	28	3.5	10,943	10,002
46-47		1,015	-	1,015	9,128	1,994	12.6	28	3.7	11,166	10,151
47-48		1,096	2,052	3,147	9,234	2,119	13.5	28	3.9	11,398	8,250
48-49		1,182	-	1,182	9,341	2,251	14.4	28	4.1	11,638	10,456
49-50		1,267	-	1,267	9,449	2,391	15.3	29	4.3	11,888	10,621
50-51		1,358	-	1,358	9,559	2,540	16.4	29	4.5	12,149	10,790
51-52		1,457	-	1,457	9,670	2,698	17.5	30	4.8	12,420	10,963
52-53		1,563	334	1,897	12,659	2,832	18.8	30	(193.2)	15,346	13,449
53-54		1,678	-	1,678	12,805	3,008	20.1	30	(13.1)	15,850	14,173

Detailed Project Report for Thane Metro Rail

^F Year	Capital Cost without land, R&R and IDC - 83%	O & M - 87%	Addition cost +Replacement Cost- 83%	Total Cost	Travel Time Savings (VOT Savings)- 100%	Savings in Vehicle Operating Cost (VOC)- 90%	Accident Reduction Benefits - 90%	Pollution Reduction Benefits- 100%	Reduced Road Infrastructure Costs -87%	Total Savings /Benefits	Net Benefits (Rs. in Crore)
	9,758	20,080	2,691	32,529	1,79,868	44,191	294	749	(334)	2,24,768	1,92,239
										EIRR	23.80%

Chapter – 21

IMPLEMENTATION PLAN

21. IMPLEMENTATION PLAN

21.1 PROJECT IMPLEMENTATION PLAN

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as DPR is approved by Government of India. The possible dates of important milestones are given in **Table 21.1**.

TABLE 21.1: PROJECT IMPLEMENTATION SCHEDULE

S.No	Tasks	Timelines
1	State Government Approval of DPR	August, 2021
2	Approval of GoI	January, 2024
3	Appointment of Interim Consultant	January, 2024
4	Appointment of General Consultants	April, 2024
5	Commencement of Civil Works	October, 2024
6	Commencement of Operation	January, 2029

The commercial operation on Thane Metro corridor may start from January 2029.

21.2 IMPLEMENTATION STRUCTURE

Maharashtra has a successful example of metro operation in Mumbai on SPV model by Mumbai Metro Rail Corporation Limited (MMRCL). Nagpur Metro Rail Phase-1 and Pune Metro project is also implemented on SPV model by Maha Metro. Similarly, Thane Metro project may also be implemented on SPV model. However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model.

The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

21.3 LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE PROJECT

21.3.1 Legal Framework

The legislation for construction of Nagpur and Pune Metro may also provide legal cover for construction of Thane Metro. Implementation of proposed Thane Metro can be done under “The Metro Railways (Amendment) Act 2009”.

21.3.2 Institutional Arrangements

Metro construction is a very specialized and multi-disciplinary job. It is therefore, impossible to have a single organizational set up which can be responsible for all aspects of metro implementation, namely investigation, planning, design, drawing up of specifications, preparation of tender documents, fixing of contractors, supervising the contractors’ works, ensuring interface fusion between different contractors, ensuring quality and safety during constructions, planning and supervising integration system trials and getting the project commissioned in time.

Effective institutional arrangement is needed to enable the Metro project to be implemented without any loss of time and cost over-run. The details of possible arrangements are discussed in following sections. Experience of implementing Delhi, Mumbai and Nagpur & Pune Phase 1 metro projects has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro rail project.

It is suggested to have a two tier organization with well-defined responsibilities for getting this project executed. At the apex will be the Maha Metro - the organization with full mandate and total power. The second level will be a project management team called “General Consultants” who will be engaged by the Maha Metro on contract basis and who will be fully responsible for planning, design and project management. In fact they will be the “Engineers” for the Maha Metro, who is the “Client”. The detailed design consultants as required may be engaged by General Consultants as their Sub-Consultants within their own contract responsibilities. Since most of the alignment length is elevated, it is recommended that the contracts be made on “design and build” basis, based on broad technical specifications and performance requirements drawn up by the General Consultants.

21.3.3 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 may be set up. Other members of this Committee may be the Secretaries of concerned Departments of State Government and Heads of civic bodies who are connected in one way or the other with the implementation of the project. Thane Municipal Commissioner may also be the member of this committee.

21.3.4 Empowered Committee

At the Central Government level an Empowered Committee, under the chairmanship of Cabinet Secretary, is presently functioning for Delhi Metro project. Other members of this Committee are Secretaries of Planning Commission, Ministry of Home Affairs, Ministry of Housing and Urban Affairs, Ministry of Road Transport and Highways, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi and a representative from the PMO. The Empowered Committee meets regularly and takes decisions on matters connected with inter-departmental coordination and overall planning, financing and implementation of the Delhi Metro project.

It is suggested that the role of this Empowered Committee is enlarged to include Thane Metro project also and the Chief Secretary, Maharashtra is inducted as a member of this Committee.

21.4 ROLE, RESPONSIBILITY AND INVOLVEMENT OF CITY GOVERNMENT

21.4.1 Unified Metropolitan Transport Authority (UMTA)

The National Urban Transport Policy 2006 has recommended setting up of Unified Metropolitan Transport Authorities (UMTA's) in million plus cities. The policy document stipulates following on UMTA.

“The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. These structures were put in place well before the problems of urban transport began to surface in India and hence do not provide for the right coordination mechanisms to deal with urban transport. The central government will, therefore, recommend the setting up of Unified Metropolitan Transport Authorities (UMTA's) in all million cities to facilitate more coordinated planning and implementation of urban transport programs & projects and integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful.”

The metro rail policy - 2017 makes it mandatory for the cities which are planning to have MRTS to address their mass transport requirements to have city level UMTA.

For integrated approach in planning and management of urban transport in the city, State Government shall constitute Unified Metropolitan Transport Authority (UMTA) as a statutory body. This Authority would implement various proposals as per CMP for the city, organize investments in urban transport infrastructure, establish effective coordination among various urban transport agencies, manage the Urban Transport Fund (UTF) etc. UMTA will have to play active role in the implementation of Thane Metro being a city government authority.

21.4.2 Steering Committee

Apart from a High Power Committee under the chairmanship of Chief Secretary, Maharashtra, a 'Steering Committee' may be set up under the chairmanship of Commissioner of Thane Municipal Corporation. Other members of this Committee may be District Collector, Municipal Commissioner, and other heads of civic bodies who will be connected in one way or the other with the implementation of the project.

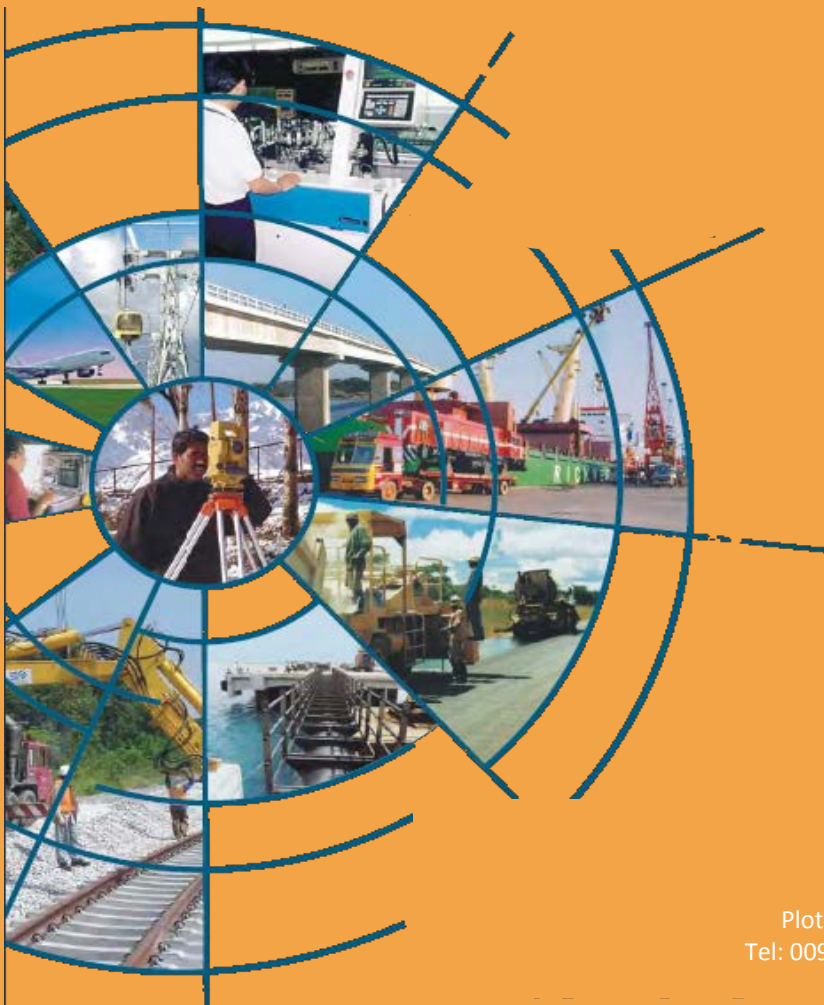
During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. The steering committee will work for expeditious resolution of these problems at local level. This Committee may meet regularly to sort out all problems brought before it by Maha Metro.

21.4.3 Way Forward

On acceptance of the Detailed Project Report, following actions may be initiated for implementing of Thane Metro project:

- Approval of State Government to the Detailed Project Report
- Issue of notifications for the project, alignment and setting up of UMTA
- DPR to be forwarded to the Ministry of Housing and Urban Affairs, Niti Aayog and Finance Ministry with request for approving the Metro project and for financial participation through equity contribution to the SPV
- Appointment of Interim Consultants (IC)
- Appointment of Detailed Design Consultants (DDC)
- Packaging and invitation of bids for various contracts

- Appointment of General Consultants (GC)
- Land acquisition
- Examination and appraisal of DPR by bilateral/multilateral funding agencies for possible funding
- Stakeholder consultation on environmental and social impact of the project
- Signing of an MOU between Maharashtra State Government and Government of India giving all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure etc.
- Agreement between the State and Central Government for financing the debt portion of the project along with the setting up of time frame for completing the Project
- Loan approval
- Providing legal cover for construction as well as O&M stages of the Project
- Memorandum of Understanding between various service providers to provide seamless integration between various transport modes.



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