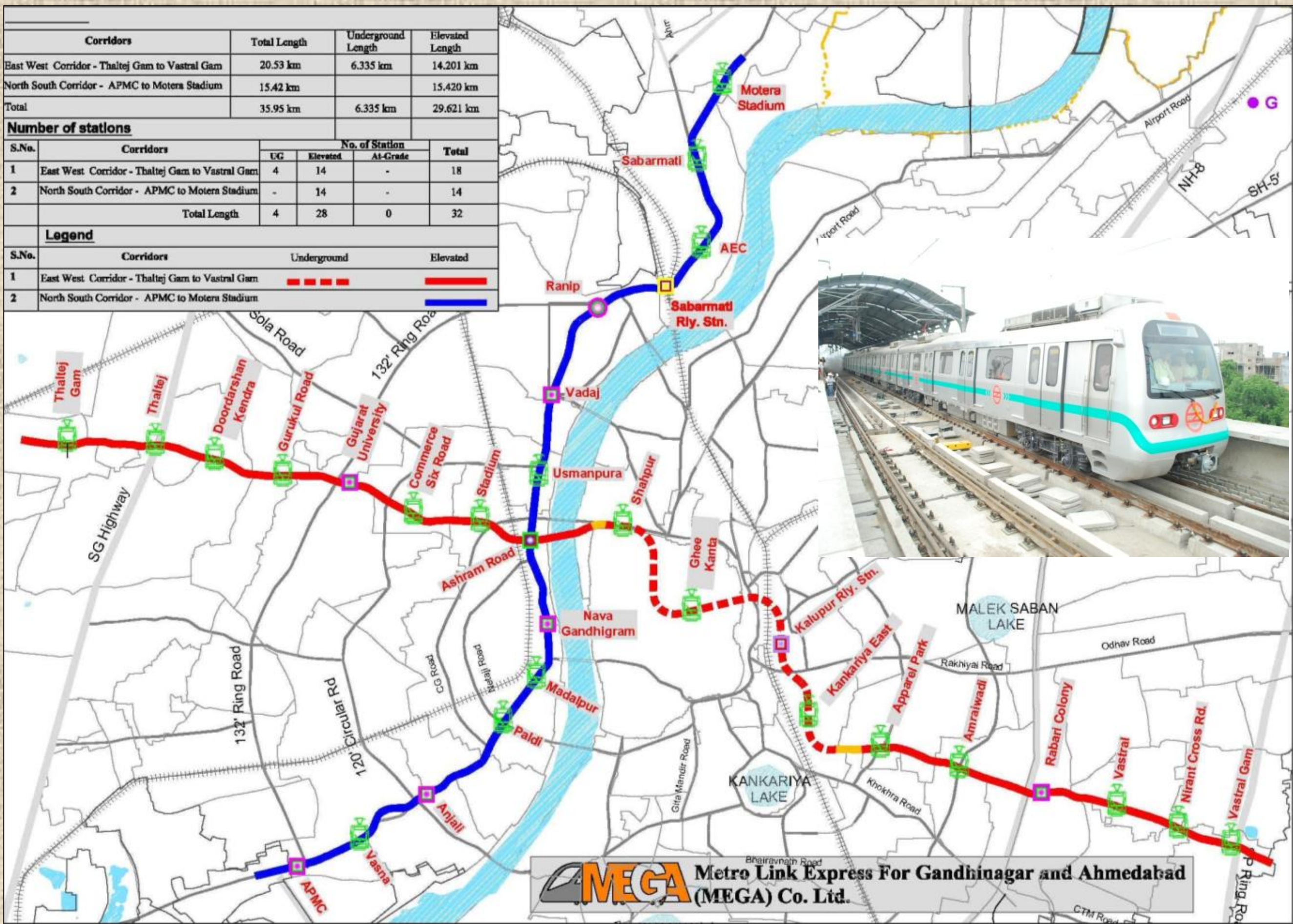
DETAILED PROJECT REPORT FOR

AHMEDABAD METRO RAIL PROJECT (PHASE – I)

Client: Metro Link Express for Gandhinagar and Ahmedabad (MEGA) Company Ltd.



Corridors	Total Length	Underground Length	Elevated Length
East West Corridor - Thaltej Gam to Vastral Gam	20.53 km	6.335 km	14.201 km
North South Corridor - APMC to Motera Stadium	15.42 km		15.420 km
Total	35.95 km	6.335 km	29.621 km

Number of stations

S.No.	Corridors	No. of Station UG	No. of Station Elevated	No. of Station At-Grade	Total
1	East West Corridor - Thaltej Gam to Vastral Gam	4	14	-	18
2	North South Corridor - APMC to Motera Stadium	-	14	-	14
	Total Length	4	28	0	32

Legend

S.No.	Corridors	Underground	Elevated
1	East West Corridor - Thaltej Gam to Vastral Gam		
2	North South Corridor - APMC to Motera Stadium		

Prepared By:

दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड

DELHI METRO RAIL CORPORATION LTD.

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I N D E X

Salient Features

SALIENT FEATURES

1. Gauge (Nominal) 1435 mm

2. Route Length (between dead ends)

Corridors	Total Length	Underground Length	Elevated Length
East-West Corridor	**20.536**	**6.335**	**14.201**
North-South Corridor	**15.420**	**-**	**15.420**
Total	**35.956**	**6.335**	**29.621**

3. Number of stations

S. No	Corridor Name	UG	Elevated.	Total
i)	East-West Corridor	4	14	18
ii)	North-South Corridor		14	14
	Total:	**4**	**28**	**32**

4. Traffic Forecast

Daily ridership				
Corridor/Year	**2018**	**2021**	**2031**	**2043**
North South Corridor	210928	299824	429074	624492
East West Corridor	246743	361780	493781	619118
Total	**457671**	**661604**	**922855**	**1243610**
Trip length	**6.68**	**6.70**	**6.82**	**6.64**
PHPDT				
Corridor/Year	**2018**	**2021**	**2031**	**2043**
North South Corridor	8476	12097	17778	26484
East West Corridor	10593	15659	19251	22944

5. Train Operation Plan

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

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Capacity Provided for North- South Corridor							
APMC to Madalpur	2018	12		3-car		3335	3820 (4865*)
Madalpur to Motera Stadium		6	12 Rakes of 3-car	3-car	36	8476	7640 (9730*)
APMC to Madalpur	2021	8		3-car		4576	5730 (7298*)
Madalpur to Motera Stadium		4	17 Rakes of 3-car	3-car	51	12097	11460 (14596*)
APMC to Madalpur	2031	6		3-car		6685	7640 (9730*)
Madalpur to Motera Stadium		3	22 Rakes of 3-car	3-car	66	17778	15280 (19460*)
APMC to Madalpur	2043	4	32 Rakes of 3-car	3-car		8532	11460 (14595*)
Madalpur to Motera Stadium		2		3-car	96	26484	22920 (29190*)
Capacity Provided for East-West Corridor							
Thaltej Gam to Ashram Road	2018	8.5		3-car	51	6797	5393 (6868*)
Ashram Road to Apparel Park		4.25	17 Rakes of 3-car	3-car		10593	10786 (13736*)
Apparel Park to Vastral Gam		8.5		3-car		4303	5393 (6868*)
Thaltej Gam to Ashram Road	2021	6		3-car	66	9202	7640 (9730*)
Ashram Road to Apparel Park		3	22 Rakes of 3-car	3-car		15659	15280 (19460*)
Apparel Park to Vastral Gam		6		3-car		6287	7640 (9730*)
Thaltej Gam to Ashram Road	2031	4		3-car	96	13249	11460 (14595*)
Ashram Road to Apparel Park		2	32 Rakes of 3-car	3-car		19251	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		9629	11460 (14595*)
Thaltej Gam to Ashram Road	2043	4		3-car	96	15609	11460 (14595*)
Ashram Road to Apparel Park		2	32 Rakes of 3-car	3-car		22944	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		12135	11460 (14595*)

* @ 8 persons per square meter of standee area

6. Speed

Designed Speed 80kmph

Scheduled speed

East-West Corridor	33kmph
North-South Corridor	32kmph

7. Traction Power Supply

a) Voltage — 750v dc

b) SCADA system — Provided

c) Power Demand (MVA)

Power Demand (in MVA)

Corridor		Year			
		2018	**2021**	**2031**	**2043**
APMC To Motera Stadium (North-South)	Traction	4.74	6.38	8.14	11.43
	Auxiliary	6.79	6.92	8.03	10.01
	Sub-total	**11.53**	**13.30**	**16.17**	**21.44**
Thaltej Gam To Vastral Gam (East-West)	Traction	6.38	8.47	12.04	12.26
	Auxiliary	17.05	17.66	19.76	22.73
	Sub-total	**23.43**	**26.13**	**31.80**	**34.99**

8. Rolling Stock

a) 2.90 m wide modern rolling stock with stainless steel body.

b) Axle load - 16 T

c) Seating arrangement - Longitudinal

d) Capacity of 3 coach unit

Normal - 450 Passengers

Crush - 764 Passengers

e) Class of accommodation - One

9. Maintenance Facilities

East-west Corridor - New Cotton Mill

North-South Corridor - Vasana

10. Signalling, & Train Control

'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

11. Telecommunication and Fare Collection

i) Integrated System with Fibre Optic cable, SCADA, Train Radio, PA system etc.
ii) Train information system, Control telephones and Centralized Clock System.
iii) Automatic Fare collection system with POM and Smart card etc.

12. Construction Methodology

Elevated viaduct consisting prestressed concrete "Box" shaped Girders on Single pier with pile / Open foundations, and underground section with Tunnel Boring and station in underground station cut and cover.

13. Total estimated cost (at March 2014 prices)

Corridor-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	East-West Corridor	5077	754	5831
2.	North-South corridor	3052	444	3496
	Total	**8129**	**1198**	**9327**

14. Total estimated completion cost

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

Figures in Rs. Crore

Cost at March-2014 Price Level			Completion Cost(2021)		
Corridor-I	**Corridor-II**	**Total**	**Corridor-I**	**Corridor-II**	**Total**
5692.00	**3410.00**	**9102.00**	**6681.00**	**3994.00**	**10675.00**

15. Financial Indices

a) FIRR (Without PD) - **7.44%**
b) FIRR (With PD) - **8.54%**

c) EIRR The EIRR (without taxes) in economic terms work out to be **17.09%** for the project.

Executive Summary

EXECUTIVE SUMMARY

0.1 Introduction

The historic city of Ahmedabad is amongst the major metropolitan cities in India. With the increasing opportunities for trade and commerce and as a center for higher education, the population of the city is already touching 6 million and this heavy growth continues.

The city, known as Ashapalli or Ashaval in ancient times, was founded by King Karnadeva Vaghela as Karnavati in 11th Century as capital of his kingdom. Later on Sultan Ahmed Shah of Gujarat Sultanate shifted his capital from Patan to Karnavati and renamed it as Ahmedabad in 1411 AD. A number of monuments built during his era are spread over the old city area. The walled city was also built during this era and its 12 gates are still existing though most of the wall can't be seen anymore. The city thrived as the capital of strong kingdom but later became part of the Moghul Sultanate in 1573. Shahjahan spent the prime of his life in this city and developed the present Shahi Baug area. The city was invaded by the Marathas in the year 1707 and ruled by them from 1753 AD to 1817 AD, when the city was taken over by the British.

During the British period the city became "Manchester of India" due to large scale manufacturing of textile. The first textile mill was set up in 1854 and more such mills followed soon after with rapid industrialization. However, the textile industry in the city is no more a force to reckon with, yet it is fifth largest producer of denim cloth in the world. The eastern part of the walled city is mostly inhabited by the families of mill mazdoors, who have been forced to find alternative jobs due to closure of most of the textile mills. However many chemical and pharmaceutical industries have come up around the city. Trade is still flourishing in the city as textile weaving, tie-and-dye work, zari work and intricate silk embroidery produced by this city has been famous for centuries.

Originally DPR for Ahmedabad Metro Rail Network and Regional Rail System was submitted by DMRC in 2005, consisting following corridors.

Regional Rail System

- Line –1 Barajedi-Kalupur-Kalol
- Line –2 Kalupur-Naroda

Metro Rail System:

- Line –1 APMC Vasna – Aayakar Bhawan-Sabarmati - Akshardham (North-South corridor)
- Line –2 Kalupur-Aayakar Bhawan -Thaltej (East-West corridor)

Subsequently, in 200 DMRC was again commissioned by GIDB to prepare DPR for metro connectivity from Gandhinagar to GIFT city & from Gandhi Nagar to Airport and review certain portion of the corridors proposed in 2005 DPR. Accordingly study was carried by DMRC and reports were submitted in 2010.

MEGA vide their letter no MEGA/Chm/Oct/2013/, dated 20/10/2013 requested to DMRC for upgradation of earlier DPR submitted by DMRC. This is an upgardtion of earlier DPR submitted by DMRC in the context of the letter as referred here above.

0.1.1 Introduction to the study area

The proposed metro alignment provides north-south connectivity in Ahmedabad city from Visat to APMC running along the Ashram road on most of the sections. The other corridor Thaltej to Vastral provides east to west connectivity and passes through important nodes of Kalupur, Ashram road, Thaltej and Industrial areas on the east of Ahmedabad.

As per the Draft Development Plan and Integrated Mobility Plan for Greater Ahmedabad Region, the future growth in this area is expected to intensify between Ahmedabad and Gandhinagar. The study area definition would be carried out keeping in view the future growth expected in the study region.

0.2 TRAFFIC CHARACTERISTICS AND DEMAND FORECASTING

This topic provides an overview of the existing transportation system outlines the travel characteristics and presents the demand forecasting carried out for estimating ridership on metro.

0.2.1 ROAD NETWORK

The transportation system in Ahmedabad and Gandhinagar is predominantly dependent on roadway systems. The major road network in the study area is around 3045 km in length, of which 125 km are National Highways and 103 km are under State Highways which are being maintained by National Highways Authority of India and Roads & Building Department respectively. The rest of the roads are managed by respective urban local bodies of AMC, AUDA, GNA and GUDA.

0.2.2 DAILY RIDERSHIP ON AHMEDABAD METRO CORRIDORS IN HORIZON YEARS

Daily ridership on the Ahmedabad metro rail network in 2021 is expected to be 4.6 lakh passengers. The average trip length will be 6.68km in year 2021. Corridor wise total daily ridership for the years 2021, 2031 and 2043 and PHPDT are shown in **Table 0.1.**

Table 0.1 - Corridor wise Daily Ridership and PHPDT

Daily ridership				
Corridor/Year	**2018**	**2021**	**2031**	**2043**
North South Corridor	210928	299824	429074	624492
East West Corridor	246743	361780	493781	619118
Total	**457671**	**661604**	**922855**	**1243610**
PHPDT				
Corridor/Year	**2018**	**2021**	**2031**	**2043**
North South Corridor	8476	12097	17778	26484
East West Corridor	10593	15659	19251	22944

0.3 SYSTEM SELECTION

A. Options for Public Transport System

The following systems are mainly available for Urban Mass Transit:

i) **High Capacity Metro System:** Metro system is a grade separated dedicated system for high peak hour traffic densities exceeding 40,000 PHPDT. It is characterized by short distances of stations spaced at 1 km, high acceleration and declaration and average speeds of 30-35 kmph.

ii) **Light Capacity Metro System:** This is a dedicated metro rail system for moderate peak hour traffic densities exceeding 8000 PHPDT.

iii) **Light Rail Transit:** Modern trams-Street Cars running on Rails at grade or elevated with sharp curves of 24m radius. These are extremely popular and operating in large number of European countries. Generally the stations are spaced at 500m to 1 km and have high acceleration and deceleration characteristics. In most of the countries, they are operating at-grade with prioritized signaling at road inter-section.

iv) **Sky Train:** This is an experimental rail based system under development by Konkan Railway.

v) **Other Rail Based Systems:** A number of options are available but have not been introduced in India. Some of these are very briefly mentioned below:

(a) Maglev

This is an advanced Rail based transit system in which Magnetic Levitation is used to raise the vehicles above the rail surface. Rail wheel interaction is thus avoided and very high speeds are attainable. Maglev Levitation can either be due to attractive force or due to repulsive forces.

(b) Linear Induction Motor (LIM) Train

This is also an advanced Rail based transit system in which propulsion is through a Linear Induction Motor whose stator is spread along the track. The rotor is a magnetic material provided in the under frame of train. In the technology the tractive force is not transmitted through rail-wheel interaction, and so there is no limitation on account of adhesion. This technology is most appropriate for turnouts, as the height of the tunnel can be reduced to lower height of cars.

(c) Monorail

Monorail trains operate on grade separated dedicated corridors with sharp curves of up to 50m radius. This is a rubber tyred based rolling stock, electrically propelled on concrete beams known as guide-ways. The system is extremely suitable in narrow corridors as it requires minimum right of way on existing roads and permits light and air and is more environmental friendly. This is prevalent in several countries for traffic densities of over 20,000 PHPDT.

(d) Bus Rapid Transit System

This system involves operation of buses on a dedicated corridor (except of traffic integration) at a high frequency to achieve PHPDT. For providing a very high transport capacity say 20,000 PHPDT, about 200 buses shall be required per hour *i.e.,* at headway of 20 seconds. Such a high PHPDT can be achieved by providing two lanes of traffic in each direction and elimination of traffic intersection on the route.

(e) Automated Guide way Transit System

The term is used for systems other than conventional rail based system on grade separated guide ways. The system can be rail based or rubber tire based but fully automated guided systems with driver less operation.

B. Capacity of Various Modes (as per the recommendations of Working Group on Urban Transport for 12th Five Year Plan)

In their report **on Urban Transport for 12th Five Year Plan**, the Working Group has set the guidelines for the choice of different modes are as follows:

Table 0.2 - Guidelines for the Choice of Different Modes

SYSTEM	PHPDT IN 2021	POPULATION IN 2011	AVG. TRIP LENGTH
Metro Rail #	>=15000 for at least 5km continuous length	More than 20 Lakhs	More than 7 Km
LRT primarily at grade	=<10,000	More than 10 Lakhs	More than 7 Km
Monorail @@	=<10,000	More than 20 Lakhs	About 5-6 Km
Bus Rapid Transit System	>=4,000 and upto 20000	More than 10 Lakhs	>5 Km
Organised City Bus Service as per urban bus specifications		>1 lac, >50,000 in case of hilly towns	>2 to 3 Km

 # for having Metro Rail, the city should have a ridership of at least 1 million on organized public transport (any mode)

@@ Monorail is desirable only as a feeder system or where the narrow roads are flanked on either side by high rise buildings. In monorail while the cost of construction, operation and maintenance is almost the same as elevated metro rail, the carrying capacity is much lesser.

0.4 SELECTION OF MODE

Selection of a particular mode for any pre-determined traffic corridor depends mainly on demand level of a corridor Right of Way (ROW) on the road and the capacity of the mode. The demand forecast is estimated considering the traffic growth for about 30 years. Other considerations in mode choice are, location of building lines, possibility of increasing ROW. Cost of some mode may vary depending up on the location in view of engineering constraints. Therefore final choice of mode to be adopted for a particular corridor is based on techno economic considerations. As regards the location of a particular mode like at-grade, elevated and underground depends up on the ROW. If

ROW is 20 M or more, elevated alignment is preferred over underground as the cost of underground alignment is 2- 2½ times of elevated alignment.

Hence, keeping in view the above points, it is recommended to adopt an stable, tested and reliable Metro technology i.e. **Light Capacity Metro System** having capacity to cater PHPDT from 15000 to 25000.

0.4.1 GEOMETRIC DESIGNING PARAMETERS AND ALIGNMENT DESCRIPTION

This topic deals with geometrical standards adopted for horizontal and vertical alignments, route description, etc. The proposed corridors under Phase I network will consist of Standard Gauge (SG) lines, however extension of the BG line will be in the BG only. For underground corridors, track centres are governed by spacing of tunnels and box design.

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80kmph. Planning for any higher speed is not desirable as the average inter-station distance is about 1.06 km and trains will not be able to achieve higher speed.

The elevated tracks will be carried on box-shaped elevated decking supported by single circular piers, generally spaced at 25-m centres and located on the median of the road to extent possible. The horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road and ground levels followed by the alignment.

The underground tracks will be carried in separate tunnels to be drilled by Tunnel Boring Machine. Stations will, however, be constructed by cut and cover method except one station which has been proposed by NATM with TBM going through.

0.4.2 GEOMETRIC DESIGN PARAMETERS

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

0.4.3 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 300 m or more is 80 km/h. On elevated sections minimum radius of 175m has been used at two locations having speed potential upto 50 km/h. However in underground section desirable minimum radius of curve shall be 300 m for ease of working of Tunnel Boring Machine (TBM).

0.4.4 Horizontal Curves

Table 0.3

Description	Underground Section	Elevated Section
Desirable Minimum radius	300 m	200 m
Absolute minimum radius	200 m (only c/c)	120 m
Minimum curve radius at stations	1000 m	1000 m
Maximum permissible cant (Ca)	125 mm	125 mm
Maximum desirable cant	110 mm	110 mm
Maximum cant deficiency (Cd)	85 mm	85 mm

0.4.5 Transition Curves

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

- Length of Transitions of Horizontal curves (m)

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

  Desirable : 0.72 times actual cant or cant deficiency, (in mm), whichever is higher.

- Overlap between transition curves and vertical curves not allowed.
- Minimum straight between two Transition curves (in case of reverse curves): either 25 m or Nil.
- Minimum straight between two Transition curves (in case of same flexure curves): either 25 m or both curves should be converted in to the compound curve by introducing single transition between the two circulars.
- Minimum curve length between two transition curves: 25 m

0.4.6 Vertical Alignment and Track Centre

(a) Elevated Sections

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

The track center on the elevated section is kept as 4.1 m uniform throughout the corridor to standardize the superstructure, except at few locations, wherever scissors crossovers are planned, it is kept 4.5 meter.

(b) Underground sections

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level. At stations, the desirable depth of rail below ground level is 13.5 m, so that station concourse can be located above the platforms.

Track center in underground sections are follows:

Track center in underground sections are follows: Sections where stations are to be constructed by cut & cover and running section by TBM to Accommodate 13 m wide platform	16.04 m (for lesser width of platform, track center to be reduced)
Sections where stations are to be constructed by NATM and running section by TBM to facilitate Construction of stations	23.04 m
Sections where stations as well as running section both are to be constructed by cut and cover method	4.50 m

(c) Gradients

Normally the stations shall be on level stretch. In exceptional cases, station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 3.0 %. However, where existing road gradients are steeper than 2% or for Switch Over Ramps gradient up to 4% (compensated) can be provided in short stretches on the main line.

(d) Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%.

However, it is recommended to provide vertical curves at every change of gradient.

(e) Radius of vertical curves:

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

0.4.7 ROUTE ALIGNMENT

Two Corridors have been identified for implementation in Ahmadabad Metro Rail Project network (Phase 1).

Table 0.4

S. No.	Corridors	Total (km)
i)	North South Corridor : APMC to Motera Stadium	15.420
ii)	East West Corridor : Thaltej Gam To Vastral Gam	20.536
	Total	**35.956**

The above corridors are shown in figure 0.4.

0.5 CIVIL ENGINEERING

0.5.1 Underground Construction

The most of the underground section passing under the road, cut and cover method of the underground construction easily can be employed for the construction of the underground sections. However keeping in view obstruction of traffic movement and inconvenience to the general public; during the construction as an open cut around 10.00m wide required to be cut through entire length of underground section it is proposed to tunnel through Tunnel Boring Machine (TBM) or New Austrian Tunneling Method (NATM) in the overburden soil mass. This will reduce substantially inconvenience to general public during construction. Tunnel excavation for a major part of this underground section is expected to be carried out by Tunnel Boring Machines. There is some smaller section along the underground part of the alignment where Cut & Cover method has been considered for construction after Switch Over Ramp (SOR). Tunnel boring machines (TBMs) capable of drilling in soft soil with a finished internal diameter of 5.2 m. can be successfully employed for boring tunnels through this stratum. The tunnels are proposed with a minimum soil cover of 6.0m.

0.5.2 Underground Stations

Total 4 underground stations have been proposed out of which 3 will be constructed by cut and cover with top-down method and 1 by NATM. The diaphragm walls for such station constructions would be 80 to 100 cm. thick and will function as a permanent side wall of the station. It is, therefore, necessary to construct the diaphragm walls absolutely watertight and with the required concrete strength as has been done in the Delhi Metro station constructions. By resorting to top-down method the surface could be restored quickly and further excavations and construction of the station will not hamper the surface activity.

0.5.3 Cut and Cover Method of Construction of Underground Stations

Cut and Cover mainly consists of following steps:

1. Diversion of utilities
2. Construction of support walls
3. Excavation between the support walls along with the installation of struts between the two walls to keep them in position.
4. Construction of tunnel/structure and removal of temporary struts.
5. Back filling and restoration of the surface

0.5.4 Utility Diversion:

It is suggested that all utilities falling within excavation area are diverted away in advance to avoid damage to such utilities during the excavation/ construction phase. The cross utilities, however has to be kept supported. It is suggested that pressure water pipelines crossing the proposed cut area are provided with valves on both sides of the cut so that the cut area can be isolated in case of any leakage to the pipeline to avoid flooding of the cut/damage to the works.

0.5.5 Elevated Section - Choice of Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability and the maximum standardization of the formwork for a wide span ranges.

The segmental construction has been chosen mainly due to the 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.

- Segmental construction permits a reduction of construction time as segments may be manufactured while substructure work proceeds and assembled rapidly thereafter.

- Segmental construction protects the environment as only space required for foundation and sub-station is required at site. The superstructure is manufactured at a place away from busy areas and placement of superstructure is done with the system erected from piers at heights.

- Segments are easy to stack in the casting yard/stacking yard in more than one layer, thereby saving in requirement of space.

- It is easier to transport smaller segments by road trailers on city roads.

- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Interference to the traffic during construction is significantly reduced.
- Segmental construction contributes towards aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

0.5.6 Types of Superstructures for Elevated Section

(A) Pre-cast segmental box girder using external unbounded tendon

(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.

0.5.7 GEO-TECHNICAL INVESTIGATIONS

0.5.7.1 Physiography

Ahmedabad is the largest city in the state of Gujarat. It is located in Western India on the banks of the River Sabarmati, 32 km from the state capital Gandhinagar. It is the former capital of Gujarat and also the financial capital of Gujarat. Ahmedabad is located at 23.030 N and 72.580 E at an elevation of 53 m. The Sabarmati River frequently dries up in summer, leaving only small stream of water. Except for the small hills of Thaltej - Jodhpur Tekra, the city is almost flat. Gandhinagar is the capital of the state of the Gujarat. Gandhinagar has an average elevation of about 81 m. The city sits on the banks of the River Sabarmati in North - Central - East of Gujarat.

0.5.7.2 Geology

The well known agriculturally rich alluvial basin of Gujarat rises from the estuarine tacts between Narmada and Tapi rivers, and extends 402 Km Northwards merging into the deserts plains of Rajasthan and the Rann of Kutch.

The alluvial plains of Gujarat are belongs to Quaternary group. The project site area is covered with deep layers recently placed alluvial sands.

0.5.8 LAND

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

0.5.9 Land Requirement for following Major Components

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

0.5.10 Land for Traction and Receiving Substation and Radio Towers

Two RSS each is proposed to be located for Thaltej Gam to Vastral Gam and APMC to Motera Stadium Corridor. Hence, an area of 22400 m² has been earmarked exact location will be decided at the time of implementation of the project. No additional land proposed for locating radio towers. These will be accommodated in the land already acquired. Land required for RSS will be as tabulated below.

Table 0.5 - Details of Land Required for RSS

S. No.	Name of Corridor	Area (m²)	Ownership
1.	Thaltej Gam to Vastral Gam	11200	Government
2.	APMC to Motera Stadium	11200	Government
	Total	**22400**	

0.5.11 Land Requirement for Stations & Running section

As indicated earlier, the ROW of the roads along which the alignment is planned is adequately wide and hence no land is required for acquisition as long as the alignment is

straight and in the centre of the road. However, at curved portions, the alignment could not be kept in the centre of the road and land acquisition at such locations is inevitable in spite of introduction of sharper curves.
To the extent possible the Entry and Exit points of stations (underground and elevated) were planned on the in open spaces between foot paths and building offsets as far as possible. But, for locating other station facilities such as chiller plants, ventilation shafts, underground water tanks, generator set room etc., land acquisition is proposed

The details of land permanently required for depot, running sections and stations are indicated in the **Tables below –**

Table 0.6 - Details of Land Required for Depot

S. No.	Location	Area(m^2)	ownership	Purpose
1.	New Cotton Mill	190936	Government	Depot
2.	Vasana	250000	Government	Depot
	Total	**440936**		

0.5.12 Summary of Land Requirements

Abstract of land requirements for different components of this corridor is given in **Table 0.7 and 0.8.** However, the land requirement is summarized below:

a) Govt Land permanently required for stations, Depot, Ramp and running section **77.406ha.**

b) Private Residential and Commercial Required for stations, Ramp and Running section **5.348ha**

c) Total land required for the project is **82.754ha.**

Table 0.7 - Summary of Permanent Land Requirement

(All figures in Sq. m)

S. No.	Description	Thaltej Gam to Vastral Gam		APMC to Motera Stadium		Total
		Govt.	Pvt.	Govt.	Pvt.	
1	Stations	5020	9840	2100	10920	27880
2	Running Section	197672	22073	54283	10643	284671
3	Depot	190936		250000		440936
4	Staff Quarter,Office Complex and OCC	50000				50000
5	Receiving	11200		11200		22400

S. No.	Description	Thaltej Gam to Vastral Gam		APMC to Motera Stadium		Total
		Govt.	Pvt.	Govt.	Pvt.	
	Substation(RSS)					
6	Mid Shaft	1650				1650
	Total	**456478**	**31913**	**317583**	**21563**	**827537**

*** Total land required for the project is mentioned here above does not include land require for traffic integration/parking.**

Total = 82.754 Ha
Government = 77.406 Ha
Private = 5.348 Ha

Table 0.8 - Summary of Temporary Land Requirement

S. No.	Description	Thaltejgam to Vastral Gam		APMC to Motera Stadium		Total
		Govt.	Pvt.	Govt.	Pvt.	
1	Temporary office accommodation	8213		6168		14381
2	Segment Casting Yard	80000		60000		140000
	Total	**88213**		**66168**		**154381**

Total = 15.438 Ha
Government = 15.438 Ha

Total land required for temporary acquisition is **15.4ha** which assumed that it will be government open land.

0.6 Station Planning

The proposed Ahmedabad Metro consists of two corridors namely:

Corridor I: North-South Corridor (APMC-Motera Stadium)

The length of this corridor is 15.42 km. Total 14 no. of stations have been planned on this corridor. All stations on this corridor are planned as an elevated.

Corridor II: East West Corridor (Thaltej Gam – Vastral Gam)

The length of this corridor is 20.536 km. Total 18 no. of stations have been planned on this corridor. Four stations on this corridor are planned to be underground while the rest will be elevated.

0.6.1 Station Types

A total of 32 stations have been proposed across both the corridors. These are mostly elevated stations located at a clear height of 5.5m above the road. The stations shall be accessible from both sides of the road in order to better serve the catchment area. Two side platforms are planned on this type of station. Approximately 6 km of alignment in the E-W corridor is located underground. This alignment will include four underground stations. These underground stations will be island types in configuration.

The Ashram Road station is planned as an important metro interchange providing interchange between North-South & East-West lines. Other interchange stations include those interconnecting transport nodes such as Railway stations, GSRTC Terminals, BRTS and AMTS stops. The stations would be physically connected to these nodes to ensure comfortable and hassle-free transfers.

0.6.2 Planning And Design Criteria For Stations

Salient features of a typical station are as follows:

1. The stations can be divided into public and non-public areas (those areas where access is restricted). The public areas can be further subdivided into paid and unpaid areas.
2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
3. The platform level at elevated stations is determined by a critical clearance of 5.50 m under the concourse and above the road intersection, allowing 3.00 m for the concourse height, about 2-m for concourse floor and 2.00 m for structure of tracks above the concourse. Further, the platforms are 1.09 m above the tracks. This would make the platforms in an elevated situation at least 14.0 m above ground.
4. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.
5. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators.

Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.

6. Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.
7. Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS.
8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station.
9. Tunnel Ventilation fans and ASS in underground stations are provided at platform level/ concourse level depending on availability of land for locating vent shafts.
10. The DG set, bore well pump houses and ground tank would be located generally in one area on ground.
11. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:
    - Minimum distance of travel to and from the platform and between platforms for transfer between lines.
    - Adequate capacity for passenger movements.
    - Convenience, including good signage relating to circulation and orientation.
    - Safety and security, including a high level of protection against accidents.
12. Following requirements have been taken into account:
    - Minimum capital cost is incurred consistent with maximizing passenger attraction.
    - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    - Flexibility of operation including the ability to adapt to different traffic conditions changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.
    - Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.

- o Provision of display of passenger information and advertising.

13. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions.
14. In order to transfer passengers efficiently from street to platforms and vice versa, station planning has been based on established principles of pedestrian flow and arranged to minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers.
15. Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

0.7 TRAIN OPERATION PLAN & MAINTENANCE FACILITIES

0.7.1 OPERATION PHILOSOPHY

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

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- A short train consists of 3 coaches.
- Multi-tasking of train operation and maintenance staff.

The PHPDT capacity provided on the two corridors in different years of operation Capacity Provided for North- South Corridor is tabulated below:

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
APMC to Madalpur	2018	12	12 Rakes of 3-car	3-car	36	3335	3820 (4865*)
Madalpur to Motera Stadium		6		3-car		8476	7640 (9730*)
APMC to Madalpur	2021	8	17 Rakes of 3-car	3-car	51	4576	5730 (7298*)
Madalpur to Motera Stadium		4		3-car		12097	11460 (14596*)
APMC to Madalpur	2031	6	22 Rakes of 3-car	3-car	66	6685	7640 (9730*)
Madalpur to Motera		3		3-car		17778	15280

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT	PHPDT Capacity
Stadium							(19460*)
APMC to Madalpur	2043	4	32 Rakes of 3-car	3-car	96	8532	11460 (14595*)
Madalpur to Motera Stadium		2		3-car		26484	22920 (29190*)

* @ 8 persons per square meter of standee area

Capacity Provided for East-West Corridor

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Thaltej Gam to Ashram Road	2018	8.5	17 Rakes of 3-car	3-car	51	6797	5393 (6868*)
Ashram Road to Apparel Park		4.25		3-car		10593	10786 (13736*)
Apparel Park to Vastral Gam		8.5		3-car		4303	5393 (6868*)
Thaltej Gam to Ashram Road	2021	6	22 Rakes of 3-car	3-car	66	9202	7640 (9730*)
Ashram Road to Apparel Park		3		3-car		15659	15280 (19460*)
Apparel Park to Vastral Gam		6		3-car		6287	7640 (9730*)
Thaltej Gam to Ashram Road	2031	4	32 Rakes of 3-car	3-car	96	13249	11460 (14595*)
Ashram Road to Apparel Park		2		3-car		19251	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		9629	11460 (14595*)
Thaltej Gam to Ashram Road	2043	4	32 Rakes of 3-car	3-car	96	15609	11460 (14595*)
Ashram Road to Apparel Park		2		3-car		22944	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		12135	11460 (14595*)

*@ 8 persons per square meter of standee area

0.7.2 Train frequency

North- South Corridor

Sections	2018		2021		2031		2043	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Madalpur to Motera Stadium	6 min	10 to 30 min	4 min	6 to 20 min	3 min	5 to 15 min	2 min	3 to 10 min
APMC to Madalpur	12 min	20 to 60 min	8 min	12 to 40 min	6 min	10 to 30 min	4 min	6 to 20 min

East-West Corridor

Sections	2018		2021		2031		2043	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Thaltej Gam to Ashram Road	8.5 min	12 to 40 min	6 min	10 to 30 min	4 min	6 to 20 min	4 min	6 to 20 min
Ashram Road to Apparel Park	4.25 min	6 to 20 min	3 min	5 to 15 min	2 min	3 to 10 min	2 min	3 to 10 min
Apparel Park to Vastral Gam	8.5 min	12 to 40 min	6 min	10 to 30 min	4 min	6 to 20 min	4 min	6 to 20 min

No services are proposed between 00.00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

0.8 ROLLING STOCK

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

0.8.1 Optimization of Coach Size

The following optimum size of the coach has been chosen for this corridor as mentioned in Table0.9.

Table 0.9
Size of the 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*

0.8.2 Passenger Carrying Capacity

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

Therefore, for the Medium Rail Vehicles (MRV) with 2.9 m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 43 seated, 204 standing thus a total of 247 passengers for a Driving motor car, and 50 seated, 220 standing thus a total of 270 for a trailer/motor car is envisaged.

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

Table 0.10 shows the carrying capacity of Medium Rail Vehicles.

Table 0.10
Carrying Capacity of Medium Rail Vehicles

Particulars	**Driving Motor car**		**Trailer car**		**3 Car Train**	
	Normal	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**
Seated	43	43	50	50	136	136
Standing	102	204	110	220	314	628
Total	145	247	160	270	450	764

NORMAL-3 Person/sqm of standee area

CRUSH -6 Person/sqm of standee area

0.8.3 Weight

The weights of driving motor car, trailer car and motor car have been estimated as in Table 0.11, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 0.11
Weight of Light Rail Vehicles (TONNES)

	DMC	TC	3 Car Train
TARE (maximum)	40	40	120
Passenger			
(Normal)	9.425	10.4	29.25
(Crush @6p/sqm)	16.055	17.55	49.66
(Crush @8p/sqm)	20.475	22.295	63.245
Gross			
(Normal)	49.425	50.4	149.25
(Crush @6p/sqm)	56.055	57.55	169.66
(Crush @8p/sqm)	60.475	62.295	183.23
Axle Load @6 person/sqm	14.014	14.388	
Axle Load @8 person/sqm	15.119	15.577	

The axle load @ 6persons/sqm of standing area works out in the range of 14.014T to 14.388T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should, therefore, be designed for **16 T axle** load.

0.8.4 Performance Parameters

The recommended performance parameters are:

Maximum Design Speed: 90 kmph
Maximum Operating Speed: 80 kmph
Max. Acceleration: 1.0 m/s^2 (with AW3 load)
Max. Deceleration 1.1 m/s^2 (Normal brake)
More than 1.3 m/s^2 (Emergency brake)

0.8.5 Coach Design and Basic Parameters

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

(i) Proven equipment with high reliability

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

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

0.9 POWER REQUIREMENTS

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

(i) Specific energy consumption of rolling stock – 75KWh/1000 GTKM
(ii) Regeneration by rolling stock – 20%
(iii) Elevated/at –grade station load – initially 250KW, which will increase to 400 KW in the year 2043
(iv) Underground station load – initially 2000 KW, which will increase to 2500 KW in the year 2043
(v) Depot auxiliary load - initially 2000 KW, which will increase to 2500 KW in the year 2043.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2018, 2021, 2031 and 2043 are summarized in table 0.12 below:-

Table 0.12 Power Demand Estimation (MVA)

Corridor		Year			
		2018	2021	2031	2043
APMC To Motera Stadium (North-South)	Traction	4.74	6.38	8.14	11.43
	Auxiliary	6.79	6.92	8.03	10.01
	Sub-total	11.53	13.30	16.17	21.44
Thaltej Gam To Vastral Gam (East-West)	Traction	6.38	8.47	12.04	12.26
	Auxiliary	17.05	17.66	19.76	22.73
	Sub-total	23.43	26.13	31.80	34.99

The high voltage power supply network of Ahmedabad city was studied in brief. The city has 220, 132 and 66kV network to cater to various types of demand in vicinity of the proposed corridor. Series of meetings were held with M/s Torrent Power AEC Limited (Licensee of the area) and various sub-stations sites were inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, Four Receiving Sub-stations (two for N-S line and Two for E-W line) are proposed to be set up. This is an economical solution without compromising reliability. Based on the discussions with M/s Torrent AEC Ltd., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 or 66kV voltage through cable feeders: -

Table 0.13 Sources of Power Supply

S. N.	Corridor	Grid sub-station of Torent AEC Ltd. (Input voltage)	Location of RSS of Metro Authority	Approx. length of 132 or 66kV cables
	APMC To Motera Stadium (North-South)	Pirana Grid sub-station (132kV)	Vasna Depot	5 km Transmission Line (Double circuit)
		Sabarmati Grid sub-station (132kV)	Sabarmati	1km. (Double circuit)
	Thaltej Gam To Vastral Gam (East-West)	Thaltej Grid sub-station (132kV)	Thaltej	1km. (Double circuit)
		Grid sub-station Near Apparel Park	Apparel Park Depot	(Double circuit) To be idendified

The summary of expected power demand at various sources is given in table 0.14.

Table 0.14 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand* – Emergency (MVA)	
		Initial Year (2018)	Year (2043)	Initial Year (2018)	Year (2043)
APMC To Motera	**Vasna RSS**				
	Traction	3.20	6.82	4.74	11.43
	Auxiliary	4.63	6.55	6.79	10.01
	Sub-total (A)	**7.82**	**13.37**	**11.53**	**21.44**
	Sabarmati RSS				

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand* – Emergency (MVA)	
		Initial Year (2018)	Year (2043)	Initial Year (2018)	Year (2043)
Stadium (North-South)	Traction	1.54	4.61	4.74	11.43
	Auxiliary	2.16	3.46	6.79	10.01
	Sub-total (B)	**3.70**	**8.07**	**11.53**	**21.44**
Thaltej Gam To Vastral Gam (East-West)	**Thaltej RSS**				
	Traction	2.36	5.03	6.38	12.26
	Auxiliary	7.29	9.82	17.05	22.73
	Sub-total (C)	**9.65**	**14.85**	**23.43**	**34.99**
	Apparel Park				
	Traction	4.02	7.23	6.38	12.26
	Auxiliary	9.76	12.91	17.05	22.73
	Sub-total (C)	**13.78**	**20.14**	**23.43**	**34.99**

* Incase of failure of other source of power

The 132 kV power supply will be stepped down to 33 kV level at the RSS's of metro authority. The 33kV power will be distributed along the alignment through 33kV Ring main cable network for feeding traction and auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct and tunnel.

Interconnection of 33kV power supply between the two corridors has been planned at the Interchange station of Ashram Road which can be used for transfer of power from one corridor to other in emergency situations. In case of tripping of One RSS of either corridor on fault or input supply failure, train services can be maintained from stand-by source of the same line or RSS of other line the other RSS's. But if one more RSS fails, only curtailed services can be catered to. However, in case of total grid failure, all trains may come to a halt but station lighting, fire and hydraulics & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

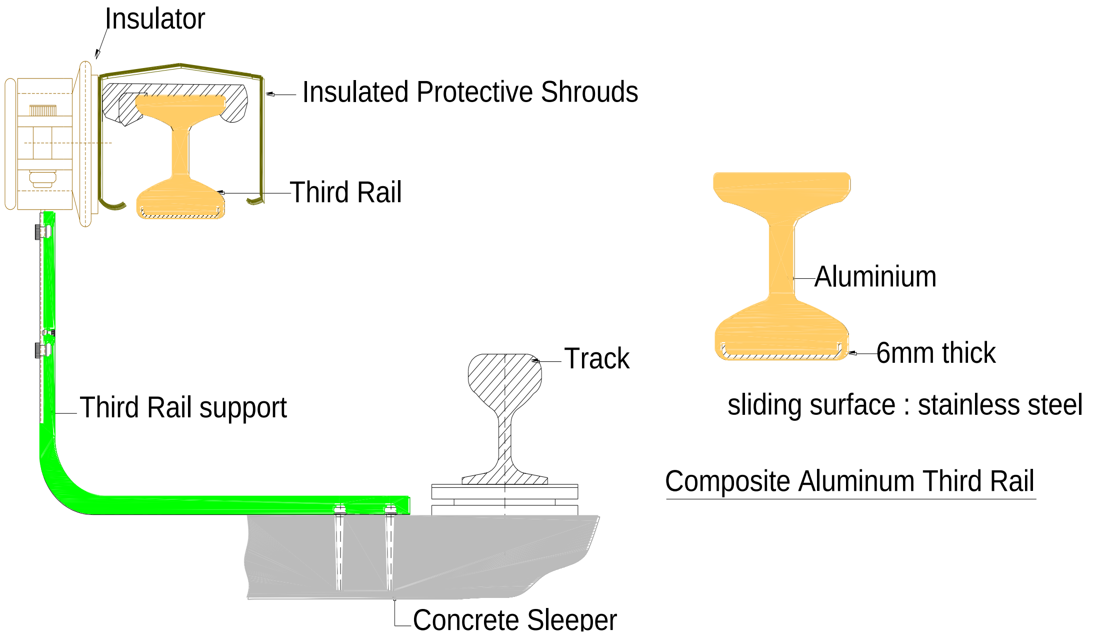
Typical High Voltage Receiving Sub-station

The 132 kV cables will be laid through public pathways from Torrent Power AEC Sub-stations to RSS of Metro Authority. RSS at Vasna and Sabarmati RSS shall be provided with 2nos. (one as standby) 132/33 kV, 25 MVA (ONAN) three phase Transformers for feeding Traction as well as auxiliary loads and RSS near Thaltej and Apparel RSS shall be provided with 2nos. (one as standby) 132/33 kV, 40 MVA (ONAN) three phase Transformers. The capacity of transformers may be reviewed considering the load requirement/distribution of both the corridors at the time of detailed design.

Conventional Outdoor type 132 kV Switchgear is proposed for all the RSS to be located in approx. 80 X 60 m (4800 sq. m) land plot as the availability of Land in this area may not be a constraint. If Gas Insulated Switchgear (GIS) type Switchgear will be planned in future due to less space and reduced maintenance the capital cost need to be enhanced.

0.9.1 750V dc Third Rail Current Collection System

For the 750V dc Third Rail Current Collection System, Bottom current collection with the use of composite Aluminum steel third rail on main lines is envisaged from reliability and safety considerations (figure below). Low carbon steel third rail available indigenously is proposed for the depot because of reduced current requirements.



750V dc Third Rail Current Collection System

The cross-section of third rail will be about 5000 mm^2. The longitudinal resistance of composite and steel third rail is about 7 and 20 milli-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

0.9.2 Special Arrangements in Depot

A separate traction sub-station (TSS) shall be provided for the depot so as to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area. Tracks of Depot area shall also be isolated from mainline through insulated rail joints (IRJ). Remote operated sectionalizing switches shall be provided to feed power from depot to mainline and vice-versa in case of failure of TSS.

The prescribed limit of highest touch potential in depot is 60V as per EN50122-1 and therefore Track Earthing Panels (TEP) shall be provided at suitable locations to earth the rail in case the rail potential exceeds this limit. In areas, where leaky conditions exist (e.g. washing lines, pit wheel lathe etc.), insulated rail joints (IRJ) shall be provided with power diodes to bridge the IRJ to facilitate passage of return current.
A detailed scheme shall be developed during the design stage.

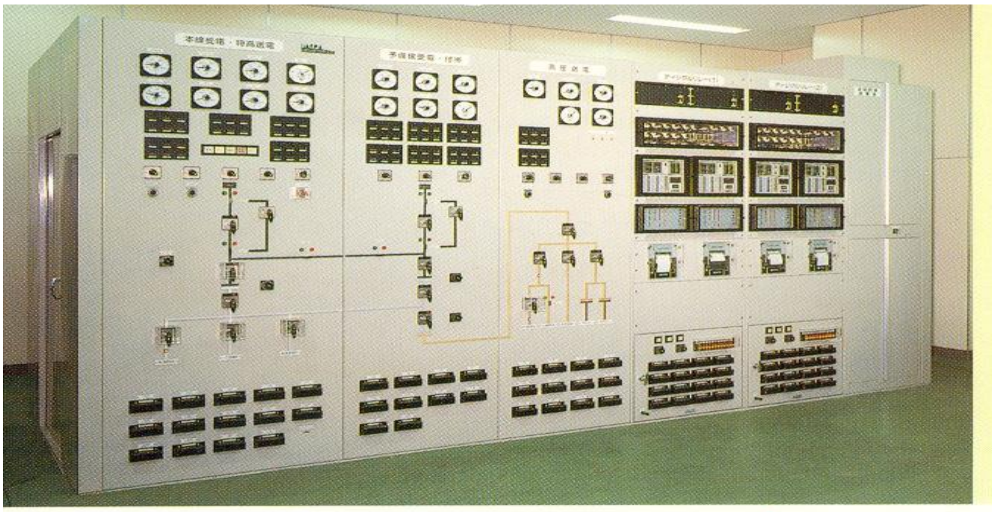
0.9.3 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. However, dc traction currents do not cause electromagnetic induction effect resulting in induced voltages and magnetic fields.

0.9.4 The rectifier-transformer used in dc traction system produces harmonic voltages, which may cause interference to telecommunications and train control/protection systems. The rectifier-transformer shall be designed with the recommended limits of harmonic voltages, particularly the third and fifth harmonics. 12-pulse rectifier-transformer has been proposed, which reduces the harmonics level considerably. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMC plan will be required to be developed during project implementation stage.

0.9.5 Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. A separate ASS is required at each depot. The ASS will be located at mezzanine or platform level inside a room. Wherever TSS is required, ASS & TSS will be housed together inside a room. The auxiliary load requirements have been assessed at 400 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the stations (one transformer as standby). Both the Depot ASSs will also be provided with 2x2500 kVA auxiliary transformers. For Underground station, the auxiliary load requirements have been assessed at 2500 kW, accordingly, two dry type cast resin transformers (33/0.415kV) of 3200kVA capacity are proposed to be installed at the stations (with one transformer as standby).



Typical Indoor Auxiliary Sub-station

2x2.5MW transformer-rectifier set shall be provided in each TSS with space provisions for an additional set to be accommodated in future as and when train composition is increased. Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. From the traction sub-stations, 750V dc cables will be laid up to third rail and return current cables will be connected to running rails.

0.10 VENTILATION AND AIR-CONDITIONING SYSTEM

0.10.1 Need for Ventilation and Air Conditioning

The underground stations are 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 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 M.R.T. underground stations cannot be extracted by simple ventilation. 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. In winter months it may not be necessary to cool the ventilating air as the heat generated within the station premises would be sufficient to maintain the comfort requirement.

0.10.2 DESIGN PARAMETERS FOR VAC SYSTEM

With hot and humid ambient conditions of Ahmedabad during the summer and monsoon months, it is essential to maintain appropriate conditions in the underground stations in order to provide a 'comfort-like' 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 centers and other public utility buildings. The standards used for buildings are not directly applicable for the underground spaces, as the heat load gets added periodically with the arrival of the train.

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 is given out 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 condition in earlier metros, in this criteria comfort is defined as the function of temperature and the air velocity experienced by a person. A new index named RWI (Relative Warmth Index) has been adopted for metro designs worldwide. This index depends upon the transient condition of the metabolic rate and is evaluated based on the changes to the surrounding ambient 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, then RWI is the preferred criterion.

(1) Outside ambient conditions:

This is based upon ASHRAE-2009 recommended design conditions for 1% criteria, as under

1% Criteria

Summer:	40.9°C (DB),	22.9°C (WB)
Monsoon:	32.9°C (DB),	28.1°C (WB)

For this corridor it is suggested to use 1% criteria, which is defined as the conditions, when the DB or WB temperatures are likely to exceed for only 1% of the total time.

(2) Inside design conditions:

Platform areas:	27°C at 55% RH
Concourse:	28°C at 60% RH

(3) Tunnel design conditions:

Normal conditions	Max. DB 40°C
Congested conditions	Max. DB 45°C

(4) Minimum fresh air: 10% or 18 cmh/person (In station public areas)

0.11 SIGNALLING

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

0.11.1 Signalling and Train Control

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

This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation and for bidirectional working.

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

Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours.

Radio for CBTC shall work in License free ISM band.

0.12 TELECOMMUNICATION & AUTOMATIC FARE COLLECTION

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

The Telecommunication facilities proposed are helpful in meeting the requirements for

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

The proposed Telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication

- Telephone Exchange
- Integrated Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralised Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving Cars and maintenance personnel.
- Data Channels for Signalling, SCADA, Automatic Fare Collection etc.
- E&M SCADA is not envisaged as part of Telecomm System as such, hence catered to separately in DPR
- Integrated SCADA is envisaged as part of Telecom System which will integrate Telecom/Traction SCADA, BMS, ATS and other systems on a single MMI

0.12.1 AUTOMATIC FARE COLLECTION

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

For Multiple Journey, the Store Value Contactless Smart Card shall be utilized and for the Single Journey, the Smart media shall be as utilized as Contactless Smart Token. System should be compatible with the Contactless Smart Chip supplied by at least 2 Chip OEMs as per ISO 14443 standard.

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

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

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

B) Automatic fare collection systems have the following advantages:

1. Less number of staff required.

2. Less possibility of leakage of revenue due to automatic ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.
4. Efficient and easy to operate, faster evacuation both in normal and emergency.
5. System is amenable for quick fare changes.
6. Management information reports generation easy.
7. System has multi-operator capabilities. Same Smart Card can be used for other applications also, including in other lines of the Metro.
8. Contactless Smarts Card based AFC systems are the worldwide accepted systems for LRT/Metro environment.

The proposed ticketing system shall be that to be of Contactless Smart Card type for multiple journey and Contactless Token for Single Journey. The equipment for the same shall be provided at each station Counter/Booking office and at convenient locations and will be connected to a local area network with a computer in the Station Control room.

C) Choice of Control Gates

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

D) Ticket Vending Machine (TVM)

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

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

E) Ticket Reader/Add Value Machines

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

F) Recharge Card terminal Machine (RCTM)

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

0.13 DISABLED FRIENDLY FEATURES

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

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

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons", 1998 and 2013 edition (under revision by MoUD), and international best practices / standards

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

(A) CONTENT

1. Rail Transport

2. Metro Rail Station

- Way finding
- Signage
- Automated Kiosks
- Public Dealing Counters
- Audio-visual Displays
- Public Telephones
- Rest Areas/Seating
- Tactile Paving - Guiding & Warning
- Doors
- Steps & Stairs
- Handrails
- Ramps
- Lifts/Elevators

- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

3. Street Design

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

4. Alighting and Boarding Area

- Approach
- Car Park
- Drop-off and Pick-up Areas
- Taxi/Auto Rickshaw Stand
- Bus Stand/Stop

(B) Metro Railway Stations

1. Level Approach

- Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should a ramp.
- Walkway surfaces should be non-slip.
- Approach walkway should have tactile pavements for persons with visual impairments.

2. Station Entrances and Exits

- These should have a minimum width of 1800mm and is level or ramped.

3. Reservation and Information Counters

- Should have clear floor space of at least 900 mm x 1200 mm in front of the counters;
- There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
- At least one of the counters should have an induction loop unit to aid people with hearing impairments; and

- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

4. Toilet Facilities

- There should be at least one unisex accessible toilet
- Ticket Gates

At least one of the ticket gates should:

- Be minimum 900 mm wide to allow a wheelchair user through; and
- Have a continuous line of guiding paver for people with visual impairments.

5. Platforms

The Platforms should:

- Have a row of warning paver installed 600mm before the track edge (photo 6);
- Have non-slip and level flooring;
- Have seating areas for people with ambulatory disabilities;
- Be well illuminated lux level 35 to 40;
- There should be no gap or difference in level between the train entry door and the platform.
- All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

- Way finding references should be available at decision points.
- Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.

- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travelers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. Signage

Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille).

8. Sign Design Specifications

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.
- Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
- The colour of the text should be in a colour that contrasts with the sign board.
- The sign board should also contrast with the wall on which it is mounted.
- The surface of the sign should not be reflective.
- Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
- Illuminated signs should not use red text on a dark background.
- Signs should be supplemented by Braille where possible.

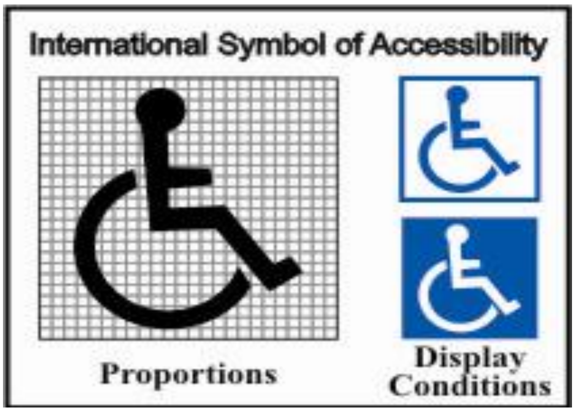


Fig. 0.2 (a) Way finding signage (b) International Symbol of Accessibility

9. SIGNAGE OF ACCESSIBLE TOILETS

All unisex accessible toilets to have access symbol in contrast colours. A distinct audio sound (beeper/clapper) may be installed above the entrance door for identification of the toilets.

Fig. 0.3 - Signage for accessible washroom

0.14 ENVIRONMENTAL IMPACT ASSESSMENT

Ahmedabad, in demographic-cum-economic terms, is the most developed region of Gujarat. Ahmedabad a 600 year old city is the district headquarters and the biggest city of the state at present. Gandhinagar is the Capital of Gujarat. Gandhinagar and Ahmedabad are located 32 km from each other, are well connected through highways and are rapidly becoming a contiguous urban area. The twin cities together constitute a buoyant economy.

Manufacturing, trade and service dominate Ahmedabad. It is a national hub for pharmaceutical, chemical and textile sector. Thus, in order to resolve traffic and pollution related issues and considering future growth and development of the city, Government of Gujarat proposes to develop a Metro Rail project to meet the local transport requirements of Ahmedabad.

MEGA (Metro-link Express for Gandhinagar and Ahmedabad), a special purpose vehicle was formed in 2009 for development and operation of Metro Rail facility in the twin cities of Ahmedabad and Gandhinagar. MEGA desires to build the Metro Rail System by adopting adequate environmental standards to provide for the protection of the people and the environment.

It is proposed that the Metro project will be taken up in Phases. Under Phase I, the length of the alignment considered is 35.95 Km and there would be 32 stations. Of the Phase I length, 6.335km, primarily in the eastern old city part of the east west corridor is proposed to be underground. There are two lines of which the East - West corridor is 20.53km and North - South corridor is 15.420km.

0.14.1 Regulatory Permissions Required

For the Phase I of Metro project, required clearances/ permissions related to environment for MEGA Phase I have been summarized in Table below.

Permissions/Clearances Related to Environment Required for Phase I Metro Project

Sl. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980). Tree removal will be guided as per state government rules.	District Forest Office/State Forest Department/ District Collector	MEGA
2	Permission for construction within the regulated / prohibited zone	Gujarat Town Planning and Urban Development Act, 1976	Town Planning Department and ASI	MEGA
B. Implementation Stage				
3	Consent to operate hot mix plant, crushers, batching plant	Air (Prevention and Control of Pollution) Act 1981	Gujarat State Pollution Control Board	Contractor
4	Permission for withdrawal of groundwater for construction	Environment (Protection) Act, 1986	Central Ground Water Authority	Contractor
5	Permission for sand mining from river bed	Environment (Protection) Act, 1986	Mining Department , Government of Gujarat	Contractor
6	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 1989	Gujarat State Pollution Control Board	Contractor
7	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 1989	Intimate local civic body to use local solid waste disposal site	Contractor
8	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	Gujarat State Pollution Control Board	Contractor
9	Permission for groundwater extraction.	Environment (Protection) Act, 1986	Central Ground Water Board (CGWB)	Contractor

Sl. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
10	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment	District Labour Commissioner	Contractor
	Setting up of Batching Plants by the Contractors.	Air Consent and Water Consent under Air Act and Water Act	Gujarat Pollution Control Board	Contractor
C. Operations Stage				
	Installation of DG Sets and discharge of Wastewater from Depot.	Air Consent and Water Consent under Air Act and Water Act	Gujarat Pollution Control Board	MEGA

0.15 SECURITY MEASURES FOR A METRO SYSTEM

Metro is emerging as the most favoured mode of urban transportation system. 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 the high cost of infrastructure, its economic impotence, being the life line of city high news value, fear & panic and man casual ties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

0.15.1 NECESSSITY OF SECURITY

It is well known that public transportation is increasingly important for urban areas to prosper in the face of challenges such as reducing congestion and pollution. Therefore, security places an important role in helping public transport system to become the mode of choice. Therefore, excellence in security is a prerequisite for Metro system for increasing its market share. Metro railway administration must ensure that security model must keep pace rapid expansion of the metro and changing security scenario.

0.15.2 THREE PILLARS OF SECURITY

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

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

0.16 DISASTER MANAGEMENT MEASURES

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

0.16.1 Need for Disaster Management Measures

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

0.16.2 Objectives:

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

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

to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

0.17 Multi Modal Traffic Integration at Metro Stations

0.17.1 Background

The proposed metro in Ahmedabad has two corridors totaling 35.956 km and 32 stations, including terminal stations. It traverses across the city in the north-south and east-west direction and along its path covers many important origins and destinations. However, its reach will not be enough to reach all origins and destinations. Fortunately, Ahmedabad has planned for a multi-modal system, where the proposed metro complements the existing BRTS and AMTS services. The need is now to ensure that people have safe, comfortable and secure access to the above modes as well as seamless integration facilities.

The AMTS, which is a much older service, has a fleet of close to 800 buses and operates over 150 routes. It has a daily ridership of close to 7 lakh. As the BRTS expands, the AMTS routes are being rationalized to avoid major overlaps and expand into new, upcoming suburbs of Ahmedabad. They are also expected to act as feeders to the BRTS. A new proposal by the AMTS calls for moving away from the traditional destination oriented services to direction based services. Accordingly, new routes have been proposed, consisting of 16 radial and 3 ring routes, running at high frequency. This new system is expected to be operational in phases beginning from May 2014.

The Centre of Excellence in Urban Transport, CEPT University has been commissioned by MEGA to undertake a study on last mile connectivity for proposed metro corridor. The Last Mile Connectivity refers to the provision of travel service from home or workplace to the nearest public transportation mode. A trip is considerd as the entire journey between origin and destination. Commuters may utilize and combine different mdes of transport for the entire trip. Metro or BRTS may cater to a majority of this kind of trip, but commuters always need to complete the access and egress part on their own.

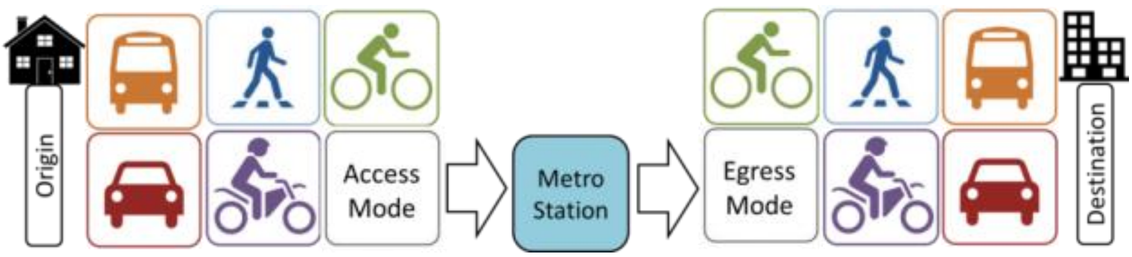


Figure 0.1 Components of trip

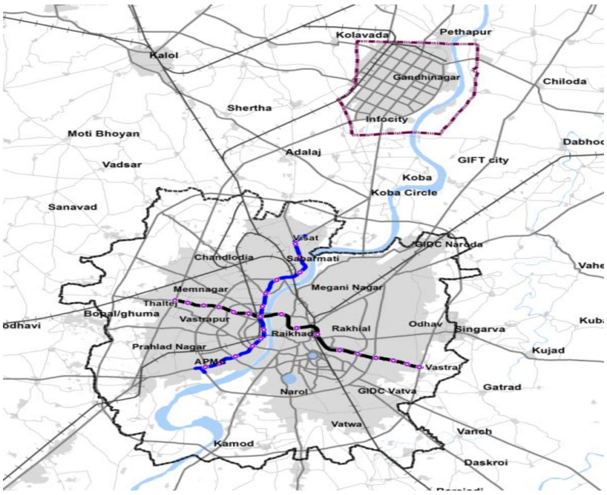


Figure 0.2 Proposed Metro corridor

The map above shows the metro corridors proposed in phase 1. Along with the BRTS and AMTS, it is expected that the mode share of public transit in Ahmedabad will increase from the present 15% to 40% by 2020. However, there is a need to ensure that these three systems are integrated in such a manner that the commuter gets benefit of single trip through fare integration as well enjoys a seamless physical transition from one mode to another. Along with this, there is a need to ensure that last mile connectivity through pedestrian and bicycle facilities are enhanced.

This chapter will look at concepts of last mile connectivity along with multi-modal integration, and identify key interchange locations that need to be identified in Ahmedabad keeping in mind present and future demand and potential.

The cost requirement for such facilities would also be estimated at block costs level to get an idea of the funds required.

0.17.2 AIM AND OBJECTIVES

The aim of this study is to suggest measures to increase last mile connectivity for metro users and to integrate metro with other modes of transit. The specific objectives are:

- To suggest measures that provide local destinations with safe, comfortable and convenient accessibility to Metro stations
- To propose design guidelines for local street environment
- To propose conceptual designs that will maximize benefits and efficiency of interchanges

0.17.3 METHODOLOGY

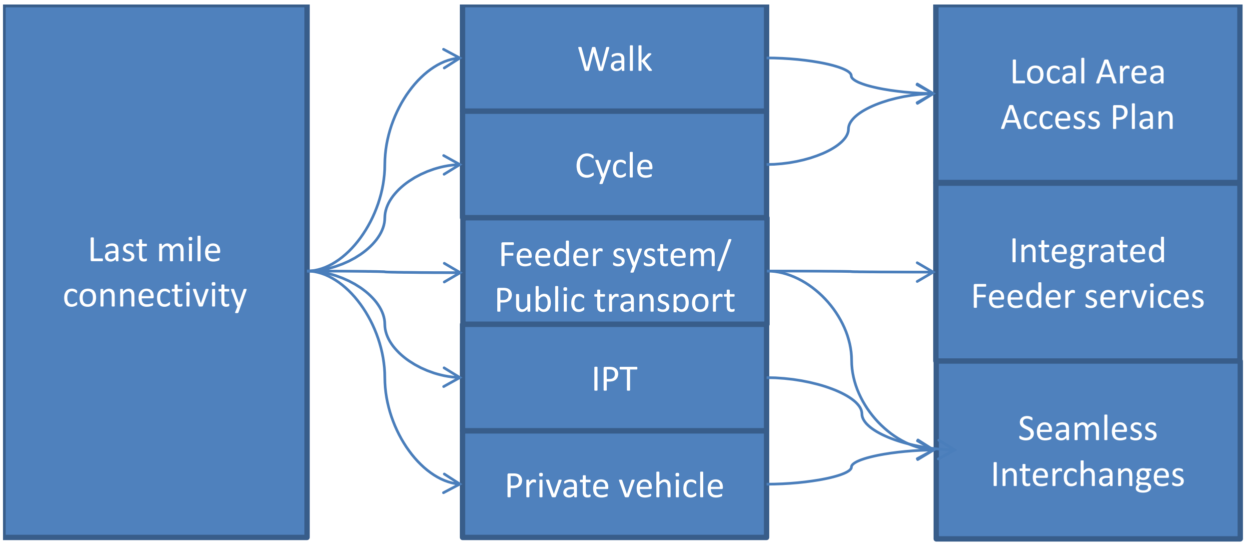


Figure 0.3 Different aspects of Last Mile Connectivity

The study will look at each metro station and the surrounding area in detail. The land use for a distance of 500m from the corridor has been surveyed to understand nature of existing development. All prominent activities such as schools, colleges, hospitals, malls etc. will be mapped to ensure that the LAAP caters to all of them. At the same time, for each station, feeder services in the form of BRTS and AMTS will be identified. Each metro station will be classified in terms of level of the interchange, which will be finalized based on the number of modes and frequency of services.

0.18 COST ESTIMATES

Project Cost estimates for the Ahemdabad metro rail network has been prepared covering civil, electrical, signalling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 750v dc traction at March 2014 price level, both for Capital and Operation & Maintenance costs.

While preparing cost estimates, various items have generally been grouped under three major heads on the basis of:-

(i) Route km. Length of alignment

(ii) No. of units of that item and

(iii) Item being an independent entity.

All items related with alignment, whether in underground or elevated or at-grade construction, permanent way OHE, signalling and telecommunication, have been estimated on rate per route km/km basis. Route km. cost for underground alignment construction, excludes station lengths. Station lengths (260m) have to be done by cut and cover in general and by tunneling under compelling exceptional circumstances.

The rates adopted for underground stations include cost of civil structures and architectural finishes. Similarly, cost of elevated and at grade stations includes civil work for station structures, architectural finishes, platform roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc, have been worked out separately. These rates do not include cost of permanent way, O.H.E., power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, VAC, etc, costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-III. A suitable escalation factor has been applied to bring these costs to March 2014 price level. Taxes & Duties such as Customs Duty, Excise Duty, Sales Tax, Works Tax, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the Ahemdabad metro rail network at March 2014 price level works out to **Rs. 9327Crores** including applicable Taxes & Duties, as tabulated hereunder.

Table 0.15 – Corridor-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	East-West Corridor	5077	754	5831
2.	North-South corridor	3052	444	3496
	Total	**8129**	**1198**	**9327**

0.19 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

The Ahmadabad Metro Project is proposed to be constructed with an estimated cost of Rs 9102.00 Crore with central taxes and land cost. The length of the metro system and estimated cost at March-2014 price level without central taxes and with central taxes is placed in table 0.16 as under:

Table 0.16 Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)
1	E-W Corridor (Thaltej Gam to Vastral Gam)	20.536	5,077.00	5,692.00

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)
2	N-S Corridor (APMC to Motera Stadium)	15.420	3,052.00	3,410.00
Total		**35.956**	**8129.00**	**9102.00**

The estimated cost at March-2014 price level includes an amount of Rs.11.12 Crore as one-time charges of security personal towards cost of weapons, barricades, and hand held and door detector machine etc. However, the recurring cost towards salary and allowances of security personal have not taken in to account in FIRR calculation. 2.12crore each station has been provide for Multi Modal Traffic Integration (first mile and last mile connectivity i.e., feeder bus services).

0.19.1 Investment Cost

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes has been calculated by taking escalation factor @7.5% per annum. It has been assumed that Gujarat State Government will exempt the local taxes or reimburse the same and provide the land worth Rs. 727.00 crore at March-2014 price level free of cost or it shall provide Interest Free Subordinate Debt.

It is assumed that the construction work will start on 01.07.2014 and is expected to be completed on 31.03.2018 with Revenue Opening Date (ROD) as 01.04.2018 for the both the corridors. The total completion costs duly escalated and the cash flow of investments shown in the table 0.17.

Table 0.17 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at March-2014 Price Level			Completion Cost		
	Corridor-I	Corridor-II	Total	Corridor-I	Corridor-II	Total
2014-15	407.00	255.00	662.00	407.00	255.00	662.00
2015-16	1459.00	878.00	2337.00	1558.00	936.00	2494.00
2016-17	1458.00	877.00	2335.00	1663.00	998.00	2661.00
2017-18	1578.00	934.00	2512.00	1960.00	1160.00	3120.00
2018-19	526.00	311.00	837.00	702.00	415.00	1117.00
2019-20	158.00	93.00	251.00	227.00	134.00	361.00
2020-21	106.00	62.00	168.00	164.00	96.00	260.00
Total	**5692.00**	**3410.00**	**9102.00**	**6681.00**	**3994.00**	**10675.00**

Although the construction is expected to get over by 31st March 2018, the cash flow spill over up to March 2021 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

The cost of Land of Rs. 727.00 crore at March-2014 price level included in the above completion cost will be provided free of cost by the Gujarat Government. However, Cost of 10 hectare land to be provided by Gujarat Government for property development has not been included in above.

0.19.2 MODELS OF FINANCING

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

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

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

SPV Model: - The corridor is a standalone one and therefore forming a separate SPV may be in the name of Ahmadabad Metro Rail Corporation may be desirable. The funding pattern under this model (SPV) is placed in table 0.18 as under: -

Table 0.18 Funding pattern under SPV model (with central taxes)

Particulars	With Taxes & Duties			
	Corridor-I	Corridor-II	Total	% of contribution
Equity By GOI	884.50	527.50	1412.00	13.23%
Equity By GOG	884.50	527.50	1412.00	13.23%
SD for CT by GOG (50%)	365.50	212.50	578.00	5.41%
SD for CT by GOI (50%)	365.50	212.50	578.00	5.41%
SD for Land by GOG (100%)	431.00	296.00	727.00	6.81%
1.40% JICA Loan /12% Market Borrowings	3750.00	2218.00	5968.00	55.91%
Total	**6681.00**	**3994.00**	**10675.00**	**100.00%**

In addition to the above, State Taxes of Rs.302.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in table 0.19 & 0.20 tabulated as under: -

Table 0.19 Funding pattern under BOT –Combined (16% EIRR)(With central taxes and without land cost and without Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1990.00	20.00%
VGF by GOG	3855.00	38.75%
Equity by Concessionaire	1368.00	13.75%
Concessionaire's debt @12% PA	2735.00	27.50%
Total	**9948.00**	**100.00**
Land Free by GOG	727.00	
IDC	239.00	
Total	**10914.00**	

Table 0.20 Funding pattern under BOT –Combined (16% EIRR)(With central taxes and without land cost and with Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1990.00	20.00%
VGF by GOG	3315.00	33.32%
Equity by Concessionaire	1548.00	15.56%
Concessionaire's debt @12% PA	3095.00	31.12%
Total	**9948.00**	**100.00**
Land Free by GOG	727.00	
IDC	274.00	
Total	**10949.00**	

In addition to the above, State Taxes of Rs.302.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

0.19.3 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 0.21 as under: -

Table 0.21 Additional Investment towards Rolling Stock

(Rs/Crore)

Financial Year	No. of Cars		Amount	
	Corridor-I	Corridor-II	Corridor-I	Corridor-II
2021-22	15.00	15.00	281.00	295.00
2031-32	30.00	15.00	914.00	480.00
2043-44	-	30.00	-	1,723.00

The total fund contribution of GOI & GOG under various alternatives is tabulated in table 0.22.

Table 0.22

Rs. In crore

Particulars	SPV Model	BOT Model without PD	BOT Model with PD
GOI	**1990.00**	**1990.00**	**1990.00**
GOG	**2717.00**	**4582.00**	**4042.00**
Total	**4707.00**	**6572.00**	**6032.00**

In addition to the above, State Taxes of Rs.302.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

0.20 ECONOMIC APPRAISALS

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

0.20.1 Economic Performance Indicators

After generating the cost and benefit stream Table, values of economic indicators are derived and are presented in **Table 0.23**. Project period is 2018-2047, EIRR (without tax) is found to be **17.09%** and B/C ratio as 4.22 and with 12 % discount, EIRR is **4.57%** and B/C ratio is 1.54. NPV without discount is Rs **87484** Cr. and with 12% discount rate, NPV is Rs. **4822**Cr. which shows that the project is economically viable.

Table 0.23 - Economic Indicator Values (with Central Tax)

PHASE I	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Total cumulative cost	27206	8902
Total cumulative benefit	114690	13724
Benefit Cost Ratio	4.22	1.54
NPV	87484	4822
EIRR	17.09%	4.54%

0.21 IMPLEMENTATION PLAN

Implementation on Delhi Metro/Chennai Metro Model

MEGA has to take action for appointment of General Consultants for project management including preparation of tender documents. Till the General Consultants are in position, MEGA should appoint an interim Consultant for all preliminary and enabling jobs such as land acquisition, detailed design of civil structures, utility diversions, etc.

The proposed date of commissioning of the both corridor with suggested dates of important milestones is given in Table 0.24

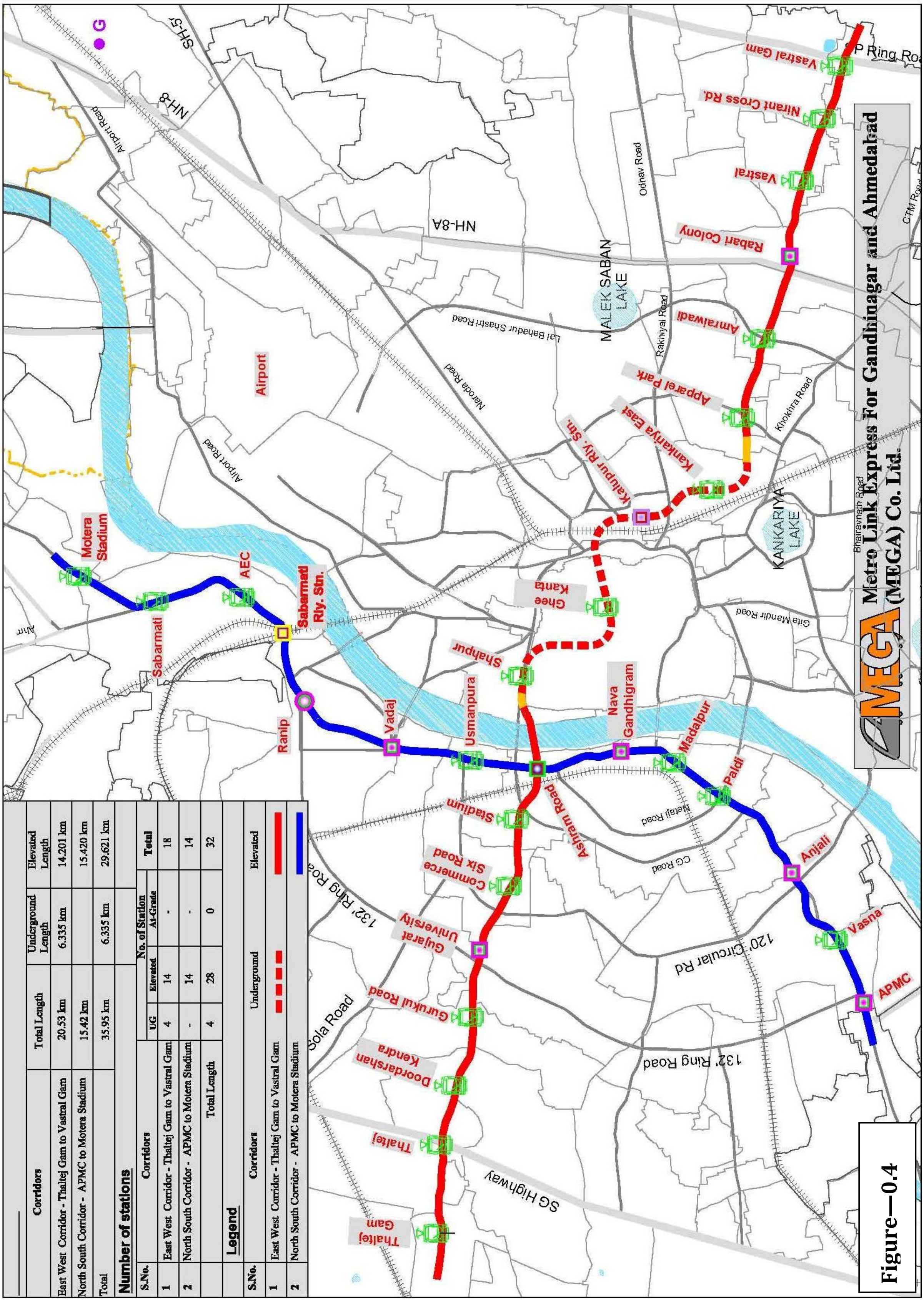
Table 0.24 - Implementation Schedule through DMRC model Phase I

S. No.	Item of Work	Completion Period
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D + 0.5momth
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D + 1month
4	Appoint interim Consultant for preliminary works	D + 3months
5	Approval of Project by Empowered Committee	D +3months
6	Sanction of Project by EGOM.	D +6months
7	Appoint General Consultant	D +9months
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	D +57months

S. No.	Item of Work	Completion Period
9	Testing and Commissioning	D +60moths
10	Revenue Operation	D +60months

0.22 CONCLUSIONS & RECOMMENDATION

The combined FIRR of both the corridors with taxes is 8.54% with additional property development of 10 hectares land and EIRR is 17.09 %. The pre-tax Equity FIRR to the BOT operator is 16% with a total VGF of only Rs.6032.00 crore excluding the cost of 10 hectare Land required for PD if the additional PD income is considered. Since the Gujarat Government is providing requisite land for PD and being social sector project, it is advisable to take up the job on DMRC model. Accordingly, the corridors are recommended for implementation.



Corridors	Total Length	Underground Length	Elevated Length
East West Corridor - Thaltej Gam to Vastral Gam	20.53 km	6.335 km	14.201 km
North South Corridor - APMC to Motera Stadium	15.42 km		15.420 km
Total	35.95 km	6.335 km	29.621 km

Number of stations

S.No.	Corridors	No. of Station UG	Elevated	At-Grade	Total
1	East West Corridor - Thaltej Gam to Vastral Gam	4	14	-	18
2	North South Corridor - APMC to Motera Stadium	-	14	-	14
	Total Length	4	28	0	32

Legend

S.No.	Corridors	Underground	Elevated
1	East West Corridor - Thaltej Gam to Vastral Gam		
2	North South Corridor - APMC to Motera Stadium		

Figure—0.4

Chapter -1

Introduction

Chapter -1

INTRODUCTION

1.1 BACKGROUND

The historic city of Ahmedabad is amongst the major metropolitan cities in India. With the increasing opportunities for trade and commerce and as a center for higher education, the population of the city is already touching 6 million and this heavy growth continues.

The city, known as Ashapalli or Ashaval in ancient times, was founded by King Karnadeva Vaghela as Karnavati in 11th Century as capital of his kingdom. Later on Sultan Ahmed Shah of Gujarat Sultanate shifted his capital from Patan to Karnavati and renamed it as Ahmedabad in 1411 AD. A number of monuments built during his era are spread over the old city area. The walled city was also built during this era and its 12 gates are still existing though most of the wall can't be seen anymore. The city thrived as the capital of strong kingdom but later became part of the Moghul Sultanate in 1573. Shahjahan spent the prime of his life in this city and developed the present Shahi Baug area. The city was invaded by the Marathas in the year 1707 and ruled by them from 1753 AD to 1817 AD, when the city was taken over by the British.

During the British period the city became "Manchester of India" due to large scale manufacturing of textile. The first textile mill was set up in 1854 and more such mills followed soon after with rapid industrialization. However, the textile industry in the city is no more a force to reckon with, yet it is fifth largest producer of denim cloth in the world. The eastern part of the walled city is mostly inhabited by the families of mill mazdoors, who have been forced to find alternative jobs due to closure of most of the textile mills. However many chemical and pharmaceutical industries have come up around the city. Trade is still flourishing in the city as textile weaving, tie-and-dye work, zari work and intricate silk embroidery produced by this city has been famous for centuries.

Ahmedabad became capital of the newly formed Gujarat State in the year 1960 but a new capital was established at Gandhinagar in 1970. At present Ahmedabad is the district headquarter and the biggest city of the state. The High Court and many offices of the Central Government still exist at Ahmedabad. A new Division of Western Railway has recently been formed at Ahmedabad due to the increasing share of rail traffic in the area with development of private ports in Gujarat.

The city is also a tourist place and gateway to Saurashtra and Kuchchh region. The main tourist attraction of the city are Ahmed Shah's Tomb, Teen Darwaza, Bhadra Fort, Swami Narayan Temple, Geeta Mandir, Shaking Minarets, Jama Masjid, Kankaria Lake, Rani Sipri's Mosque and Tomb, Rani Rupmati Mosque, Shahibaug Palace and Sabarmati Ashram. In addition number of festivals are celebrated with colour and gaiety to promote tourism.

The city has many educational institutes including Gujarat University. The other internationally and nationally known academic and research institutes are the Indian Institute of Management (IIM), the Physical Research Laboratory, the Institute of Plasma Research, the Space Application Centre, the School of Architecture and Centre for Environment Planning, the National institute of Design, L.D. Institute of Technology and Nirma University.

Gandhinagar, the Capital of Gujarat, is a carefully planned city on the lines of Chandigarh. The city is divided in 30 well-planned sectors, which are generally self-contained. The core of the city is the Assembly Building (Vidhan Sabha) with administrative offices and Secretariat surrounding it. The wide roads, lined with trees are crossing at right angles to each other and have lawns on both sides. The tree cover in Gandhinagar is one of the biggest in India.

Gandhinagar is well connected with Ahmedabad through highway from the city as well as Airport. The rail connection to Ahmedabad is also available but the same is not very popular. The city has Akshardham Temple as a tourist attraction.

1.2 STUDY BACKGROUND

Originally DPR for Ahmedabad Metro Rail Network and Regional Rail System was submitted by DMRC in 2005, consisting following corridors.

Regional Rail System

- Line –1 Barajedi-Kalupur-Kalol
- Line –2 Kalupur-Naroda

Metro Rail System:

- Line –1 APMC Vasna – Aayakar Bhawan-Sabarmati - Akshardham (North-South corridor)
- Line –2 Kalupur-Aayakar Bhawan -Thaltej (East-West corridor)

Subsequently, in 200 DMRC was again commissioned by GIDB to prepare DPR for metro connectivity from Gandhinagar to GIFT city & from Gandhi Nagar to Airport and review certain portion of the corridors proposed in 2005 DPR. Accordingly study was carried by DMRC and reports were submitted in 2010.

MEGA vide their letter no MEGA/Chm/Oct/2013/, dated 20/10/2013(Annexure I) requested to DMRC for upgradation of earlier DPR submitted by DMRC.

This is an upgardtion of earlier DPR submitted by DMRC in the context of the letter as referred here above.

Several other studies have been undertaken for a mass transit system for the Ahmedabad-Gandhinagar region. These are:

- Louis Berger undertook the first study on Integrated Public Transport System for Ahmedabad in the year 2000, on being commissioned by GIDB.
- In 2003, GIDB commissioned DMRC to prepare a Detailed Project Report for metro.
- In 2003-04, RITES on behalf of DMRC, carried out a detailed study for identifying feasible metro lines.
- In 2009, to provide metro connectivity to newly proposed financial centre - GIFT city in the Ahmedabad- Gandhinagar area, GIDB commissioned another study to DMRC. CRRI, on behalf of DMRC undertook this study and estimated demand along the proposed metro corridor of Airport-Koba-GIFT.

This study is focused on two metro corridors: East-West (Thaltej to Vastral) and North-South (Visat-APMC) identified for Metro Phase I and is shown in the Figure below. The metro is expected to commence its operation in the year 2018. For the DPR, the ridership forecasts would be carried out for the years 2018, 2021, 2031 and 2043.

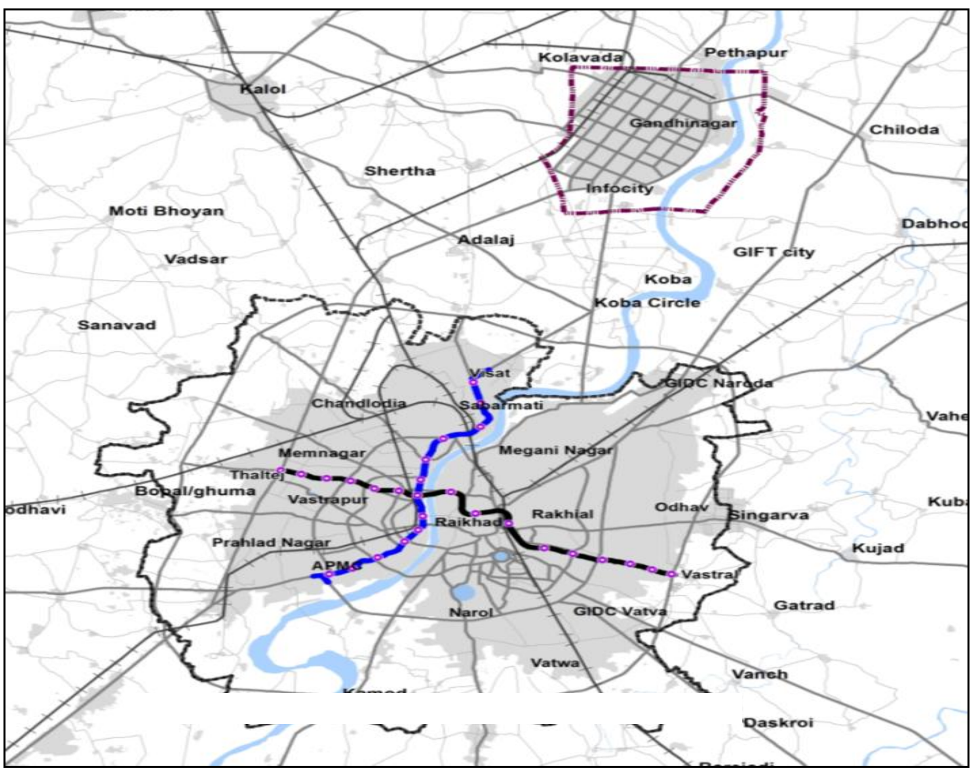


Fig. 1.1 Proposed Metro Corridors – Phase I

1.2.1 Introduction to the study area

The proposed metro alignment provides north-south connectivity in Ahmedabad city from Visat to APMC running along the Ashram road on most of the sections. The other corridor

Thaltej to Vastral provides east to west connectivity and passes through important nodes of Kalupur, Ashram road, Thaltej and Industrial areas on the east of Ahmedabad.

As per the Draft Development Plan and Integrated Mobility Plan for Greater Ahmedabad Region, the future growth in this area is expected to intensify between Ahmedabad and Gandhinagar. The study area definition would be carried out keeping in view the future growth expected in the study region.

1.2.2 Study methodology

1.2.2.1 Study area definition

The first step of the process is to define the study area for the modeling purpose. Apart from Ahmedabad and Gandhinagar area of future development around both the cities are also considered. The study area delineated is based on the administrative boundaries, urban agglomeration, functional linkages, traffic movement, and proposed and committed investment areas. This area primarily consists of area within the Ahmedabad Municipal Corporation (AMC), Gandhinagar Urban Development Area (GUDA), urban outgrowth areas of Ahmedabad i.e. Kathwada, Singarva, Bopal, Guma and 41 villages between AMC & GUDA and adjoining areas are also considered on the basis of contiguous built up and interaction with Ahmedabad.

1.2.2.2 Ahmedabad

The area within the Ahmedabad Municipal Corporation limits consists of:

- The traditional city centre within the fort walls with relatively high-density development, large concentration of commercial activities and narrow streets,
- The eastern sector accommodating large and small industries and low income residential areas
- A well planned western sector with wide roads accommodating major institutions and high-income residential areas
- The outgrowth areas (New west AMC zone) added recently to AMC comprising mainly residential developments of middle and low income households.

1.2.2.3 GUDA

Gandhinagar, Gujarat's capital city, lies on the west bank of the Sabarmati River, and approximately 32km north of Ahmedabad. Gandhinagar, a planned city is divided in to thirty sectors with a large administrative sector at its centre. Each sector has its own shopping and community centre, primary school, health centre, government and private housing. Large recreational areas and wide green open spaces are developed as a part of a city. Gandhinagar Urban Development Authority (GUDA) caters an area of 388 km^2 which includes two urban areas (Gandhinagar, Adalaj) and 39 villages. GUDA shares its geographical boundaries with AUDA.

1.2.2.4 Growth Centres around Ahmadabad and Gandhinagar

Apart from the above there are some committed growth centres around Ahmedabad and Gandhinagar:-

1. **Gujarat International Finance Tec-City (GIFT)** located around 10 km south east of Gandhinagar is an upcoming city in the vicinity of both Ahmedabad and Gandhinagar. The city is conceptualised with the purpose of provisioning high quality physical infrastructure for finance and technology firms.

2. **Industrial Estates and Special Economic Zone (SEZ):** The study area also houses 11 Industrial estates of these 7 are existing and 4 are proposed. Apart from these there are around 11 existing 4 proposed SEZ. Part of the Changodar SIR also forms a part of the study area.

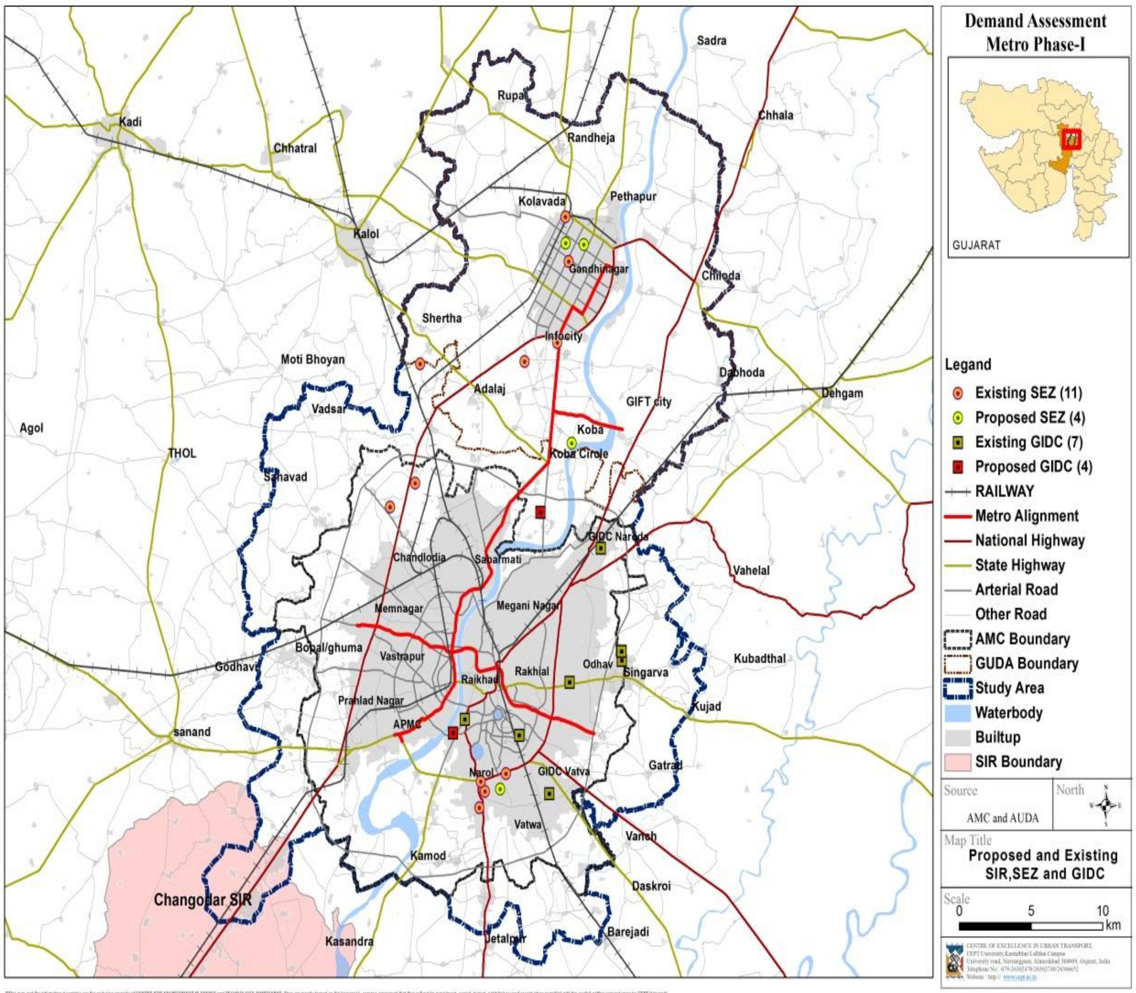


Fig. 1.1 Proposed and Existing SIR, SEZs and GIDC in study area

Source: AUDA Ahmedabad, 2012

Based on these, the study area has been defined which is an amalgam of:

Table 1.1 Areas within Study Area

	Area (km2)	Name
AMC	466	Ahmedabad Municipal Corporation
GUDA	388	Urban Area (Gandhinagar Municipal Area , Adalaj) and 39 Villages of GUDA
AUDA Urban	39.88	Urban areas (Bopal, , Singarva , Chiloda and Out growth – Kathwada and Guma)
AUDA Rural	232.56	41 Villages (Amiyapur, Aslali, Bhat, Bhuvaldi, Bilasiya, Dantali, Devdi, Chosar, Geratpur, Ropda, Gamdi, Istolabad, Gatrad, Memadpur, Geratnagar, Bibipur, Jamiyatpur, Kanbha, Karai, Khatraj, Vadsar, Khodiyar, Khoraj, Koteshwar, Lilapur, Limbadia, Nabhoi, Navapura, Palodiya, Rancharda, Nandoli, Rachhodpura, Santej, Rakanpur, Dantali, Iapkaman, Ranasan, Sanathal, Shela, Sugad, Zundal)
Outside AUDA	19.98	2 villages (Changodar ,Moraiya)
Grand Total	**1146.41**	

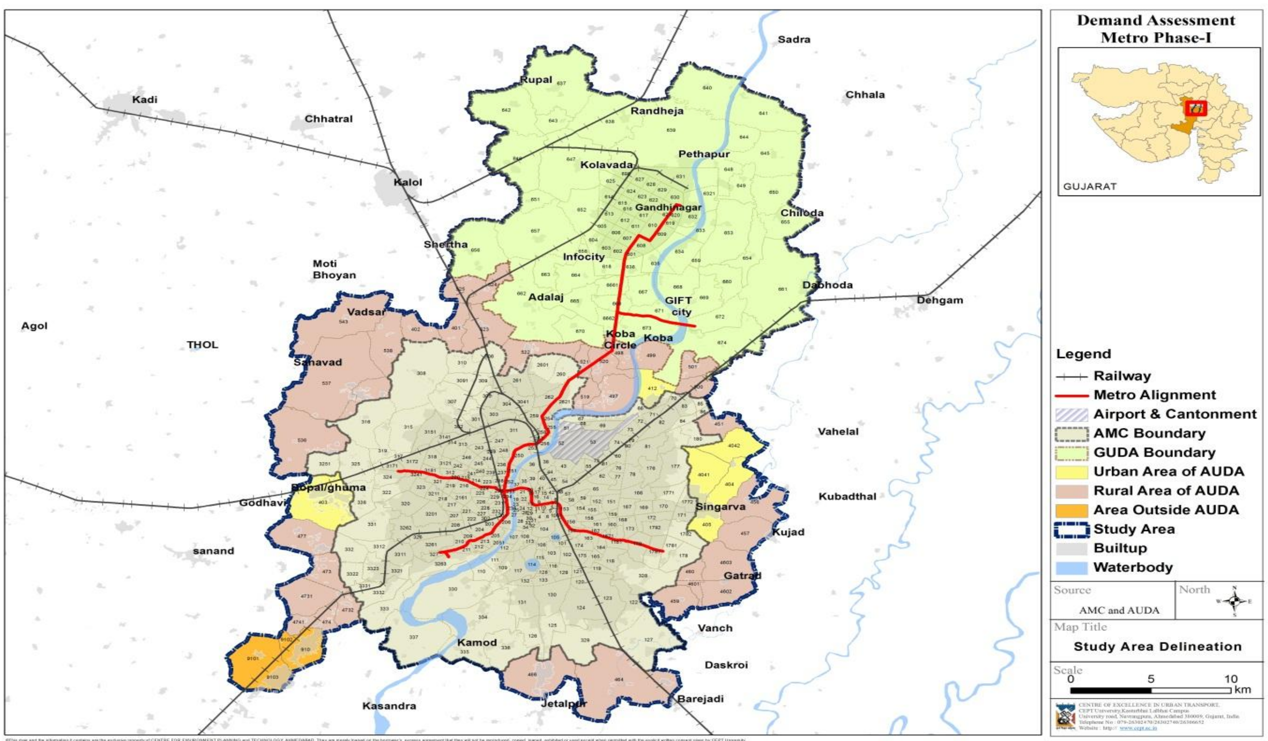


Fig. 1.2 Study Area Delineated

1.2.3 Zoning Structure

The zoning of the Study area has been based on the GIDB study on Integrated Public Transit System for Ahmedabad in the year 2000. The zoning within the AMC area has been adopted from the GIDB study, while the zoning in Gandhinagar has been taken from LASA study on Gandhinagar Master Plan in 2009. Some zones inside AMC area have been further split into smaller units owing to the size of zones and being in the influence area of Metro. Outside the city limits, each village has been taken as a single zone. The zones in the study area have been further divided into eight categories as listed below for population and employment distribution in future years. The study area has 392 internal zones and 9 external zones (towards Kalol, Mahesana, towards Sanand, Viramgam, towards Bavla, Rajkot, towards Bareja, towards Memadabad, kheda, Vadodara, towards Kapdavanj, towards Dahegam, towards Chiloda, Himmatnagar and towards Mansa.)

Table 1.2 Traffic Analysis Zones in Study area

Zone Group	No of TAZ
East -West Metro	54
MRT overlap	24
North-South Metro	26
East BRT	51
West BRT	28
East AMC	54
West AMC	40
Other Study area	121
Total Internal Zones	**398**
External Zones	**9**

Source Coe-UT CEPT University 2013

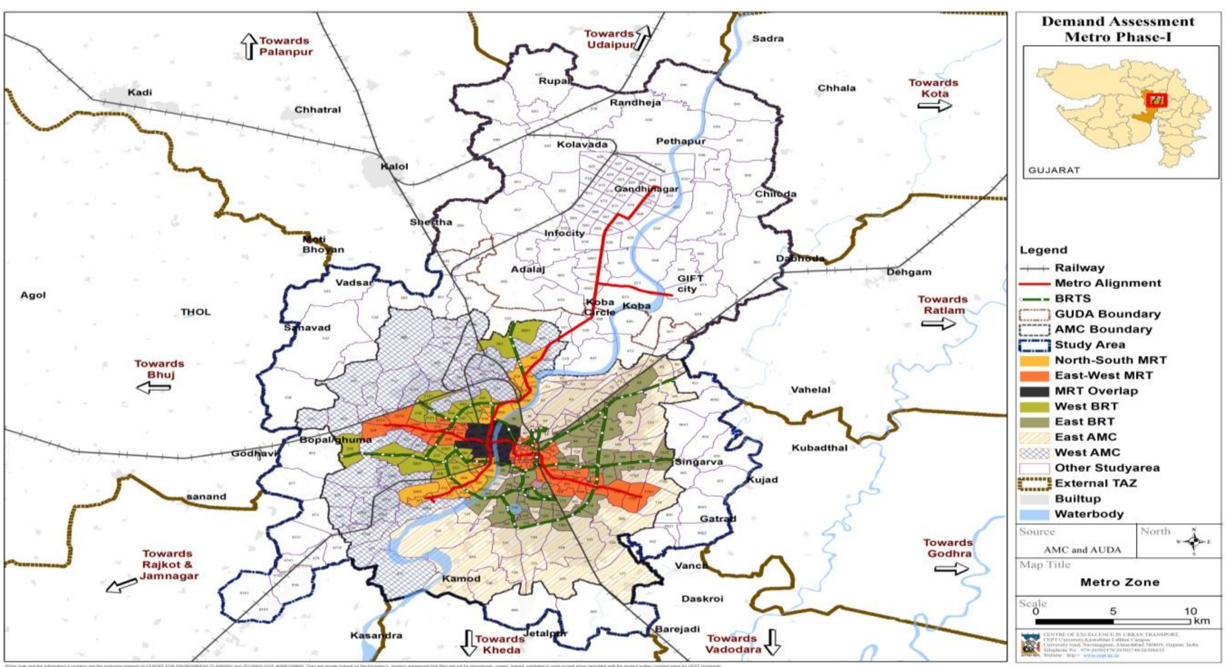


Fig. 1.3 Zone Groups

1.2.4 Data collection

This study will base its information from several studies undertaken in the recent past, in addition to some primary surveys.

Following sets of data will be used for this study:

1.2.4.1 Household Survey Data

For estimating the base year demand, the study would use the available household survey data for Ahmedabad and Gandhinagar. For GUDA area, demand data of around 1500 households is available for the year 2009 from the Lea Associates study on GUDA Master Plan. CoE-UT has also undertaken a household survey for the city of Ahmedabad of around 12000 households in the year 2011-12. This data would be used for developing the base demand matrix for the city of Ahmedabad.

1.2.4.2 Existing Land Use Details – (AUDA-2009/10 surveys)

The existing land use would be taken from the Draft Development Plan of AUDA 2021. Besides this, additional surveys will be carried out along the proposed metro corridor to have a detailed mapping of land use. This information would be useful for identification of suitable station locations and in developing Local Area Access Plans in areas around the station.

1.2.4.3 Details of Existing and Proposed Road Networks

For preparing a base model, network coding of the study area for both base and future year is important. The road network from the IMP model would be taken for developing the base year road network for the study area. For the proposed road network, Draft Development Plan of AUDA and Integrated Mobility Plan for Greater Ahmedabad Region would be considered.

1.2.4.4 Details of Public Transport Services

In order to develop an understanding of base year public transit services, detailed service information from Ahmedabad Municipal Transport Service (AMTS), Ahmedabad Janmarg Limited (BRTS), VTCOS (private operator) in Gandhinagar and GSRTC for regional services in the study area would be collected. Data on operational routes, location of stops, fare structure, fleet sizes, service frequency, journey times, vehicle capacity etc would be collected. Details of current ridership levels would also be required. This information would be used for developing a base year public transport model in Emme.

1.2.4.5 Classified Volume Count Data

Classified Volume Count Surveys have been carried out in Ahmedabad and Gandhinagar as part of previous studies like Integrated Mobility Plan for Greater Ahmedabad Region and Benchmarking for the city of Ahmedabad. The CVC data will be sourced from these studies and used for an existing situation analysis of road network in the study area. The screen line CVC for the IMP study would be would be used for model calibration. CVC have also been planned at seven locations along the metro corridor for validating the model outputs.

1.2.4.6 Speed surveys

Travel speed surveys were carried out on major corridors of the city as part of the Benchmarking study of Ahmedabad and for IMP project in 2011. Additional surveys on some major roads not covered under the above studies would be carried out. This information is critical for calibration of the traffic assignment model for the base year.

1.2.4.7 Employment Data

For estimating the employment in the base year, property tax data of AMC will be used. There are 270 property tax wards in AMC, having a total of 3.62 lakhs non-residential properties (2010). A primary survey of around 1470 properties across 28 property tax wards was carried out as a part of this study to compute trip generation rates for different types of non-residential properties. This can subsequently be used for generating employment estimates in the study area.

1.2.4.8 Willingness to pay and shift survey

A willingness to Pay and Shift Survey has been carried out along the metro corridors to assess the likely shift on metro from other modes under different conditions.

1.2.5 Modelling framework

A detailed four stage modelling has been to be carried out for this study. For the study area, analysis would be undertaken at the Traffic Analysis Zones (TAZ) level. The TAZs are based on the IPTS Study by Louis Berger and IMP Study by CoE-UT, CEPT University.

1.2.5.1 Modelling Inputs

A Base Year model of the study area has been developed for the year 2011. The network details and traffic survey information is available from the previous studies. For the demand information, household survey (2012) data would be used. Apart from this, employment data has been computed using property tax data and trip generation rates arrived at through different non-residential properties. For the education data, enrolment information from schools and colleges are being collated.

1.2.5.2 Model Characteristics

For the purpose of this study, public transport modelling has been carried out. The project start year for metro is being taken as 2018 and the forecast year is 2043. The model period for assignment would be morning peak. Appropriate expansion factors have been used for computing average daily ridership.

1.2.5.3 Scenario Specification

The following scenarios will be developed for this study:

Scenarios	Purpose	Network	Demand
Base 2011	Calibration of the base model	Existing road and PT network from IMP – updated	• Household survey of 12000 households in Ahmedabad (2011-12) • Household Survey in GUDA as part of GUDA Master Plan (2009) – to be updated • Household survey in TAZs outside AMC and GUDA but within the study area: To be conducted
Future 2018, 2021 & 2031	Metro ridership in the commissioning year	Proposed metro network, proposed BRT network to be completed by 2018, changes in AMTS and GSRTC services	• Proposed demand 2018 based on Population, Employment, School/College enrolment forecasts
Future 2043	Metro ridership 30 years from the base year	Proposed metro network, proposed BRT network and services in 2043, changes in AMTS and GSRTC services	• Proposed demand 2043 based on Population, Employment, School/College enrolment forecasts

1.2.5.4 Model Software

For the four stages modelling process, MS-Excel and SPSS has been used for Trip Generation and Trip Distribution purposes, while EMME has been used for Trip Distribution and Assignment Process. Mode Split would be carried out based on “Willingness to Shift Survey” which has been carried out as a part of this study.

1.2.6 Demand forecasting

A four stage model is developed for the study area. The public transport model would be calibrated for the base year of 2011 and forecasts are generated for the years 2018, 2021, 2031 and 2043.

1.3 GROWTH DYNAMICS

This chapter deals with the growth in the study area in terms of population and employment which forms the basis on which productions and attractions for demand analysis has been carried out.

1.4 POPULATION OF THE STUDY AREA

The study area has a population of 6.3 million, the region has witnessed moderate growth rate of 2.25 % over last decade.

Table 1.3 Population of the study area

Sr No	Location	Population			Area (in Ha)	Density (Person / Ha)			Annual Growth Rate (%)	
		1991	2001	2011		1991	2001	2011	1991-01	2001-11
1	**Ahmedabad Municipal Corporation (AMC)**									
	Total	**3421045**	**4517194**	**5589941**	**46683**	**73**	**97**	**120**	**2.82%**	**2.15%**
1a	Central	589194	577797	565914	1650	357	350	343	**-0.20%**	**-0.21%**
1b	East	664971	936767	1169549	6107	109	153	192	**3.49%**	**2.24%**
1c	New West	428171	740609	1226931	20526	21	36	60	**5.63%**	**5.18%**
1d	North	627214	781108	865116	3467	181	225	250	**2.22%**	**1.03%**
1e	South	480234	714196	904408	7995	60	89	113	**4.05%**	**2.39%**
1f	West	619293	752010	846023	5869	106	128	144	**1.96%**	**1.18%**
1.1	**Airport & Cantonment**	**11967**	**14707**	**12001**	**568**	**21**	**26**	**21**	**2.08%**	**-2.01%**
2	**AMC Adjoining Area**									
	Total	**120065**	**150335**	**221698**	**27244**	**4**	**6**	**8**	**2.27%**	**3.96%**
3	**Other area outside AUDA**									
	Total	**6075**	**6938**	**14656**	**2001**	**3**	**3**	**4**	**1.34%**	**7.77%**
4	**Gandhinagar**									
	Total	**278558**	**381183**	**437111**	**38800**	**7**	**10**	**11**	**3.19%**	**1.38%**
4a	**Gandhinagar (GNA)**	**123357**	**195985**	**209374**	**5745**	**21**	**34**	**36**	**4.74%**	**0.66%**
4b	Rest of Gandhinagar	155201	185198	227737	33055	5	6	7	**1.78%**	**2.09%**
	Study area	**3825743**	**5055650**	**6263406**	**114728**	**33**	**44**	**55**	**2.83%**	**2.17%**

Source: Census 2011

The population in the AMC limits is 5.5 million in 2011 from 4.5 million in 2001 (AMC, 2012). Spatial distribution of this population within the city over the decades shows that up to 1981, most of the new population added to the city was concentrated within the old AMC limits itself, especially in the eastern part. Expansion of the peripheral areas particularly on west began in the 1980s and has continued till date.

Gandhinagar on the other hand has a moderate to low growth of 1.38% during the last decade.

1.4.1 Population Density

The population density for AMC area is 119 persons per hectare. However, if we consider only the developed area, the density figure shoots upto 215 persons / hectare. There is dense development on many parts of the eastern city, however, the density differences between east and west are not much (density for developed area is 194 pph and 234 in western and eastern Ahmedabad respectively). While western area accommodates high income residences, institutional areas, it also accommodates low income areas in the southwest and north-western part. The density of Gandhinagar Notified Area (GNA) is 86 pph which is less compared to 119 pph for AMC.

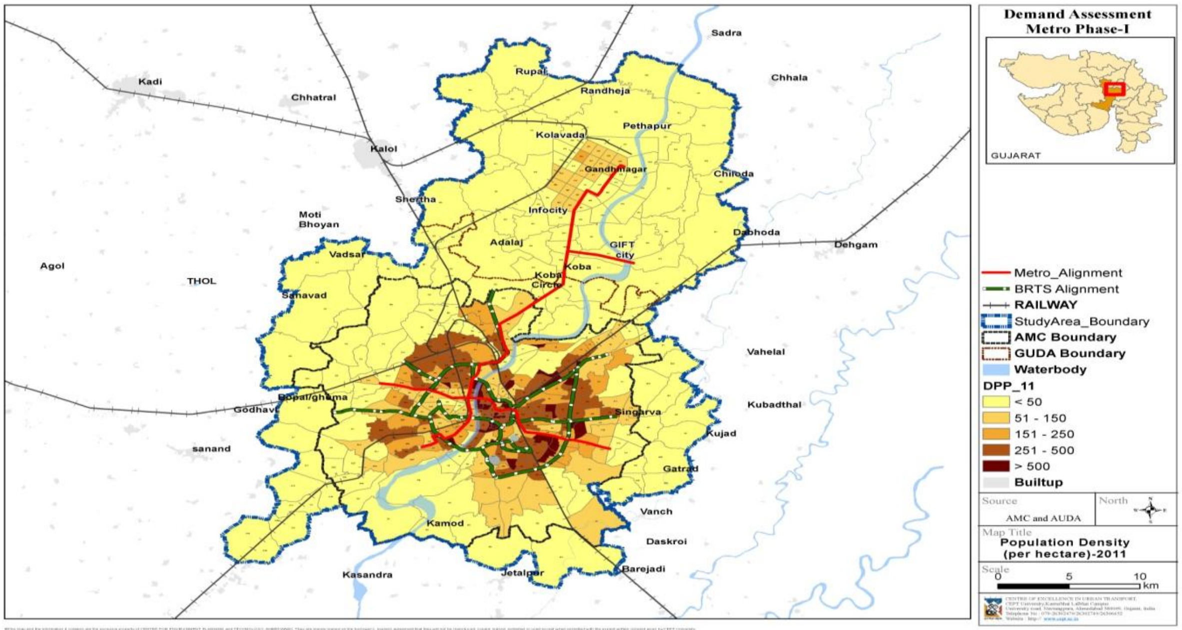


Fig. 1.5 Population density of study area 2011

1.5 POPULATION FORECAST

Census 2011 population has been used as the base year population and the projections have been done on taking into consideration the following criteria:

- Past population growth rates (decadal/ annual growth rate) and comparing them with the state trends.
- Industrial development
- Accessibility
- Close proximity to the urban areas

The future forecast of population is based on the projections done as a part of the Integrated Mobility Plan for Ahmedabad Gandhinagar Region, 2031. A ratio method for population projection was adopted to forecast the total population in the region. The projections were extended to 2043 which is the horizon year for the project. Forecast was also done for the metro commissioning year of 2018, intermediate years of 2021 & 2031 and the horizon year of 2043.

The total population of the study area in the horizon year of 2043 is projected to 1.1 crores. By 2043 about 70% of the population of the study area delineated will be residing in the AMC area and about 18% in AMC adjoining areas and 10 % in GUDA. The CAGR for the region is about 1.8% from 2011 to 2043. Population for the year 2018 and 2026 are interpolated from 2011 &2021 and 2021 &2031 respectively.

1.5.1 Growth Alternatives for the study area

Three alternatives for growth distribution were worked out for the horizon year of 2043:

1. **Business as Usual:** It is assumed that the growth in the study area will take place at the existing growth rate and a longer time period will be taken to realize the benefits of shift towards public transport modes i.e. market forces will dictate where growth will happen.
2. **Moderate:** This is an induced growth alternative where development will be induced along the metro. The growth will take place on a faster pace along the metro than the gradual scenario and the benefits of shift will be seen at a faster pace.
3. **Rapid:** This is a more focused policy driven alternative, where in efforts will be made in providing impetus for rapid development along the metro TAZ with the assumption that the shift towards the public transport mode will be realized much faster that the moderate alternative.

The assumptions for population projection in the year 2021 and 2031 are given below for different alternatives:-

Growth Alternative						
	Business as Usual		Moderate		Rapid	
Zones	**2021**	**2031**	**2021**	**2031**	**2021**	**2031**
East West Metro	L	M	M	M	H	H
Metro Overlap	L	M	M	M	H	H
North South Metro	L	M	M	M	H	H
East BRT	L	M	M	M	H	H
West BRT	L	M	M	M	H	H
Other Study Area	H	M	M	M	L	L
West AMC	H	M	M	M	L	L
East AMC	H	M	M	M	L	L

Medium Growth "M" : Average percentage change from 2011 to 2043
Low Growth "L": -30% of Medium Growth
High Growth "H": +30% of Medium Growth

The distribution of population in various growth alternatives also considers the availability of vacant land and areas available for infilling in the city.

1.5.2 Business as Usual Alternative

As discussed earlier this alternative will have 30% less change in the overall population as compared to the average percentage change between 2011 and 2043. The population and density in this scenario for the year 2018, 2021, 2041 and 2043 is given below:

Table 1.4 Population Distribution Business as Usual

Zone group	Business as Usual				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	820892	860793	885455	1006930	1183479
Metro Overlap	264014	267798	270295	282112	299286
North South Metro	517172	574140	605165	770723	1011341
Metro Zones Total	**1602079**	**1702731**	**1760915**	**2059765**	**2494106**
Metro Zones GR		0.87%	1.13%	1.75%	1.61%
Other Study Area	4661327	5322228	5889694	7199309	8570351
Other Study Area GR		1.91%	3.43%	2.22%	1.46%
Total	**6263406**	**7024959**	**7650609**	**9259074**	**11064457**
Total Population GR		**1.65%**	**2.88%**	**2.11%**	**1.50%**

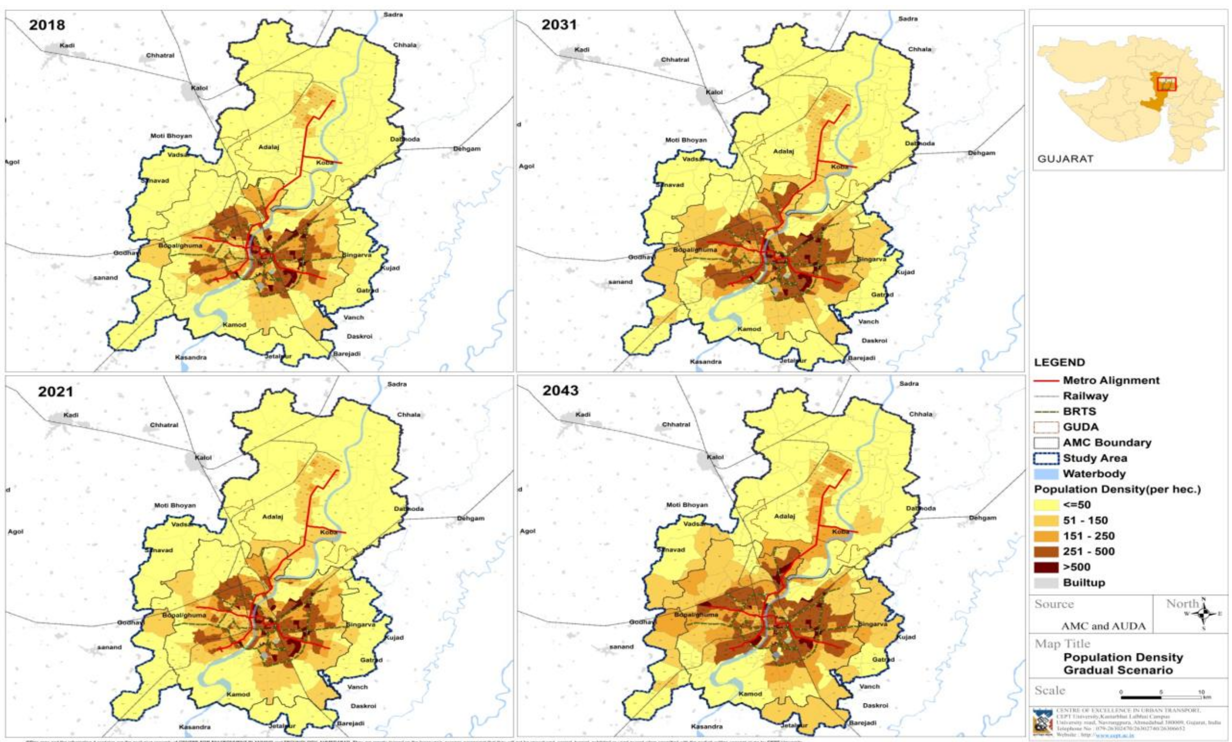


Fig. 1.6 Population Density Distribution Business as Usual

As evident from the Figure above metro is expected to trigger growth along its corridors. However, the intensity of growth will be low in the AMC areas and higher growth is observed in the AMC adjoining areas due to availability of developable land. The market forces will take their own pace as availability of land for development will be the driving factor. The densities will gradually increase along the metro corridor however the growth in the first decade (2011 to 2021) will be low at about 10%.

The proportion of population in Ahmedabad to the study area will reduce from 89% in 2011 to about 70% in 2043 with high growth rates in the AMC adjoining areas owing to the availability of developable land. It is also assumed that the population growth rate will stabilize in the decade after 2031.

Table 1.5 Density Distribution - Business as Usual

	Population Density Business as Usual (P/ha)				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	234	246	253	287	338
Metro Overlap	261	265	268	279	296
North South Metro	163	181	191	243	319
Metro Zones Total	**208**	**221**	**229**	**268**	**324**
East BRT	218	221	223	232	245
West BRT	123	129	133	151	179
West AMC	62	70	78	95	111
East AMC	67	69	71	75	79
Other Study Area	10	17	23	36	49
Total	**55**	**61**	**67**	**81**	**97**

1.5.3 Moderate Growth Alternative

An average percentage change is assumed in the moderate growth alternative from 2011 to 2043. This is also an induced growth alternative where growth along the metro corridors will be induced in the AMC area as a result of providing higher FSI along the corridors. Redevelopment along the corridors will also be triggered as a result. However, due to limited amount of land being available immediately the growth in the AMC areas will take a moderate course. The distribution of population in this alternative is provided in the table below:-

Table 1.6 Population Distribution in the Moderate Growth Alternative

	Moderate Growth Alternative				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	820892	882438	925657	1047132	1183479
Metro Overlap	264014	269712	274206	286023	299286
North South Metro	517172	606524	659956	825514	1011341
Metro Zones Total	**1602079**	**1758674**	**1859819**	**2158669**	**2494106**
Metro Zones GR		1.34%	1.88%	1.63%	1.21%
Other Study Area	4661327	5281040	5790790	7100405	8570351
Other Study Area GR		1.80%	3.12%	2.26%	1.58%
Total	**6263406**	**7039714**	**7650609**	**9259074**	**11064457**
Total Population GR		**1.68%**	**2.81%**	**2.11%**	**1.50%**

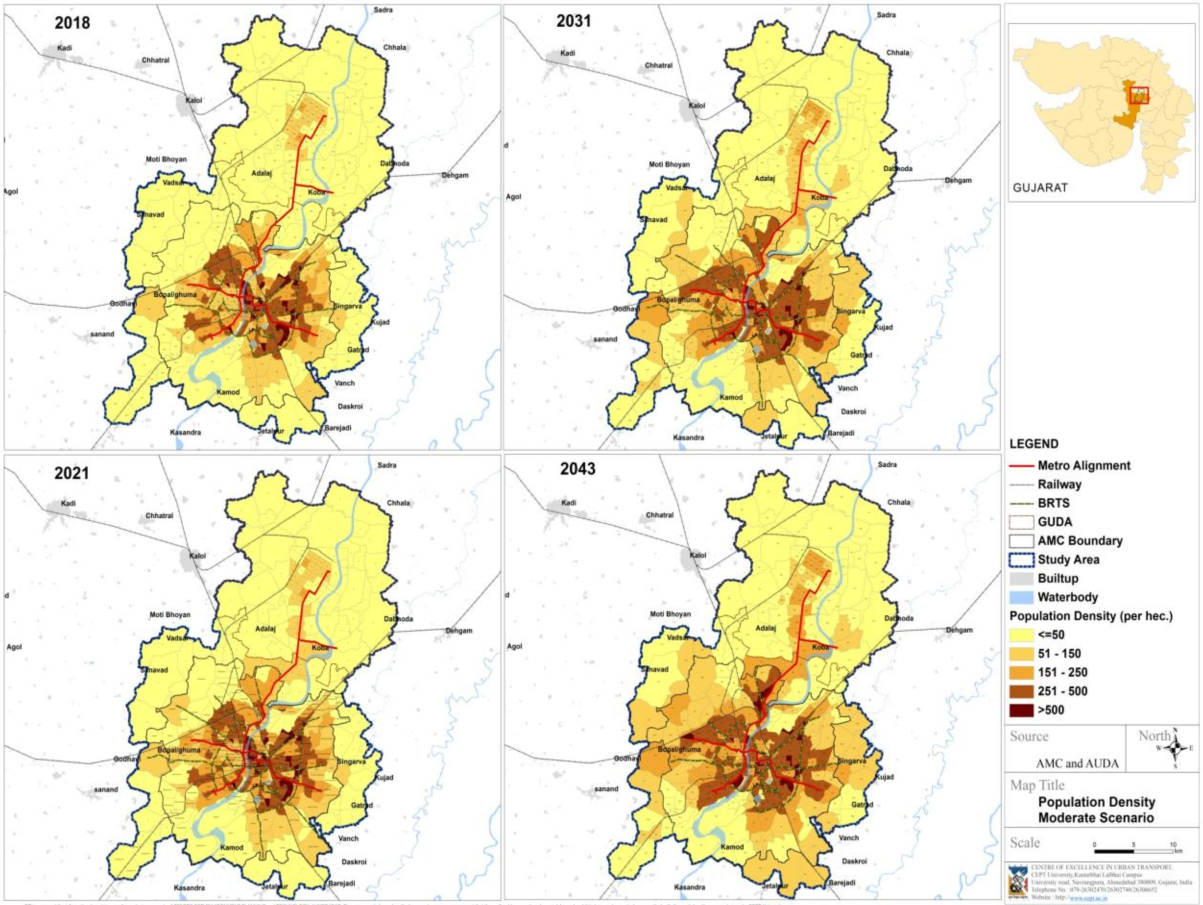


Fig. 1.7 Population Density Distribution in the Moderate Growth Alternative

Table 1.7 Density Distribution in Moderate Growth Alternative

	Population Density Moderate growth alternative(P/ha)				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	234	259	279	331	338
Metro Overlap	261	269	277	294	296
North South Metro	163	204	231	309	319
Metro Zones Total	**208**	**238**	**259**	**317**	**324**
East BRT	218	225	230	243	245
West BRT	123	137	147	175	179
West AMC	62	68	73	87	111
East AMC	67	69	70	73	79
Other Study Area	10	15	19	30	49
Total	**55**	**61**	**67**	**81**	**97**

1.5.4 Rapid Growth Alternative

As mentioned earlier this is a more focused policy driven growth alternative. Assumption taken is that the growth rates along the metro corridor will be at a high rate initially due to the policy incentives provided by the government to attract more people residing in the transit influence zone metro and BRT. This alternative would also see active integration of all modes so that they complement each other rather than competing. Metro and BRT will act as the rapid corridors in the city and most of the population will be residing within 500 m of the transit zone. The city will try to remain compact.

Table 1.8 Population Distribution in Rapid growth Alternative

	Rapid Growth Alternative				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	820892	908629	978502	1161251	1183479
Metro Overlap	264014	271858	279346	297124	299286
North South Metro	517172	646773	731978	981046	1011341
Metro Zones Total	1602079	1827260	1989826	2439421	2494106
Metro Zones GR		1.90%	2.88%	2.25%	0.18%
Other Study Area	4661327	5220906	5660782	6819653	8570351
Other Study Area GR		1.63%	2.73%	2.08%	1.92%
Total	**6263406**	**7048166**	**7650609**	**9259074**	**11064457**
Total Population GR		1.70%	2.77%	2.13%	1.50%

Most of the growth in this alternative will be realised by 2031 for the AMC area and after that growth will start spilling to the AMC adjoining areas. The densities in the city along the metro corridor will rise to above 300 pph. The growth in the initial years along the metro will also be high at 2.19% per annum.

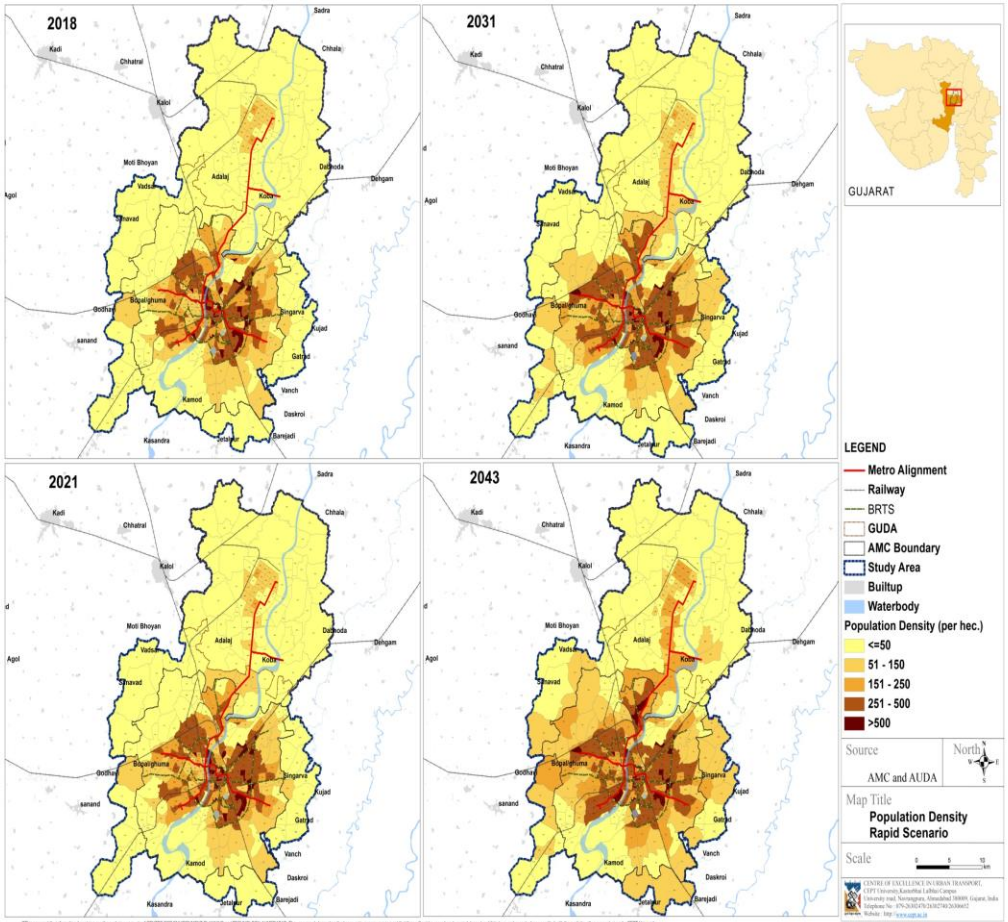


Fig. 1.8 Density Distribution in Rapid Growth Alternative

Table 1.9 Density Distribution in Rapid Growth Alternative

	Population Density Rapid Growth Alternative (P/ha)				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	234	259	279	331	338
Metro Overlap	261	269	277	294	296
North South Metro	163	204	231	309	319
Metro Zones Total	**208**	**238**	**259**	**317**	**324**
East BRT	218	225	230	243	245
West BRT	123	137	147	175	179
West AMC	62	68	73	87	111
East AMC	67	69	70	73	79
Other Study Area	10	15	19	30	49
Total	**55**	**61**	**67**	**81**	**97**

This is also a very optimistic alternative as high growth rates are expected in AMC area itself and areas along metro is expected to undergo transformation. Feeder system and interchanges will operate seamlessly providing efficient public transport service in the study area.

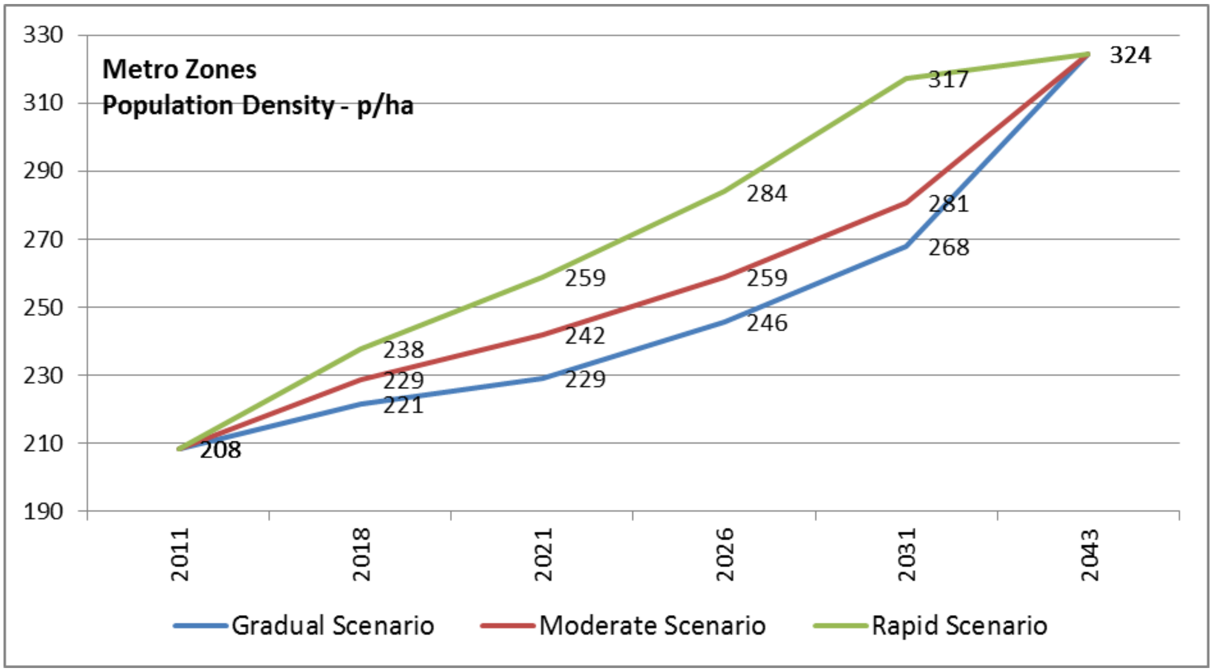


Fig. 1.9 Comparisons of Population Densities in Different Alternatives

The Work force participation rates in the study area will rise from about 35% to around 42% in future owing to the inclusion of more female workers and also the improvement in education levels in the study area.

Table 1.10 Projected Workers and Work force participation rates in the Study area

	2011	2018	2021	2031	2043
Worker	2194847	2655433	2922119	3749925	4647072
WPR	35%	36%	37%	41%	42%

1.6 EMPLOYMENT CHARACTERISTICS

Today, several key high-growth industries such as textiles, pharmaceuticals and natural gas are firmly anchored in Ahmedabad. The two of the biggest pharmaceutical companies of India - Zydus Cadila and Torrent Pharmaceuticals are based here. Also the industrial centres around Ahmedabad, its traditional strength, have witnessed a turnaround, to Ahmedabad's advantage. The city also is the corporate headquarter of the Nirma Group of Industries and the Adani Group.

The city of Ahmedabad has been undergoing rapid transformation. The city economic base, from its dependency on single sector, textile initially and then chemicals, has turned into multi-sector economy. The automobile sector, logistics and transport and finance are some of the emerging sectors. With this transformation underway, the development focus is shifting from city proper to city region.

As mentioned in the section 1.2.4.7 a non-residential property survey was conducted for Ahmedabad employment as per the LASA report was taken as a base for Gandhinagar. Apart from this employment numbers from the industries department was also used for this purpose.

It is estimated that the employment in the study area is about 2.5 million in 2011. Owing to mix land use in the city there is no single CBD in Ahmedabad. However, predominant employment centres in the city are GIDC estates in the eastern part, Income tax (Aykarbhavan), Ashram road, Wadaj, Sabarmati Railway Station, APMC, Anjali, Drive in road, Kalupur, CG Road, SG Highway, Prahlad Nagar to name a few.

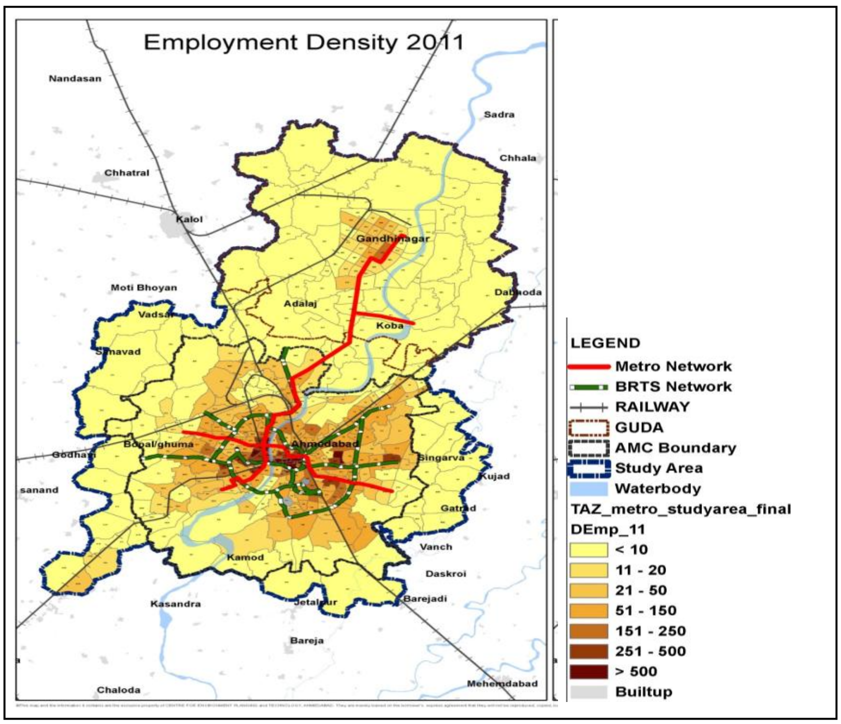


Fig. 1.10 Employment Density in Ahmedabad 2011

1.7 EMPLOYMENT FORECAST

As mentioned above an activity survey was carried and employment was estimated for the base year of 2011. Projections have been done taking into consideration the following criteria:

- Proposed investments in the study area
- Draft Development plan -major commercial and Industrial nodes identified
- Accessibility
- Close proximity to the urban areas

The future forecast of employment is bases on the projections done as a part of the Integrated Mobility Plan for Ahmedabad Gandhinagar Region, 2031. The projections were extended to 2043 which is the horizon year for the project. Forecast was also done for the metro commissioning year of 2018, intermediate years of 2021 & 2031 and the horizon year of 2043.

It is projected that the total employment in the study area in the year 2043 will be about 5 million with CAGR of 2.3%. Ahmedabad city dominates the jobs in the region with about 78% of the jobs residing in the city itself however as the city grows the employment centres like GIFT city and areas along the transit will experience growth.

Zone group	Employment		Area (in Ha)	Density (Employment / ha)	
	2011	2043		2011	2043
Total	**2538227**	**5021890**	**114641**	**22**	**44**
AMC	2263701	3921065	46600	49	84
AMC Adjoining Areas	84726	400300	27244	3	15
GUDA	166387	650488	38800	4	17
Outside AUDA	23413	50038	1998	12	25

Three growth alternatives are also created for employment projection on the similar lines as listed in section 1.5

1.7.1 Business as Usual Alternative

As mentioned in section 1.5.1 the growth in the AMC region will be low as evident from the table below, employment will grow at a steady pace in this alternative. New activity areas are expected to develop along the metro corridor however the growth in employment will not be high. More jobs are expected to come in areas outside the AMC area due to availability of land. Growth in outer areas in the first decade will be high will subsequently stabilize in the last decade (2031-2041):

Table 1.11 Employment Projection Business as Usual Alternative

Zone group	Business as Usual Alternative Employment				
	2011	2018	2021	2031	2043
East West Metro	475786	520692	548684	668957	861295
Metro Overlap	236889	249880	256687	289352	341590
North South Metro	168579	185499	195076	238792	308703
Metro Zones Total	881254	956072	1000447	1197101	1511588
Metro Zones GR		1.17%	1.52%	1.95%	1.96%
Other Study Area	1656974	1985954	2219406	2797615	3510302
Other Study Area GR		2.62%	3.77%	2.43%	1.91%
Total	**2538227**	**2942026**	**3219853**	**3994716**	**5021890**
Total Employment GR		**2.13%**	**3.05%**	**2.29%**	**1.93%**

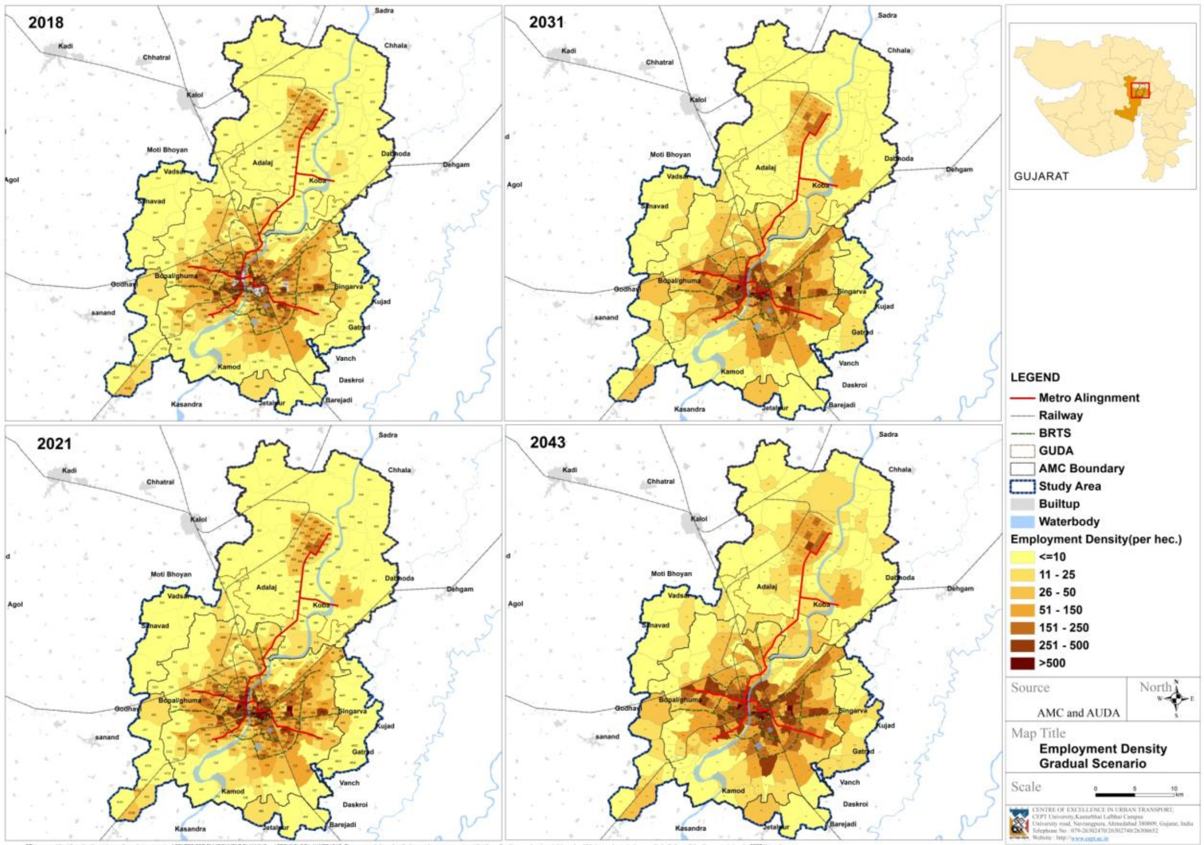


Fig. 1.11 Employment Density Business as Usual Alternative

The employment density in the Metro corridors will increase from 115 in 2011 to about 197 in the year 2043.

Table 1.12 Employment Density Business as Usual Alternative

	Employment Density Business as Usual Alternative (E/ha)				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	136	149	156	191	246
Metro Overlap	235	247	254	286	338
North South Metro	53	58	62	75	97
Metro Zones Total	**115**	**124**	**130**	**156**	**197**
East BRT	80	87	91	110	140
West BRT	39	40	41	46	52
West AMC	20	24	25	30	35
East AMC	23	27	30	37	44
Other Study Area	4	6	8	12	16
Total	**22**	**26**	**28**	**35**	**44**

1.7.2 Moderate Growth Alternative

The moderate growth alternative assumes that some growth will be induced due to the metro. The growth rates of employment will be high in the first decade as transit benefits are felt. New employment centres will emerge in Thaltej, Vastral, Motera and APMC area. There will be further intensification of the already existing employments centres along the metro corridors.

Table 1.13 Employment Projection Moderate Growth Alternative

	Moderate Growth Alternative				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	475786	538955	581587	701859	861295
Metro Overlap	236889	255344	265623	298289	341590
North South Metro	168579	192477	207035	250751	308703
Metro Zones Total	881254	986777	1054245	1250899	1511588
Metro Zones GR		1.63%	2.23%	1.83%	1.59%
Other Study Area	1656974	1963269	2165608	2743817	3510302
Other Study Area GR		2.45%	3.32%	2.50%	2.07%
Total	**2538227**	**2950046**	**3219853**	**3994716**	**5021890**
Total Employment GR		**2.17%**	**2.96%**	**2.29%**	**1.93%**

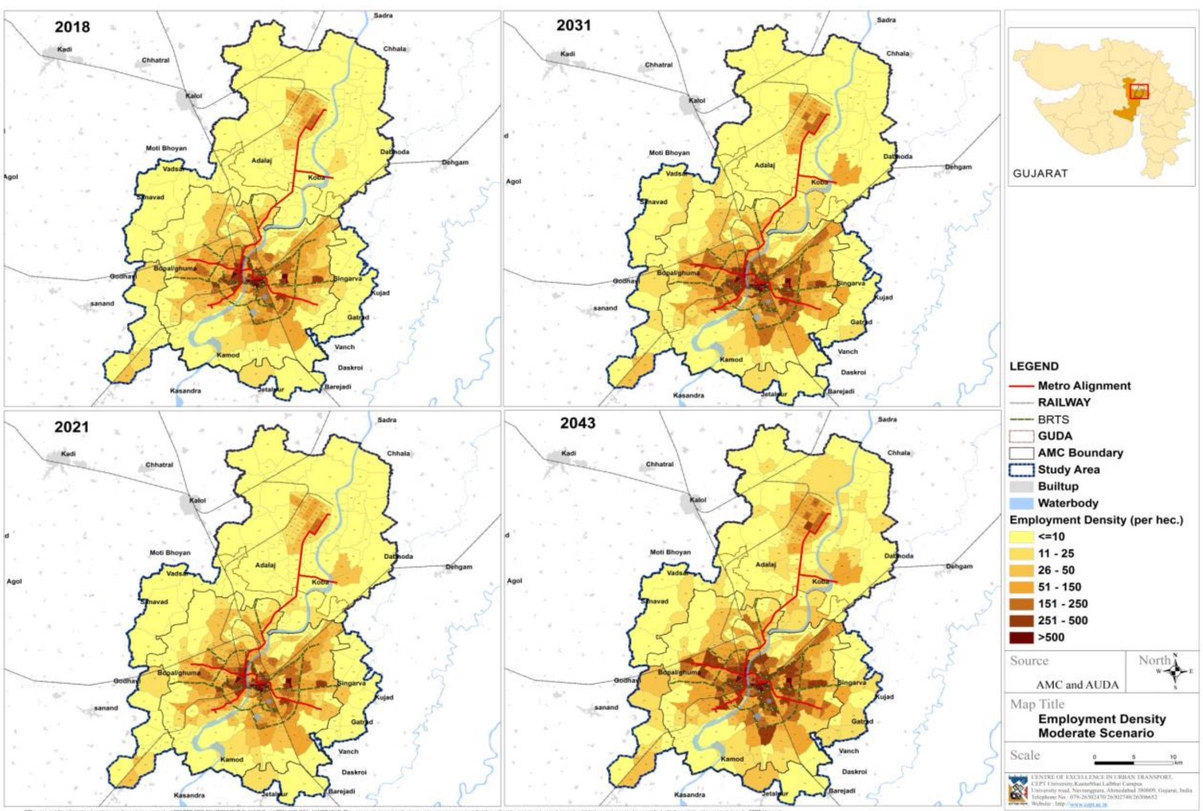


Fig. 1.12 Employment Density Moderate Growth Alternative

The employment densities along the metro corridor in this case will rise from 115 pph to 197 pph in 2043 however as compared to the gradual growth alternative the densities in the 2021 and 2031 will be higher along the metro routes.

Table 1.14 Employment Density Moderate Growth Alternative

	Employment Density Moderate Growth Alternative (E/ha)				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	136	154	166	200	246
Metro Overlap	235	253	263	295	338
North South Metro	53	61	65	79	97
Metro Zones Total	**115**	**128**	**137**	**163**	**197**
East BRT	80	91	96	115	140
West BRT	39	41	42	47	52
West AMC	20	23	24	29	35
East AMC	23	26	29	35	44
Other Study Area	4	6	7	11	16
Total	**22**	**26**	**28**	**35**	**44**

1.7.3 Rapid Growth Alternative

A more focused approach for TOD will be adopted in this alternative with employment rates being high in the transit influence areas of metro zones in the next two decades. New employment centres will also develop along the corridor with initiatives of developing regeneration areas. Transit Nodes will also be promoted for more commercial development.

Table 1.15 Employment Distribution in Rapid Growth Alternative

	Rapid Growth Alternative				
	2011	**2018**	**2021**	**2031**	**2043**
East West Metro	475786	557014	615555	774443	861295
Metro Overlap	236889	260802	274849	318002	341590
North South Metro	168579	199405	219382	277134	308703
Metro Zones Total	881254	1017220	1109786	1369579	1511588
Metro Zones GR		2.07%	2.95%	2.25%	0.83%
Other Study Area	1656974	1936757	2110067	2625137	3510302
Other Study Area GR		2.25%	2.90%	2.30%	2.45%
Total	**2538227**	**2953978**	**3219853**	**3994716**	**5021890**
Total Employment GR		2.19%	2.91%	2.28%	1.93%

The metro influence areas will experience more growth in the initial decades; jobs will be concentrated in the AMC area.

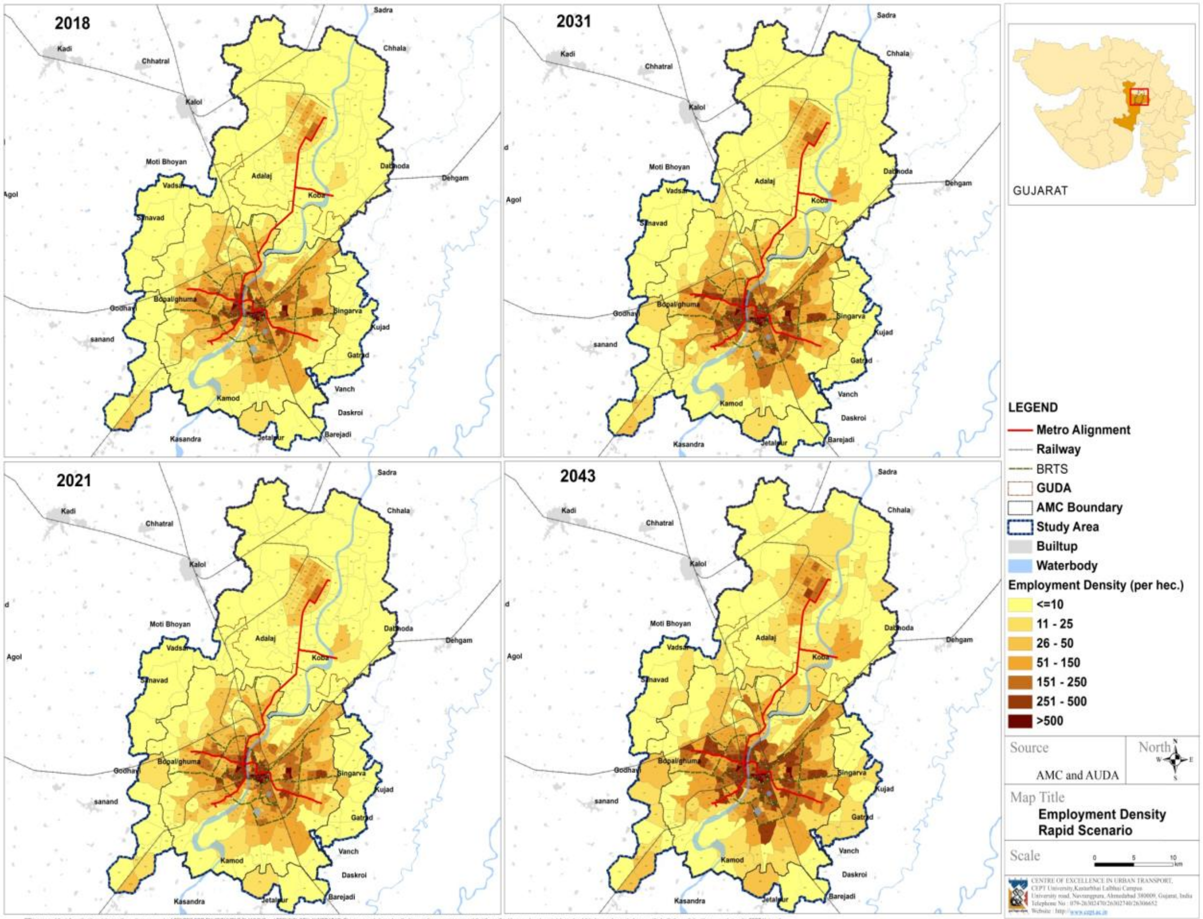


Fig. 1.13 Employment Density distribution in Rapid Growth Alternative

The employment densities along the metro zones will also be higher than the moderate zone alternatives for the intermediate years of 2021 and 31.

Table 1.16 Employment Density Rapid Growth Alternative

	Employment Density (E/ha)				
	2011	2018	2021	2031	2043
East West Metro	136	159	176	221	246
Metro Overlap	235	258	272	315	338
North South Metro	53	63	69	87	97
Metro Zones Total	**115**	**132**	**144**	**178**	**197**
East BRT	80	94	102	127	140
West BRT	39	42	44	49	52
West AMC	20	22	23	26	35
East AMC	23	25	27	32	44
Other Study Area	4	5	6	9	16
Total	**22**	**26**	**28**	**35**	**44**

The employment densities in the metro influence zone will grow from 115 pph in 2011 to 178 pph in 2031 and 197 pph in 2043.

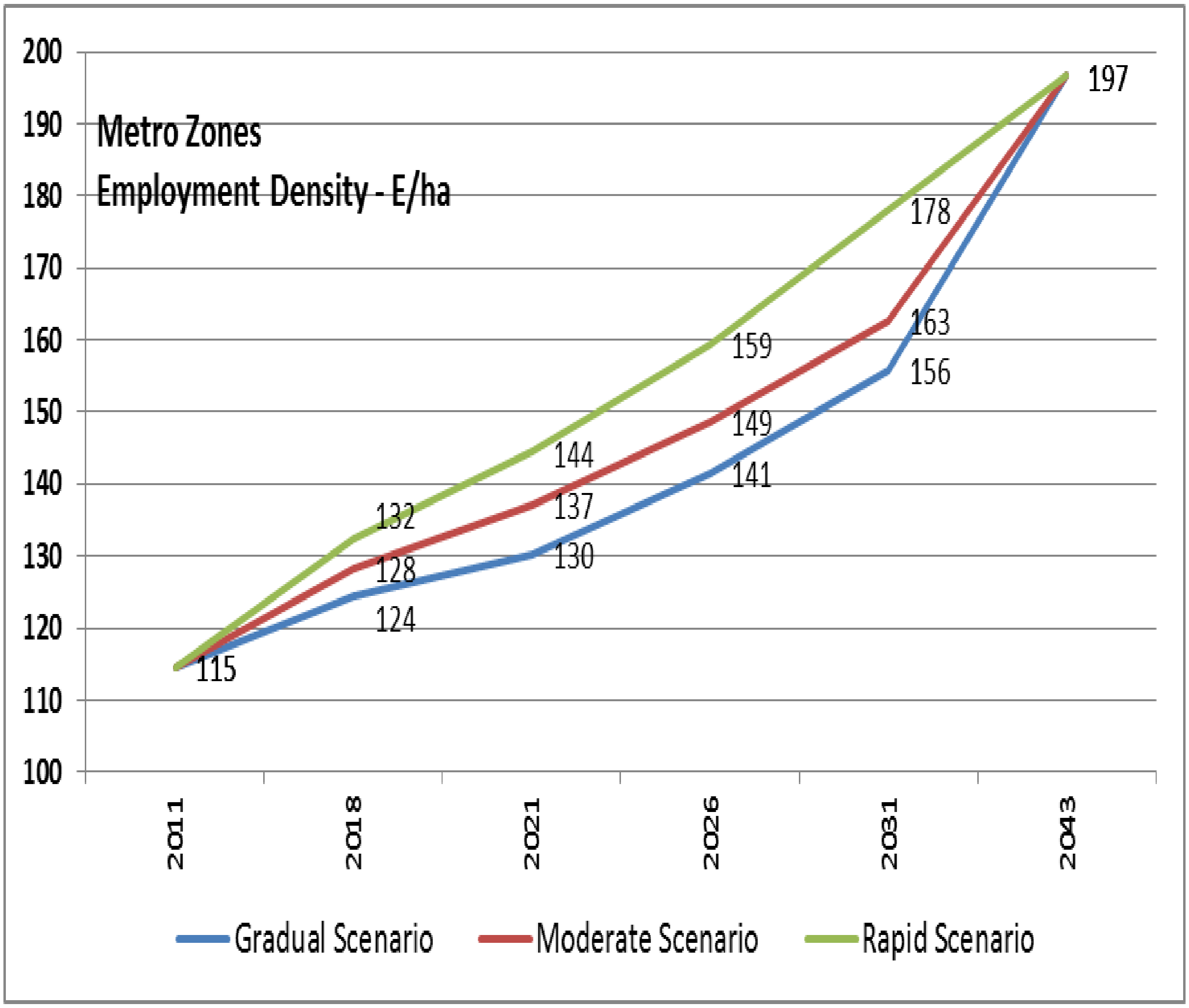


Fig. 1.14 Comparisons of Employment Densities in different Alternatives

The Influence of the metro on growth in the study area is felt in all alternatives. The realisation of the growth will however vary owing to the policy incentives taken ranging from increase in FSI along the metro corridors to integration of all public transit modes and development of interchanges. The actual growth realised will also depend on how easily the land (both vacant and infill) will be made available for development.

1.8 STRUCTURE OF THE REPORT

The report contains the chapters as mentioned below :-

CHAPTER NO.	DESCRIPTION
Chapter-1	Introduction
Chapter-2	Traffic Demand Forecast
Chapter-3	System Selection
Chapter-4	Geometric Designing Parameters & Alignment Description
Chapter-5	Civil Engineering
Chapter-6	Station Planning
Chapter-7	Train Operation Plan and Maintenance Facilities
Chapter-8	Rolling Stock
Chapter-8A	Depot
Chapter-9	Power Supply, System Of Traction And Power Tariff
Chapter-10	Ventilation And Air-Conditioning System
Chapter-11	Signalling System
Chapter-12	Telecommunication & Automatic Fare Collection
Chapter-13	Disabled Friendly Features
Chapter-14	Environmental Impact Assessment
Chapter-15	Security Measures for a Metro System
Chapter-16	Disaster Management Plan for a Metro Rail System
Chapter-17	Multi Modal Transport Integration
Chapter-18	Cost Estimates
Chapter-19	Financing Options, Fare Structure And Financial Viability
Chapter-20	Economic Appraisal
Chapter-21	Implementation Strategy
Chapter-22	Conclusion

Annexure I

GOVT. OF GUJARAT

Dr. Manjula Subramaniam, IAS (Retd.)
Chair~~person~~man

Metro Link Express
for Gandhinagar and Ahmedabad
(MEGA) Company Limited
(A Govt. of Gujarat Undertaking)

No.MEGA/Chm/Oct/2013/ 29.10.2013

OSD a response can go.

To,
Mr. Mangu Singh,
Managing Director
Delhi Metro Rail Corporation Ltd
Metro Bhawan, 13 Fire Brigade Lane
Barakhamba Road,New Delhi - 110001

Dy No. 4706 Office of DBD Date 7/11

MD DBD 11/11/13

GM/CC

DELHI METRO RAIL CORPORATION LTD. M/CS/ Dy. No. 2118 Dated 22/11/13

Dear Mr. Mangu Singhji,

I would like to introduce myself to you as I have recently taken over as Chairman, MEGA. I regret that I was unable to meet you personally last week, when I visited Delhi, as I was moving from one appointment to another.

During my meeting with Dr. Sudhir Krishna, I had indicated that MEGA would like to upgrade its earlier DPR so that we can speed up the progress. This being an upgradation of our earlier bond with DMRC, it could be done in a short span of time and would help us enormously.

I enclose herewith a copy of the letter addressed to Dr.Sudhir Krishna requesting the services of DMRC for upgrading. I would be grateful if you do the needful in the matter.

With warm regards,

Yours sincerely,

Manjula Subramaniam

Registered Office : 5th Floor, Nirman Bhavan, Opp. Sachivalay Gate No. 4, Sector - 10 A, Gandhinagar - 382010. Fax : +91-79-2324 8573
Corporate Office : 803, 8th Floor, GNFC Info Tower, S. G. Highway, Ahmedabad - 380015.
Ph.:+91-79-2680 0000, Fax :+91-79-2685 9766, Website : www.gujaratmetrorail.com

Chapter - 2

Traffic Demand Forecast

Chapter - 2

TRAFFIC DEMAND FORECAST

2.1 TRAFFIC CHARACTERISTICS AND DEMAND FORECASTING

This chapter provides an overview of the existing transportation system outlines the travel characteristics and presents the demand forecasting carried out for estimating ridership on metro.

2.2 ROAD NETWORK

The transportation system in Ahmedabad and Gandhinagar is predominantly dependent on roadway systems. The major road network in the study area is around 3045 km in length, of which 125 km are National Highways and 103 km are under State Highways which are being maintained by National Highways Authority of India and Roads & Building Department respectively. The rest of the roads are managed by respective urban local bodies of AMC, AUDA, GNA and GUDA.

Table 2.1 Length wise total road network length in km

Jurisdictional Area	Road length (km)	% of road
AMC	2365	78%
AUDA	145	5%
GUDA*	457	15%
Other areas**	78	3%
Total Study Area	3045	100%

Source; * Master Plan for Clean, Green and Solar Gandhinagar, 2009, Lea Associates Pvt Ltd.; ** COE in Urban Transport, CEPT University, Ahmedabad.

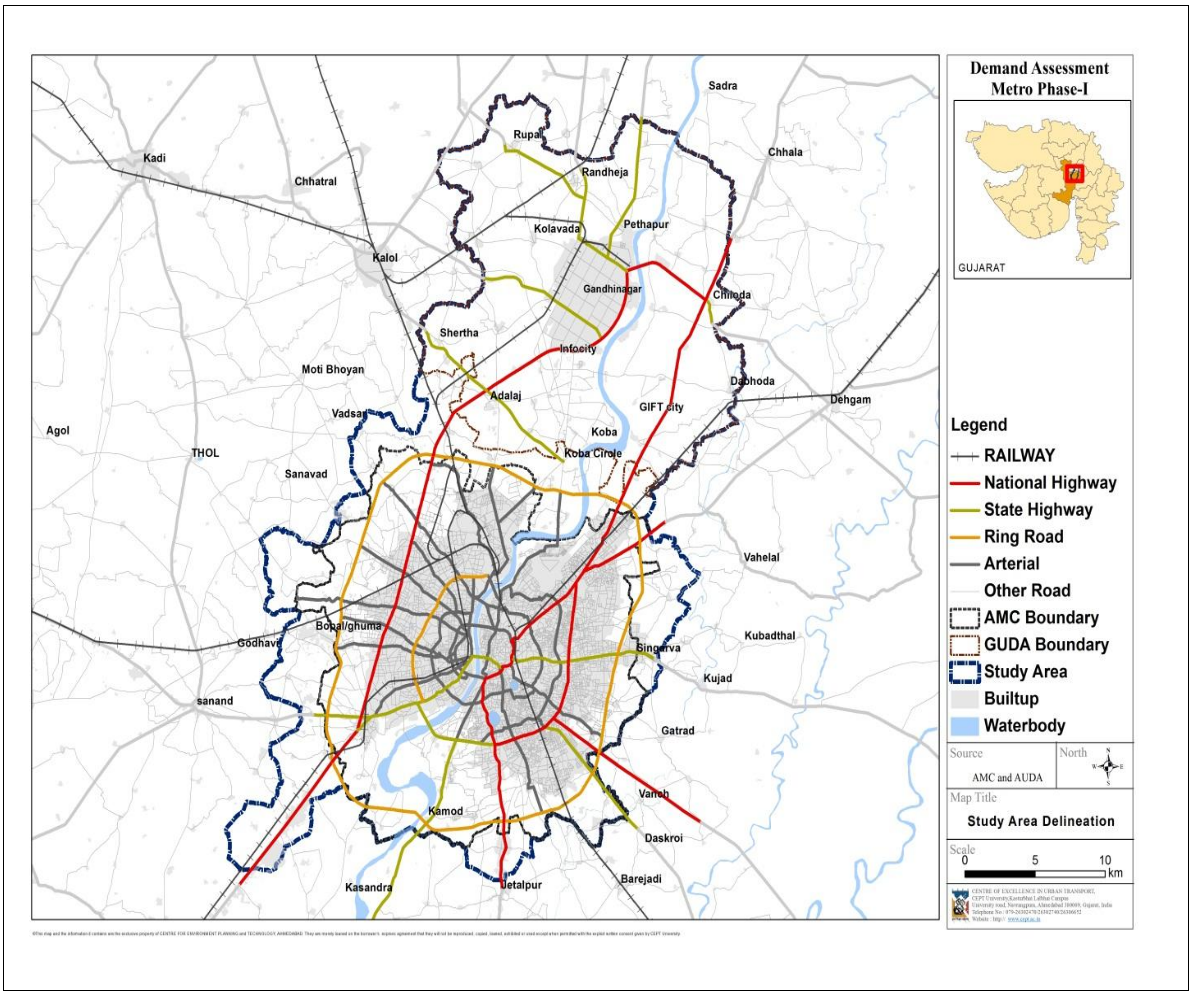


Fig. 2.1 Existing Road Network in Study area

2.2.1 Traffic Volume

Traffic congestion on the city roads of Ahmedabad and Gandhinagar is still moderate when compared to many other cities of similar size. However, with rapid rate of motorisation, the congestion levels are beginning to show up on certain stretches. The western part of Ahmedabad has developed mainly as residential area and the eastern part has the industrial estates. Because of this, the traffic flow is heavy from west to east in the mornings and vice-versa in the evening, which causes traffic congestion and frequent traffic jams on the city roads during morning and evening peak periods.

Classified volume counts were carried out at several locations along proposed metro corridors in 2014 (refer Figure below). The results of the same are presented in the table below.

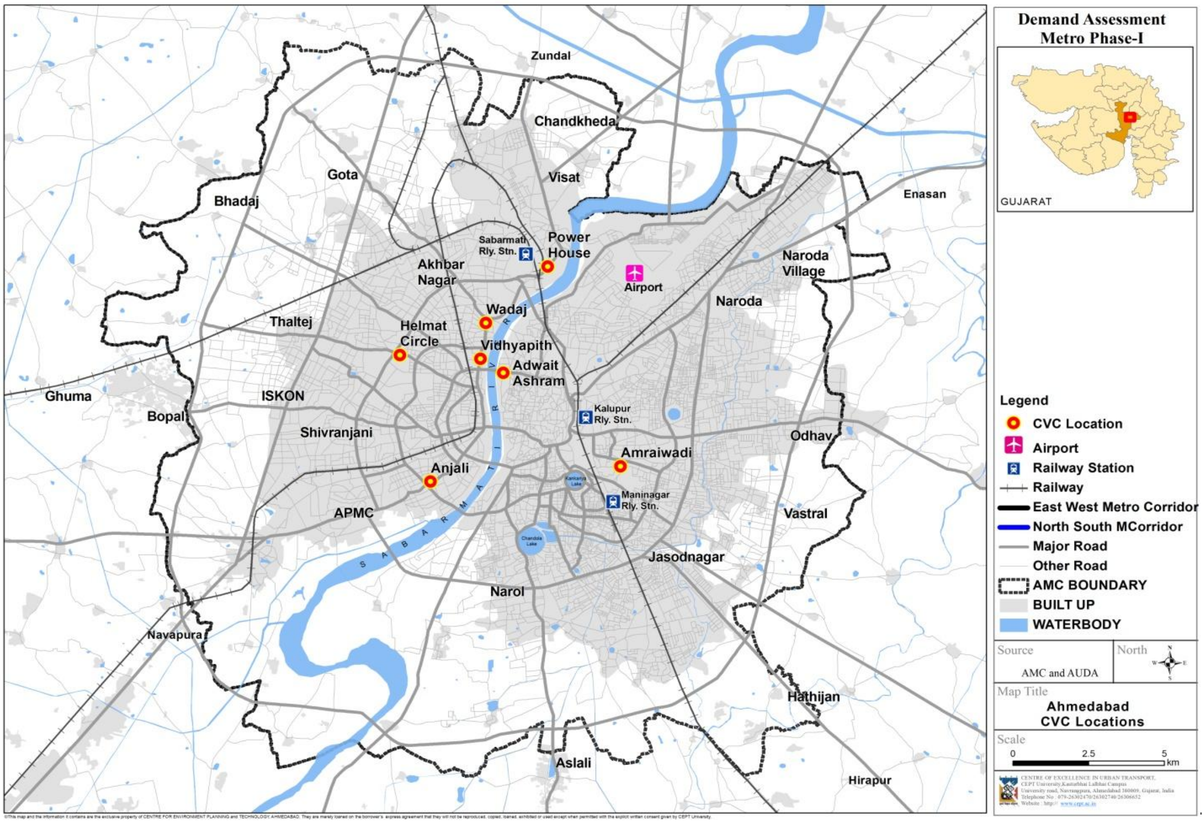


Fig. 2.2 Classified Volume Count Survey locations

Table 2.2 Classified Volume Count & PPHPDT

Location	Directions	Vehicles			PPHPDT		
		Private	Bus	Total	Private	Bus	Total
Power House	RTO to Chandkheda	6642	45	6687	11163	2470	13633
	Chandkheda to RTO	6982	107	7089	11285	5808	17093
Anjali	Vasna to Paldi	3874	63	3937	6312	3624	9936
	Paldi to Vasna	2527	62	2589	4973	3540	8513
Vidhyapith	Wadaj to income tax	2934	143	3077	5161	11297	16458
	Income tax to wadaj	3040	91	3131	5269	6136	11405
Amraiwadi	Rabari Colony to New Cotton	2520	5	2525	4108	190	4298
	New Cotton to Rabari Colony	1484	16	1500	2427	760	3187
Helmat Circle	Memnagar to Vijay Cross Road	6132	20	6152	9040	1217	10257
	Vijay Cross road to Memnagar	5186	23	5209	7983	1414	9397
Adwait Ashram	Shahapur Darwaja to Income Tax	7139	49	7188	12570	1773	14343
	Income Tax to Shahapur Darwaja	6307	43	6350	10880	2381	13261
Wadaj	Wadaj to Income Tax	5211	109	5320	9130	6709	15839
	Income tax to wadaj	7942	91	8033	13528	5852	19380

Source: Primary Surveys, 2014

2.2.2 Travel Speeds

To ascertain travel speeds across the network, speed and delay surveys were also carried out. Fig. 2.17 shows travel speeds across the network. The travel speeds along most of the corridors are more than 25kmph.

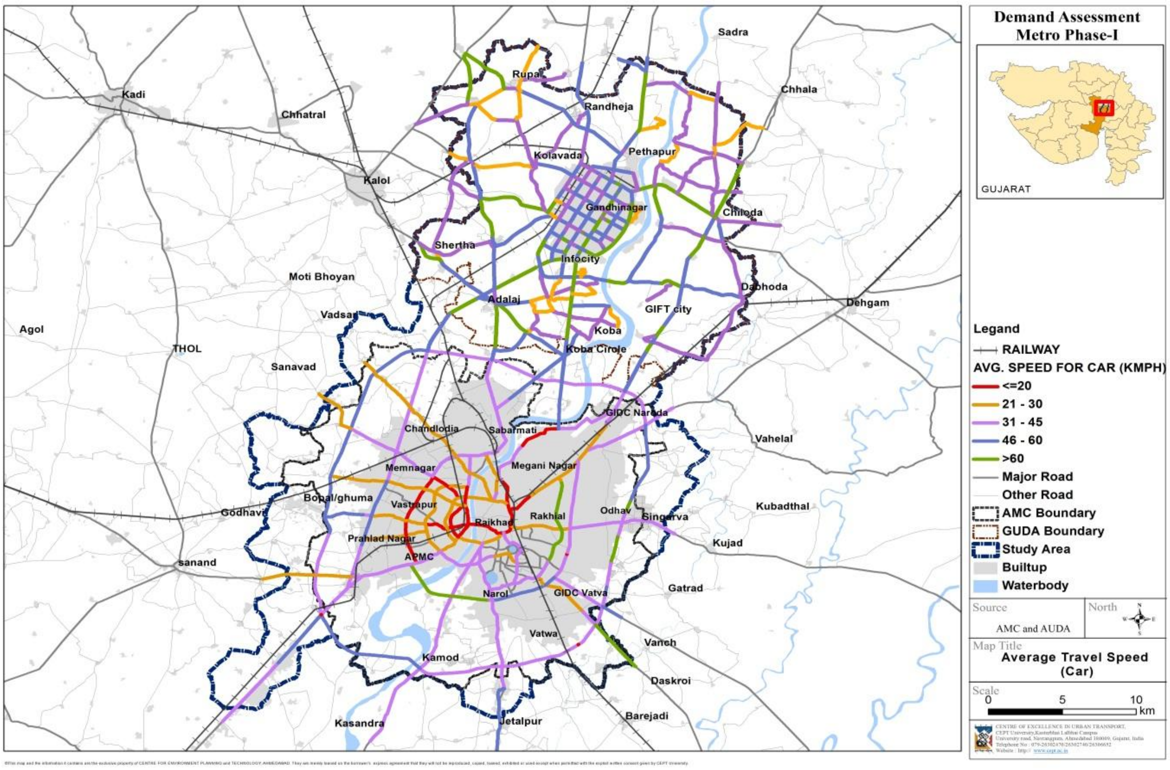


Fig. 2.3 Speeds on Major Roads in Study area

Source: CoE in Urban Transport, CEPT University, Ahmedabad & Primary Survey, LASA, 2009

In Gandhinagar the speed profile of the strategic network has high average speed (> 50 kmph) on NH and SH (including alphabet and cross roads in GNA) and lower on MDR and internal roads. The average speed on divided roads (55 kmph) is higher than undivided roads (40 kmph).

2.3 PUBLIC TRANSPORT NETWORK

The existing public transport services in Ahmedabad consist of buses and bus based rapid transit system. The bus services are provided by Ahmedabad Municipal Transport Service (AMTS) while BRTS services are operated by Ahmedabad Janmarg Limited (AJL), a special purpose vehicle (SPV) formulated by Ahmedabad Municipal Corporation, Ahmedabad Urban Development Authority and Government of Gujarat to govern the BRTS operations in the city. In Gandhinagar, the city bus services are offered by a private operator, Vallabhipur Transportation Co-Operative Society Pvt. Ltd. (VTCOS). Regional public transit demand is catered by Gujarat State Road Transport Corporation (GSRTC). GSRTC is providing regional public transport services; this public transport service brings commuters from surrounding towns and villages such as Dehgam, Mansa, Khedbrahma and Gandhinagar.

AMTS:

AMTS has been providing public transport services in the city since 1947, with 201 routes covering 549 km of road network, AMTS covers about 88% of the developed AMC area and carry 0.9 million passengers per day. It caters to roughly 11% of the trips in the city (AMTS, 2012).

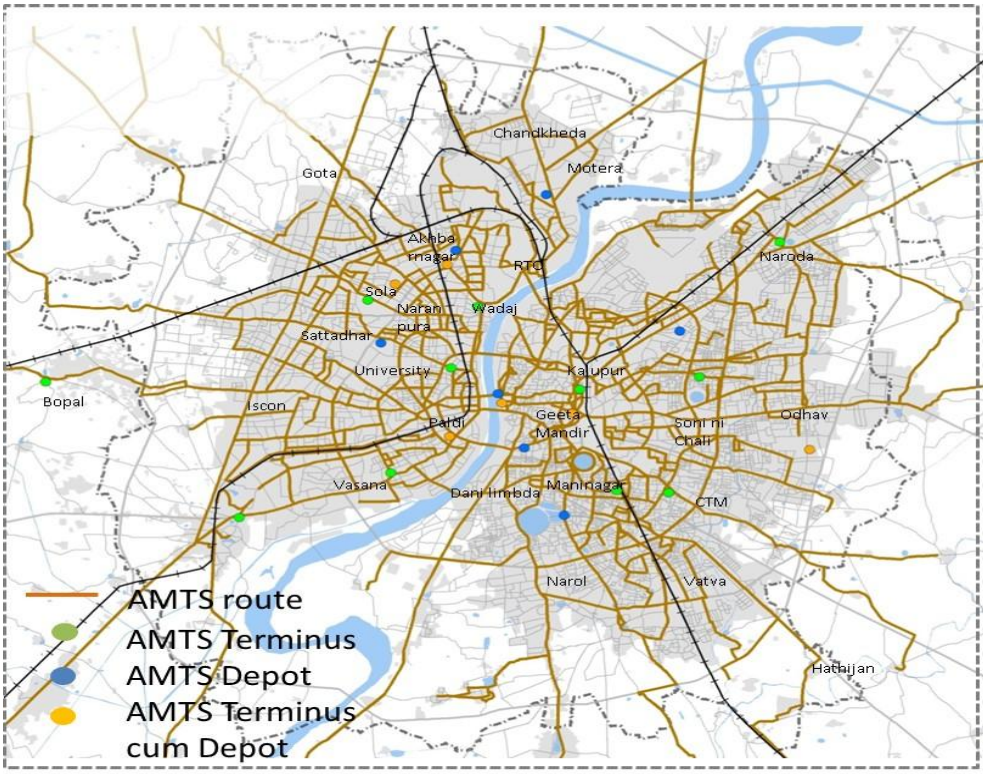


Fig. 2.4 AMTS Network

Source: COE (Centre of Excellence) in Urban Transport, CEPT University, Ahmedabad

The observed speed of AMTS is approximately 17km/hr, and most of the routes (70%) pass through walled city area, hence the city centre is very well connected to most parts of the city. Majority of the AMTS bus route is structured around the walled city, as historically walled city are used to be the commercial hub of the city. Currently, the new developed residential clusters near Sarkhej-Gandhinagar Highway, Bodakdev, Prahladnagar predominantly new-west zone is lacking in terms of high frequency of AMTS routes.

BUS Rapid Transit System (BRTS) – "Janmarg"

Janmarg BRTS services commenced operations as a closed system in Oct 2009. The BRT system currently with a network length of 63 kms attracts 1.17 lakh passengers daily. There are 10 operational routes and the peak headways are around 2.5 to 3 minutes. Due to the dedicated corridors and priority given at major intersections, the peak hour speeds of BRT buses are 25kmph. The current BRT network connects the important origins and destination plus the transit interchanges such as railway stations, regional bus terminals, and university areas, industrial areas such as Narol, Naroda; residential and commercial hubs and recreational public spaces such as Kankaria Lake.

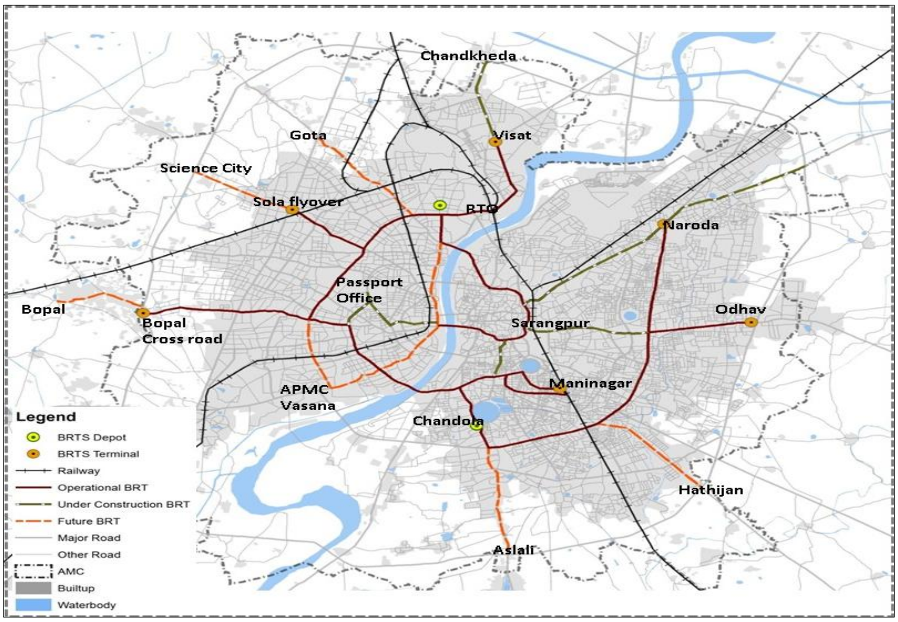


Fig. 2.5 BRTS Network

Source: COE (Centre of Excellence) in Urban Transport, CEPT University, Ahmedabad

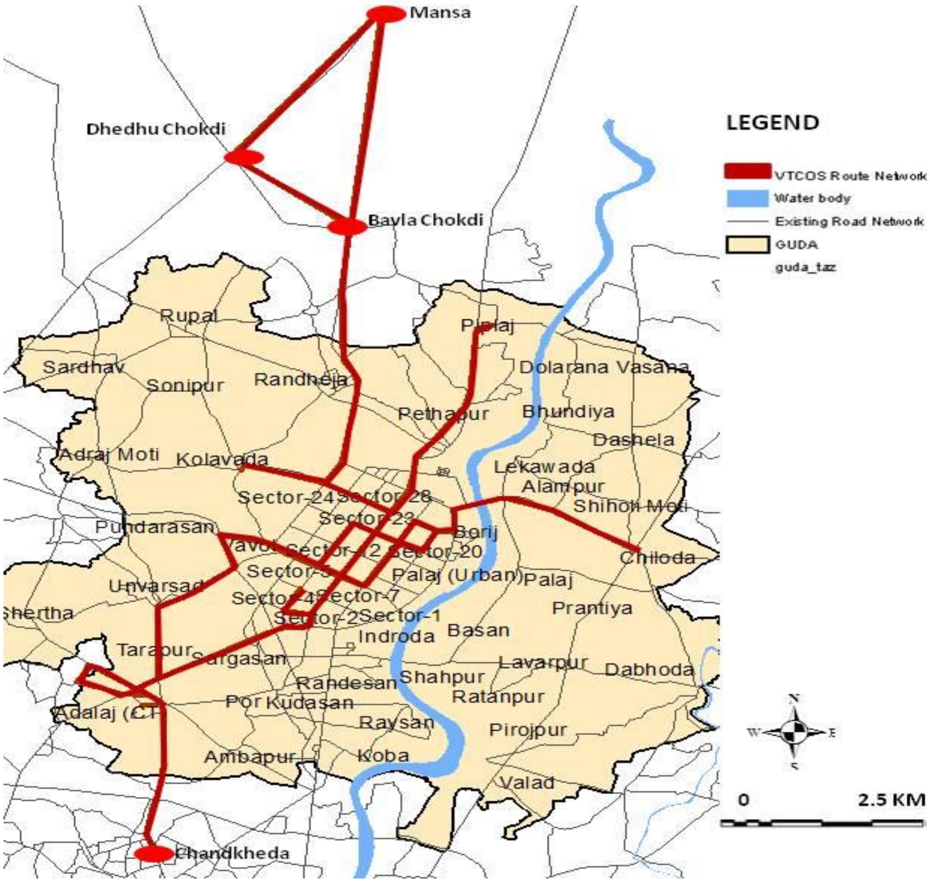


Fig. 2.6 City Bus Services in Gandhinagar

Source: COE (Centre of Excellence) in Urban Transport, CEPT University,

City Bus Services in Gandhinagar

VTCOS started its bus operations in Gandhinagar in August, 2009. In the first phase approximately 11 buses were operating, buses were running on Compressed Natural Gas (CNG). Currently, VTCOS is operating approximately 45 buses in GUDA and GNA. VTCOS is currently operating on 9 routes, the routes are Kh-1 to Akshardham, Akshardham to Pathikashram, Ch-0 to Gh-7, Ch-0 to Sector 19/20, Adalaj to Chiloda, Pethapur to Gh-1, Vasania Mahadev to Pathikashram, Vavol to Sector 21 and Gh-0 to Akshardham via sector.

The headways of the buses range from 10 minutes to 20 minutes. The average occupancy of the bus for all the routes is around 40. The observed occupancy of the bus during peak hour was more than 100%.

2.3.1 SOCIO-ECONOMIC CHARACTERISTICS

Based on the household survey data of Gandhinagar and Ahmedabad, the average household size in the study area is 4.6 in comparison to 5.04 in Census 2001. At a disaggregate level, average household size in Ahmedabad is 4.6 in comparison to 4.5 in Gandhinagar.

The Work Force Participation Rate (WPR) in the study area is 0.34. Of the total worker population in the study area, majority of them (57%) are involved in the private service, followed by around 33% in business activity. Around 5% are engaged in government services and another 5% are working as labourers. (Source: Ahmedabad Household Data (CEPT, 2012), Gandhinagar Household Data (LASA, 2009)

In terms of vehicle ownership, around 16% of the households in the study area do not own any vehicles while another 14% own only cycles. Almost half of the households own two-wheelers, while 15% households own cars.

2.3.2 TRAVEL CHARACTERISTICS

Travel patterns, defined in terms of trip rate, mode choice, geographical distribution etc., are the guiding principles in determining the system needs and its growth. It seems that socio-economic characteristics such as income, age, sex, occupation, vehicle ownership, etc., are related to travel characteristics of individual households. This chapter, attempts to describe the travel characteristics in Ahmedabad and Gandhinagar Urban Development Authority (GUDA) limit. It also describes interaction of the trips between two major urban areas Ahmedabad and Gandhinagar.

2.3.3 Trip rates

The per capita trip rate including walk, as per AMTS/CEPT (1992) was 1.2, GIDB IPTS (2000) was 1.1 trips per day, GIDB Metro study by DMRC (2003) was 1.16. However, as per the 2012 household study by CEPT shows trip rate to be high at 1.44 (all modes). The trip rate for Ahmedabad excluding all the walk trips below or equal to 500 meters, is about 1.39 in comparison to 0.99 in case of GUDA.

The following table shows the summary of trip rates in AMC and GUDA area:

Table 2.3 Trip rates information in study area

Particulars	AMC (I – I)	GUDA (I – I)
Year of Survey	**2012**	**2009**
Households surveyed	12000	1500
Trip-Rate Total	1.44	1.15
Trip rate – Motorised	0.74	0.54
By excluding walk trips which are generally short in length, the estimated PCTR is	1.39	0.99
Public transport trip rate	0.17	0.06

2.3.4 Mode shares

The share of walk and cycle trips in both AMC and GUDA is quite high. Around 46% and 42% of the trips in AMC and GUDA respectively are by NMT modes. Around 30% and 35% trips in AMC and GUDA are by private modes. Public transport ridership is quite low with 11% trips on buses and BRT.

Table 2.4 Mode share in study area

Mode Shares		
Particulars	AMC (I – I)	GUDA (I – I)
Walk	37.2%	30.9%
Bicycle	9.0%	12.8%
TW	25.9%	26.4%
Car	3.9%	9.6%
Auto Rickshaw	6.1%	9.2%
Bus	10.3%	8.0%
BRTS	1.1%	
Others (School bus, staff bus, ST bus, rail)	6.3%	3.2%
Total	100%	100%

Source: Ahmedabad Household Data (CEPT, 2012), Gandhinagar Household Data (LASA, 2009)

Trip purpose analysis shows around 47% work trips followed by education trips (34%)

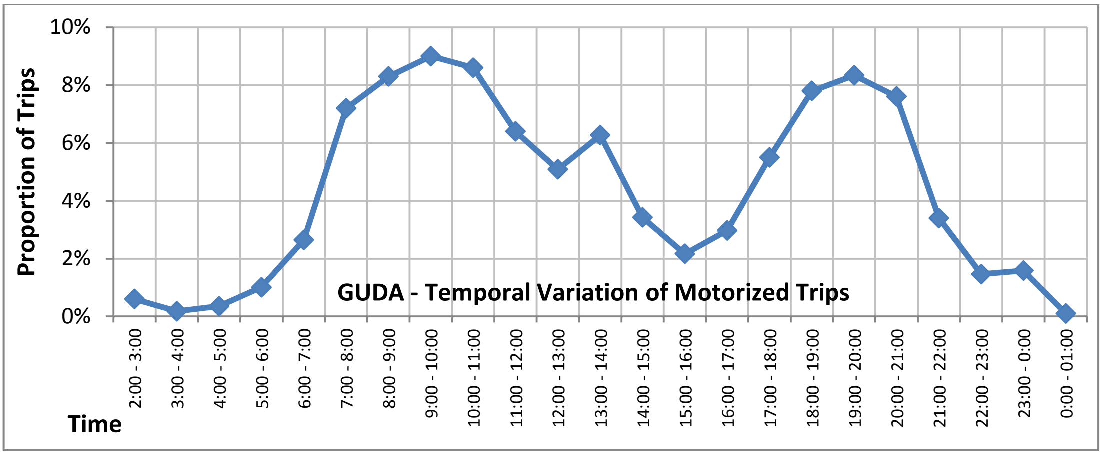
Table 2.5 Trips by purpose

Trips by Purpose		
Purpose	AMC (I – I)	GUDA (I – I)
Work	46%	49%
Education	34%	34%
Other	21%	16%
Total	100%	100%

Source: Ahmedabad Household Data (CEPT, 2012), Gandhinagar Household Data (LASA, 2009)

2.3.5 Temporal analysis of trips

A temporal analysis of trips was carried out to ascertain the peak hour factor. The following Figure shows the proportion of trips originating between different time-periods across the day.



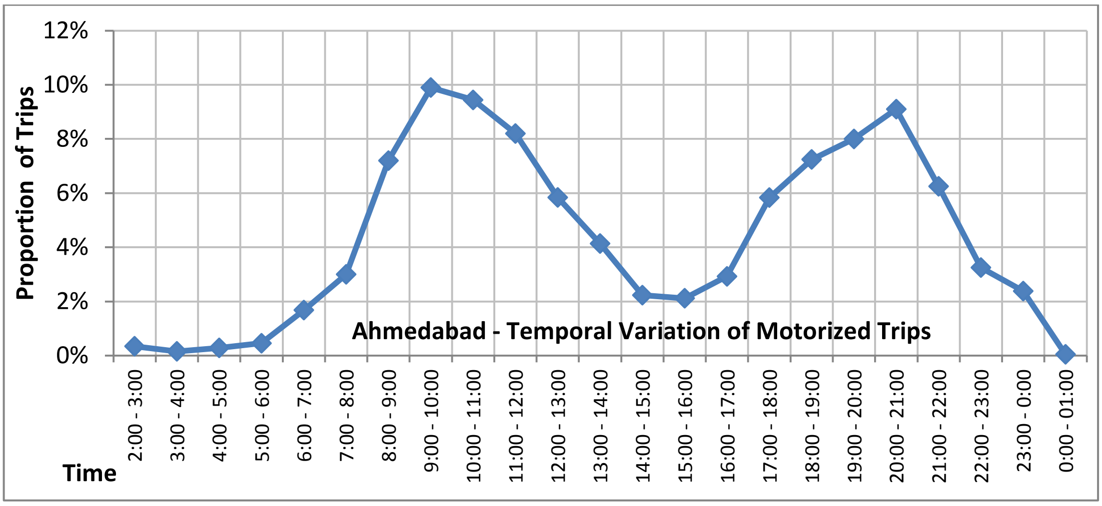


Fig. 2.7 Temporal variation of trips

It can be seen that the peak hour factor is around 10% of the full day trips.

The following Figure shows the proportion of trips in the study area originating at different time-periods across the day. It is observed that, the time of the day journey has two peaks, morning is from 8:30am to 11:30am and evening is from 5:30pm to 8:30pm. For the purpose of transit facilities and infrastructure design, it is desirable to look at the peak hour traffic, therefore travel demand model has been developed for the morning peak hour (8:30 am to 11:30 am).

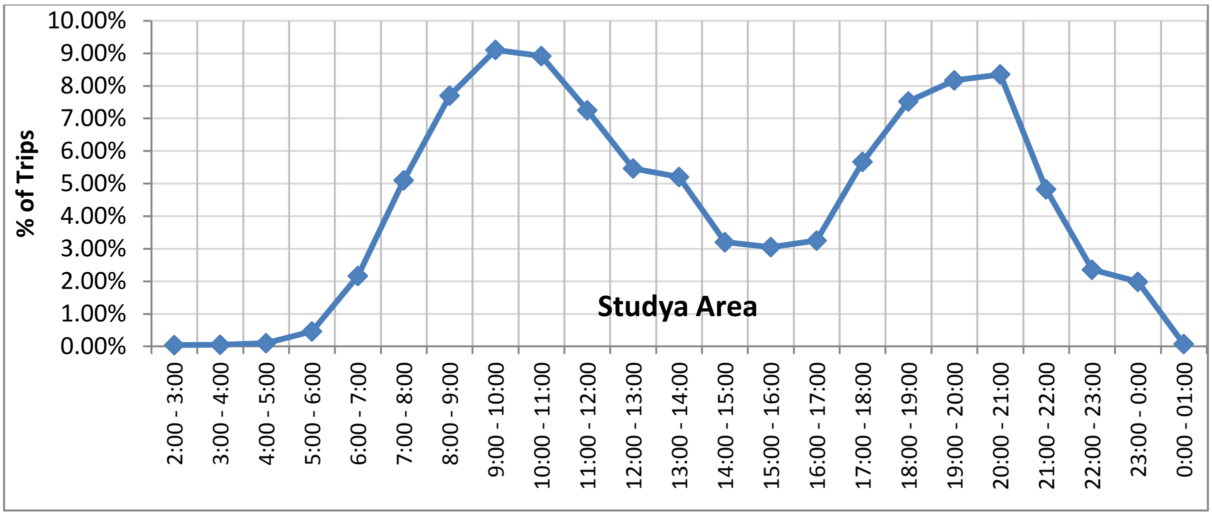


Fig. 2.8 Temporal Demand Variation of Study Area – Motorized modes

2.3.6 Trip Length Frequency Distribution

The following Figure shows the trip length frequency distribution for all trips in the study area. It can be seen that majority of the trips are of less than 8kms length.

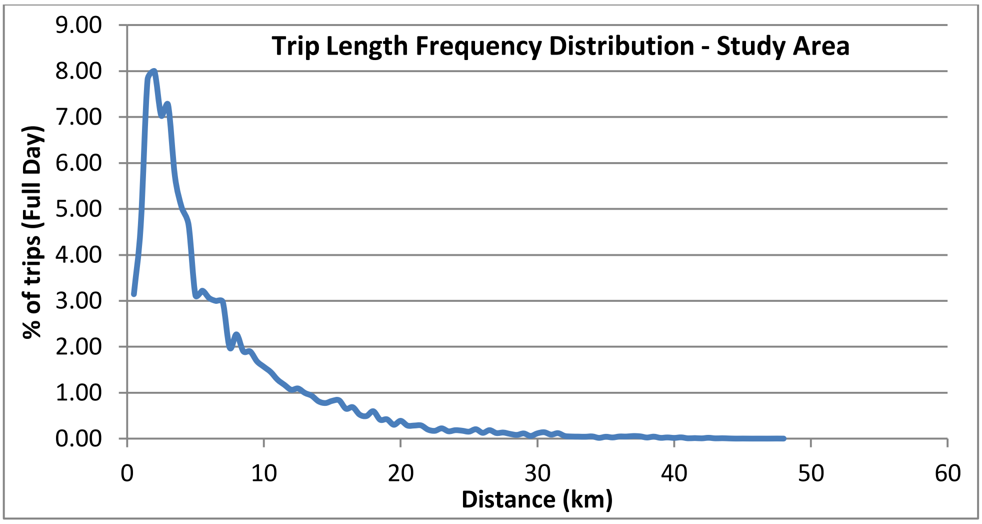


Fig. 2.9 Trip length frequency distribution – study area

The average trip length by modes is shown in the table below. It can be seen that the average trip distance by car and public transport is similar around 9.6kms, followed by two wheeler trip lengths of 7.4km. The average trip length of the study area is 6.6 kms.

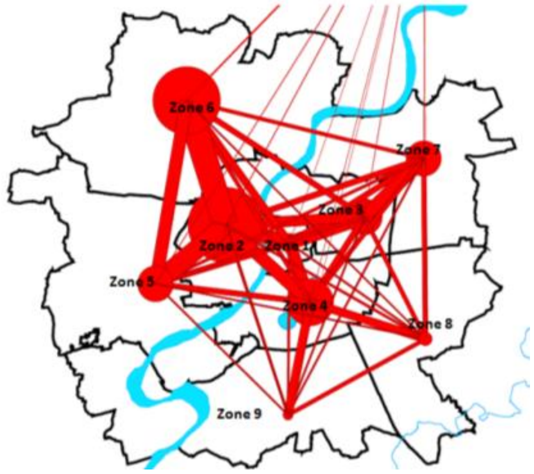
Table 2.6 Average trip length – mode wise

Modes	Average Trip length (kms)
Two Wheeler	7.36
Four Wheeler	9.66
Auto	6.38
Public Transport	9.57
Walk	2.14
Bicycle	4.27

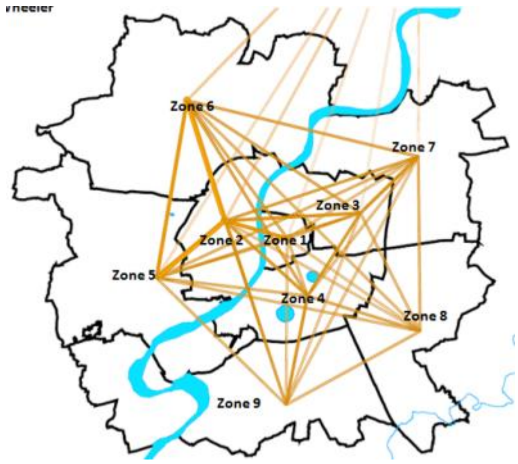
2.3.7 Travel Pattern

The Figure below shows that Ahmedabad traffic is concentrated in the walled city, eastern part of the city and across the river bridges. Bicycle movements are shorter and largely concentrated in and around North, east and central zones of Ahmedabad. Auto trips are largely dispersed over the AMC region with shorter trip lengths whereas trips made by car are largely dispersed with long distances. Trips with use of 4-wheeler is comparatively very low, as sparse red lines are seen in the Figure. The share of two wheeler trips is considerably high compared to other modes with shorter distances resulted in more compact travel movement over AMC.

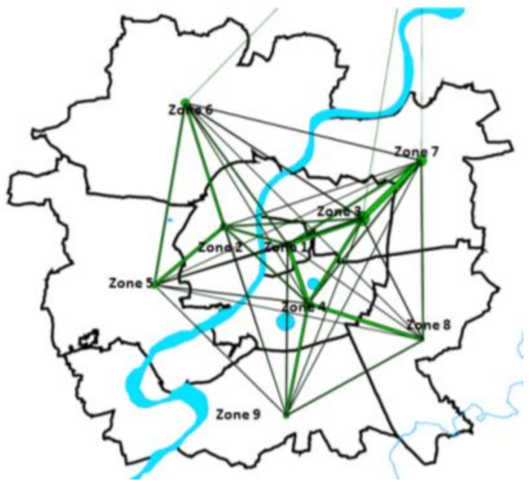
2-Wheeler



4-Wheeler



3-Wheeler



Public Transport

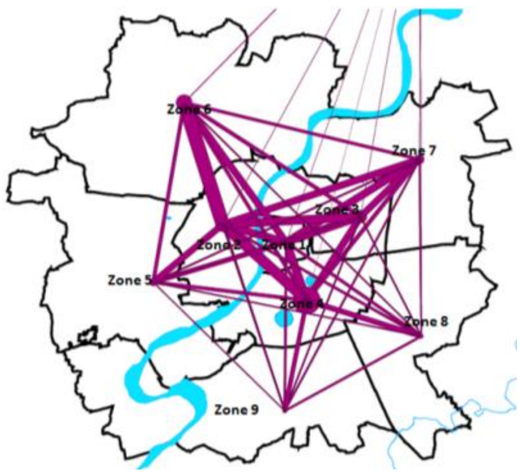
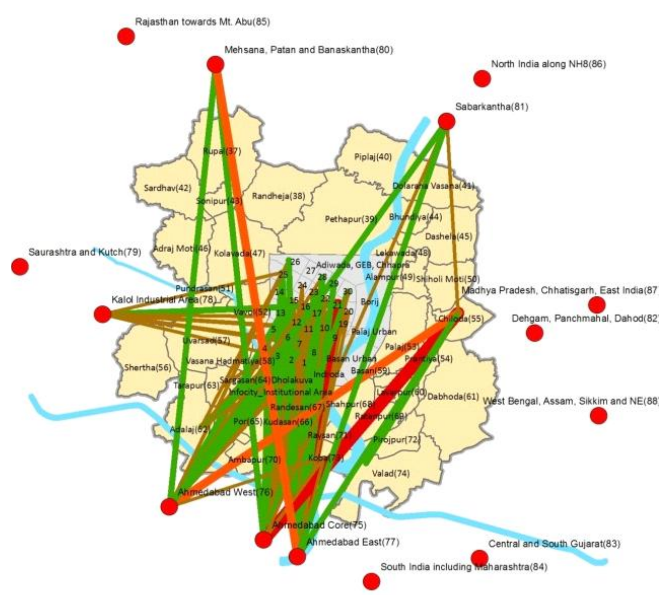


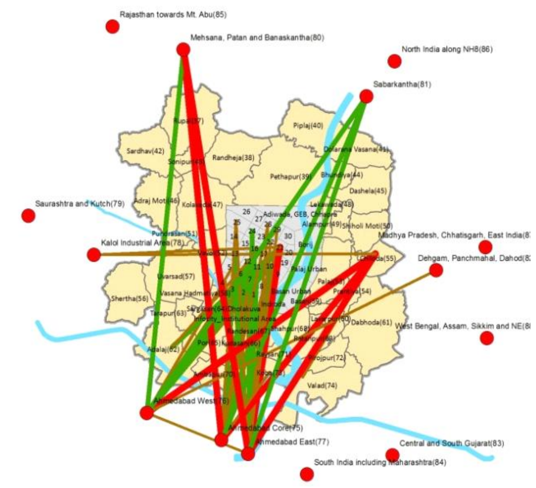
Fig. 2.10 Desire line Diagrams (AMC)

The below Figure illustrated, in Gandhinagar trips are mainly originating from GNA to external areas like Ahmedabad, Chiloda, Kalol and Mehsana. The predominant modes for these trips are two- wheelers and bus.

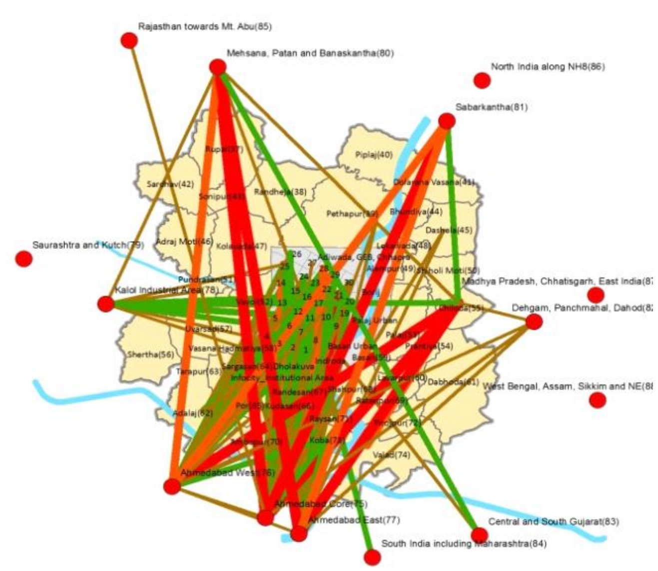
2-Wheeler



4-Wheeler



All Trips



Legend

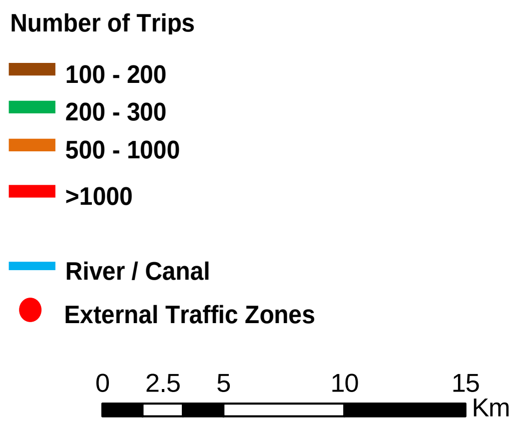


Fig. 2.11 Desire line Diagrams (GUDA)

2.4 MODEL DEVELOPMENT

A standard four stage modeling process has been followed to project travel demand and metro ridership in future. An overview of the modeling approach is presented in Figure below. This public transport model has been developed using EMME 4.0.8 software.

2.4.1 Modelling framework

The study area defined in section 1.3.1 has been taken as the modelling area. The zoning structure has been outlined in section 1.3.2. The modelling area has been subdivided into 398 internal zones and 9 external zones.

For this exercise, a public transport model has been developed for 3-hour morning peak period based on the temporal analysis carried out in section 3.4.3. The major road network in the study area along with the existing public transport network of AMTS and BRTS and proposed networks of metro, AMTS and BRTS has been taken into account for developing base and future scenarios. For the analysis of travel pattern four trip purposes - Home based Work, Education, Others, Non-home based, has been taken into account.

This modelling exercise has been carried out for 2011(Base Year) and future years of 2018, 2021, 2031 and 2043. The following table shows the PT network taken for different years:

Year	Public Transport Network
2011	Base AMTS network across 549 km, 187 routes 45 km of BRTS network, 5 routes 9 VTCOS routes 18 GSRTC routes in the study area
2018 and 2021	Restructured routes of AMTS across 568 km - 47 routes 9 VTCOS routes with improved frequencies GSRTC routes with improved frequencies GSRTC routes between Ahmedabad and Gandhinagar removing segments which are overlapping with metro 120 km BRTS network – 10 routes 35 km of Metro Ph 1 – 2 routes
2031 and 2043	Restructured routes of AMTS across 568 km - 47 routes VTCOS routes GSRTC routes between Ahmedabad and Gandhinagar removing segments with overlaps with metro 120 km BRTS network – 10 routes 60 km of Metro Ph 1 &2 – 3 routes

For each of these years, demand scenarios of Business As Usual, Gradual and Rapid Scenarios (discussed in section 2.2) has been considered for modelling.

The data inputs used for modelling are as below:

Type of data	Details
Demand Data	Existing demand – household surveys, RSI at cordon points Socio-economic data – population, employment data existing and proposed, student enrolment existing and proposed
Supply Data	Road network – physical attributes, network speeds, delays at junctions
	Public Transport network – stops, corridors, routes, service details
Model calibration data	Travel speeds on major network (2012-13) Classified volume counts, vehicle occupancy surveys

2.4.2 Four stage Modelling Process

2.4.2.1 Trip Generation

Trip generation is the first step of four stage modeling exercise which estimates number of trips produced and attracted to each TAZ. Regression equations were formulated for this purpose using the variables listed below in the table:

Table 2.7 Trip Generation variables

Trip Productions	Independent Variables	Trip Attractions	Independent Variables
HBW	Resident Workers	HBW	Employment
HBE	Resident Students	HBE	Students Enrolment
HBO	Population + Employment	HBO	Population + Employment
NHB	Employment	NHB	Population + Employment

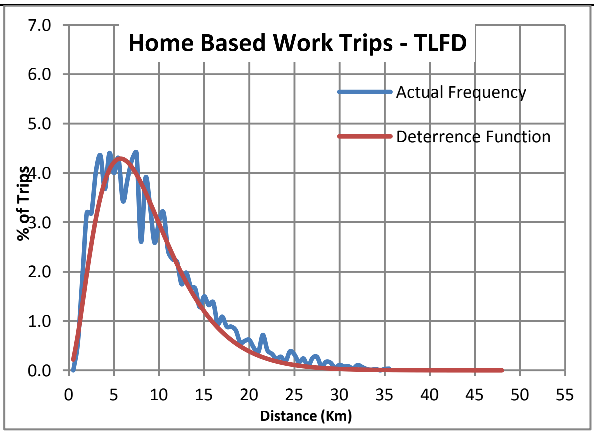
Following table shows the trip productions and attractions by zone groups in the study area for different scenarios and forecast years.

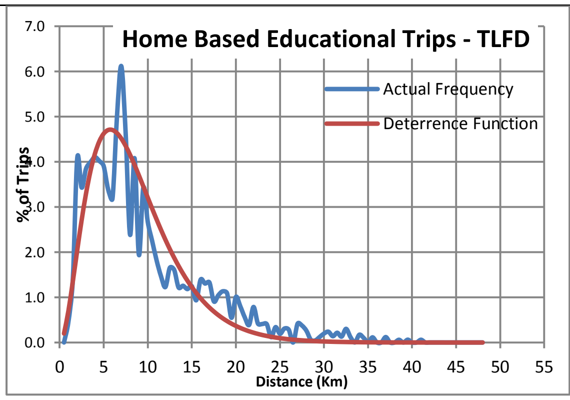
Table 2.8 Productions and Attractions in different zone groups for different growth scenarios

Zones	2018		2021		2031		2043	
	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
BUA Scenario								
East West Metro	795642	999907	863392	1090381	1096125	1357031	1282343	1655645
Metro Overlap	243416	527300	258965	568572	310737	688498	348927	815572
North South Metro	503751	472816	552829	521988	761117	672595	927381	834630
GUDA	489021	511957	589162	644047	767864	898718	1059826	1149136
Other Study Area	4111336	3631185	4594442	4033801	5767374	5086374	7034075	6197570
Moderate Scenario								
East West Metro	804582	1014910	878463	1116348	1076516	1379303	1282343	1655645
Metro Overlap	244713	533481	261263	578325	304783	697290	348927	815572
North South Metro	519080	481380	578247	536228	747542	683031	927381	834630
GUDA	477881	488729	566371	595204	802212	856174	1059826	1149136
Other Study Area	4109910	3637664	4574446	4032684	5772338	5087593	7034075	6197570
Rapid Scenario								
East West Metro	814718	1029590	897985	1143515	1118651	1436112	1282343	1655645
Metro Overlap	246013	539604	264173	588443	311059	718418	348927	815572
North South Metro	537725	490064	611518	551567	819379	715252	927381	834630
GUDA	462886	463362	536959	544246	738743	749666	1059826	1149136
Other Study Area	4102234	3640956	4548154	4031019	5715559	5083944	7034075	6197570

2.4.2.2 Trip Distribution Model

Trip distribution model works on gravity model which is based on assumption that trip interaction between TAZ is directly proportional to relative attractiveness of each zone, while inversely proportional to some function of spatial separation between the TAZs. This model was developed for each of the four purposes - Home Based Work, Home Based Education, Home Based Other and Non Home Based trips. The following Figure shows the modelled and actual Trip Length Frequency Distribution (TLFD) for HBW and HBE trips. Combined Tanner's function was used for trip distribution.





Home Base Work Trips	Home Base Educational Trips
Combine Function with α = 1.95 & β = 0.34	Combine Function with α = 2.07 & β = 0.36
Co – Incidence Ratio = 85%	Co – Incidence Ratio = 74%

Fig. 2.12 Trip Length Frequency Distribution – Different Purpose wise

2.4.2.3 Mode Split

The 2011 base year PT (BRT + Bus service) share is about 25% of the motorized trips which has further declined to around 19% in 2013. It is however being assumed that with improvements in public transport facility in the city with introduction of metro and completion of BRT network, more and more people will be attracted to public transport. Therefore, in order to undertake mode split, a willingness to shift survey was carried out in Ahmedabad in 2013. The Figure above shows the willingness to shift to metro of passengers with different trip lengths. The passengers willing to shift increases as the trip length increases. On the whole, around 50% of the surveyed passengers are willing to shift to metro systems.

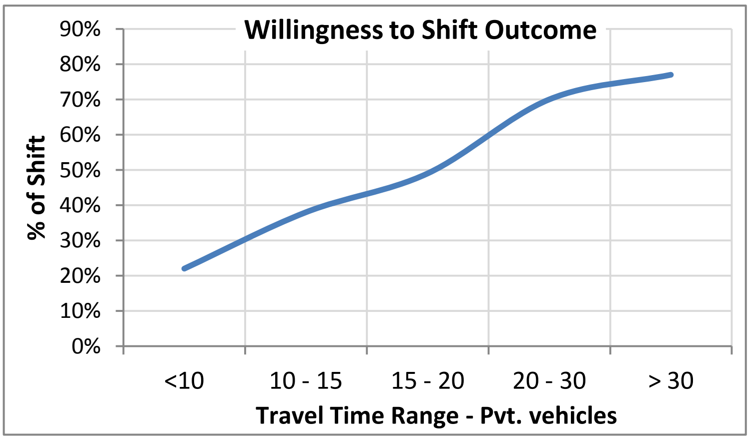


Fig. 2.13 Willingness to Shift Survey Outcome

2.4.2.4 Transit Assignment

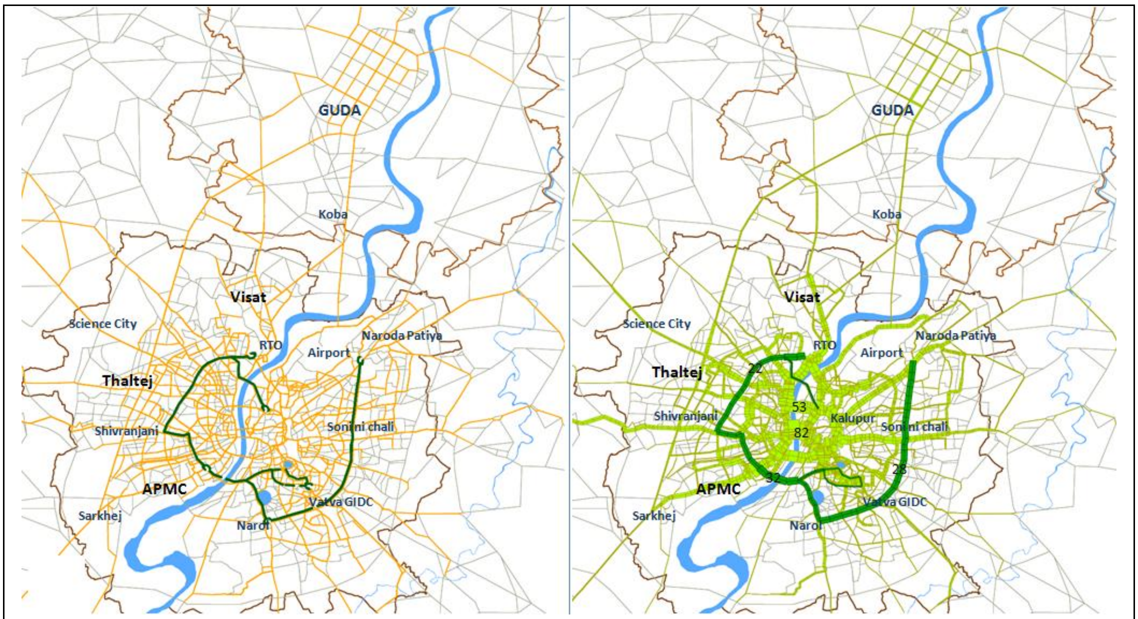
Transit assignment is the final stage of the four stage modeling process. Base transit demand (internal & external) is about 3.2 lakhs of three hours morning peak (11.12 lakhs per day). The share of the PT trips is 25% in motorized trips. The total PT demand was assigned on the existing public transport network consisting of BRTS, AMTS, VTCOS and GSRTC modes.

2.4.3 Network and demand development

2.4.3.1 Base Transit Network Development

A base year network has been developed in GIS which has been ARC GIS and the modelling process has been carried out in travel demand modeling software i.e. EMME 4.0.8.

In 2011 base year, 45 km BRTS network was in operation; and about 187 AMTS & 9 VTCOS routes were plying as city bus services. Other than these, GSRTC were operating routes between Ahmedabad & Gandhinagar. Since the model has been developed for the peak hour, only peak hour frequency has been taken for each route.



Base Public Transport Network - 2011	Base Bus Flows (Buses per Hour) - 2011

Fig. 2.14 Base Transit Network

2.4.3.2 Base Demand

As discussed in the previous section, household surveys were carried out in AMC & GUDA respectively in 2011-2012 & 2009 which have been used for developing the base year demand matrix. For capturing the external public transport demand, passenger surveys at Kalupur and Maninagar railway station and Geeta Mandir bus terminal were also carried out.

There are about 43 lakhs motorized trips produced in a day in the study area, of which PT share is around 25% of these motorized trips.

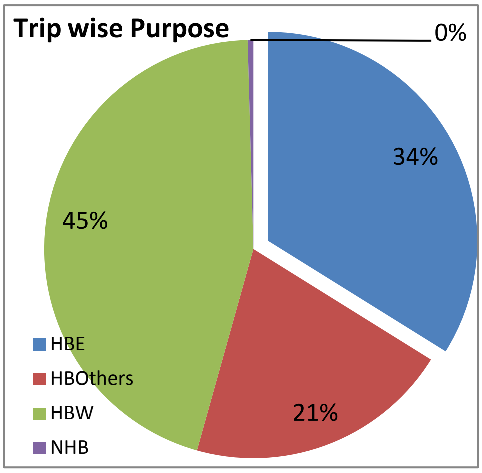


Fig. 2.15 Purpose wise trips distribution (all modes)

Four different proposes have been captured, i.e. Home based work (HBW), Home based Education (HBE), Home based others (HBOthers) & Non home based (NHB) for all the modes.

Table 2.9 Purpose wise trips distribution

Purpose	Motorized	% Motorized
HBE	1215039	28%
HB Others	515848	12%
HBW	2571467	59%
NHB	30210	1%
Total	**4332565**	**100%**

2.4.3.3 Future Transit Network Development

Figure below show the future transit corridors for the years 2018 & 2021 and 2031 & 2043.

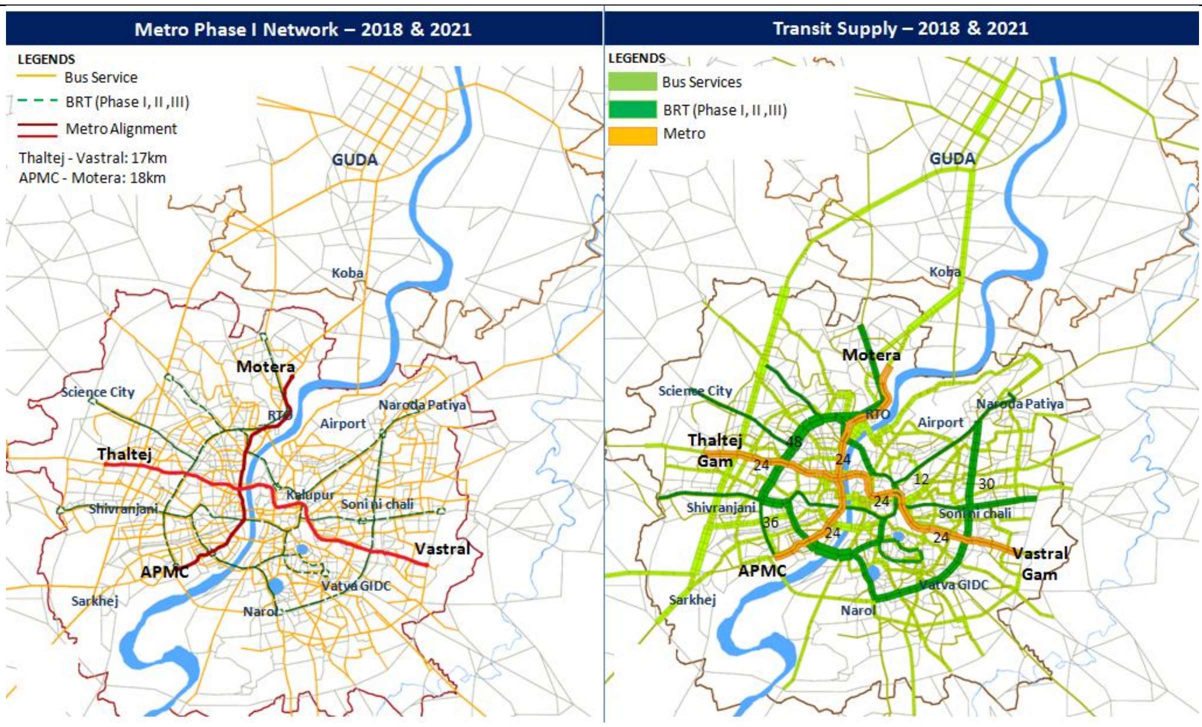


Fig. 2.16 Future Transit Network & services per hour – 2018 & 2021

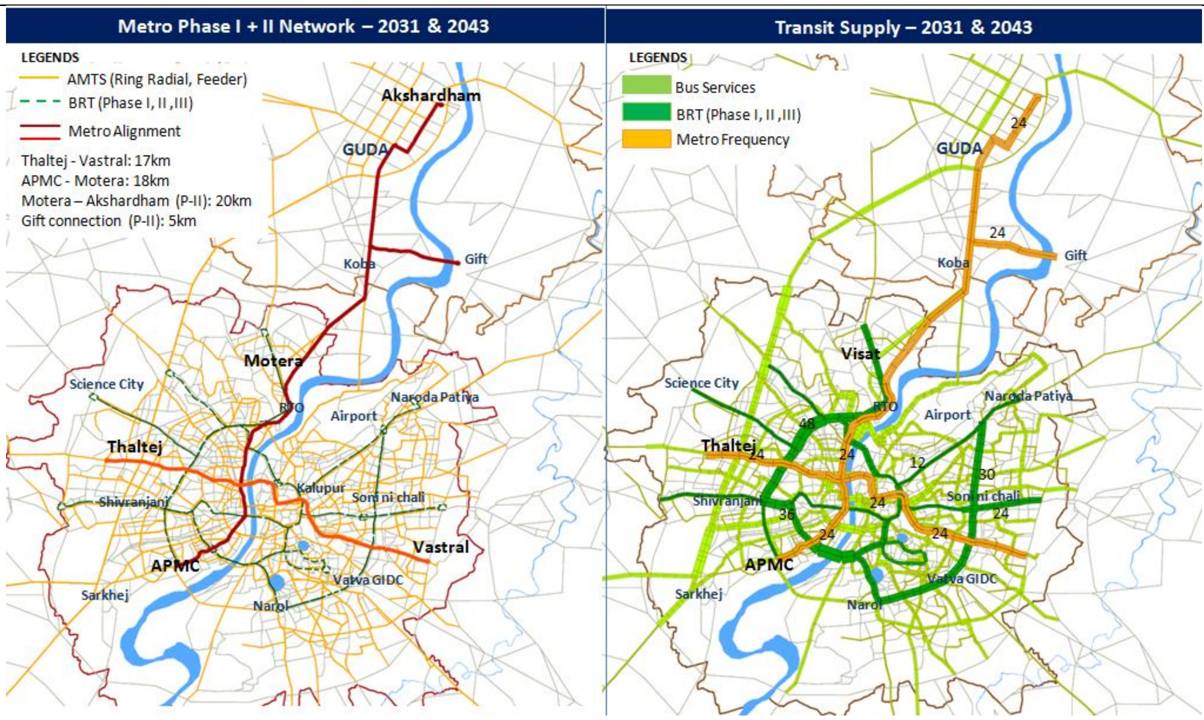


Fig. 2.17 Future Transit Network & services per hour – 2031 & 2043

2.4.3.4 Future Alternative Development

The land use scenarios for the study area are discussed in section 2.2. Three growth alternatives have been considered – Business As Usual, Moderate and Rapid Scenarios. The BAU scenario is expected to have development in vacant areas outside the current development areas and focus on development along metro is assumed to happen once the project has been completely realised. Therefore, the rate of development along the metro corridor would happen at a much slower pace and will be realised at a much later time period. The other two scenarios are more pro-active scenarios, where growth along the metro corridors will be facilitated leading to transit oriented development. The rate of this development is much higher in Rapid Scenario than the Moderate Scenario.

Further it is expected that shift to public transport system will happen as the metro corridors are implemented. Based on the WTS survey, a maximum shift of 50% to PT is assumed by the year 2043. However, different build-up trajectories are assumed for the different growth scenarios. In case of Moderate scenario, two shift options are being considered, the first one focusing on shift to PT from across the city while the second one assuming higher shift from catchment zones along the corridor.

The table below shows the demand scenarios for modelling:

Table 2.10 Future PT shares assumptions

Demand Scenarios	Growth Alternatives	Years			
		2018	2021	2031	2043
Business as Usual	Business As Usual	19%	26%	35%	50%
Gradual	Moderate	22%	28%	37.50%	50%
Moderate		22%	28%	37.50%	50%
Rapid	Rapid	25%	30%	40%	50%

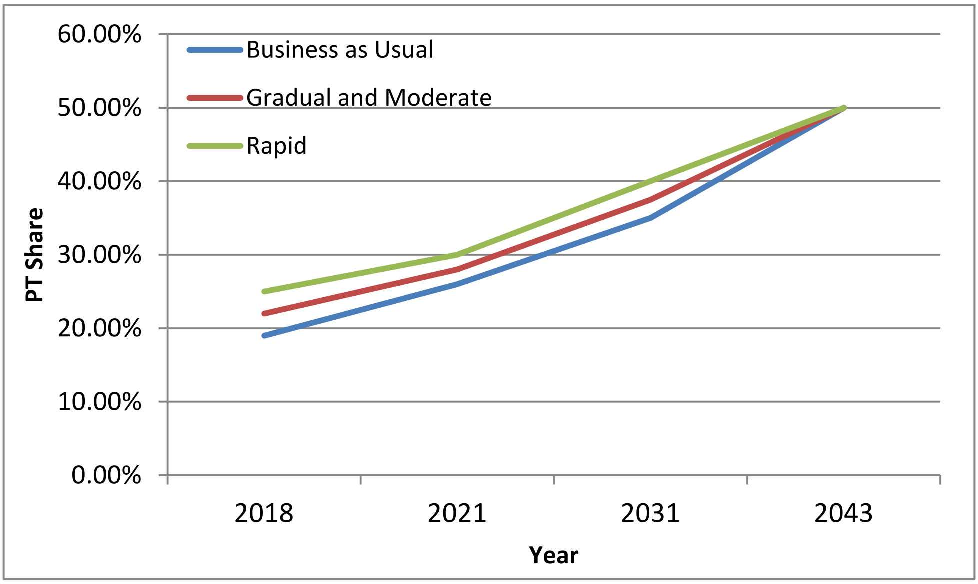


Fig. 2.18 Future Scenarios PT share build up

2.5 MODEL OUTPUTS

2.5.1 Base Year

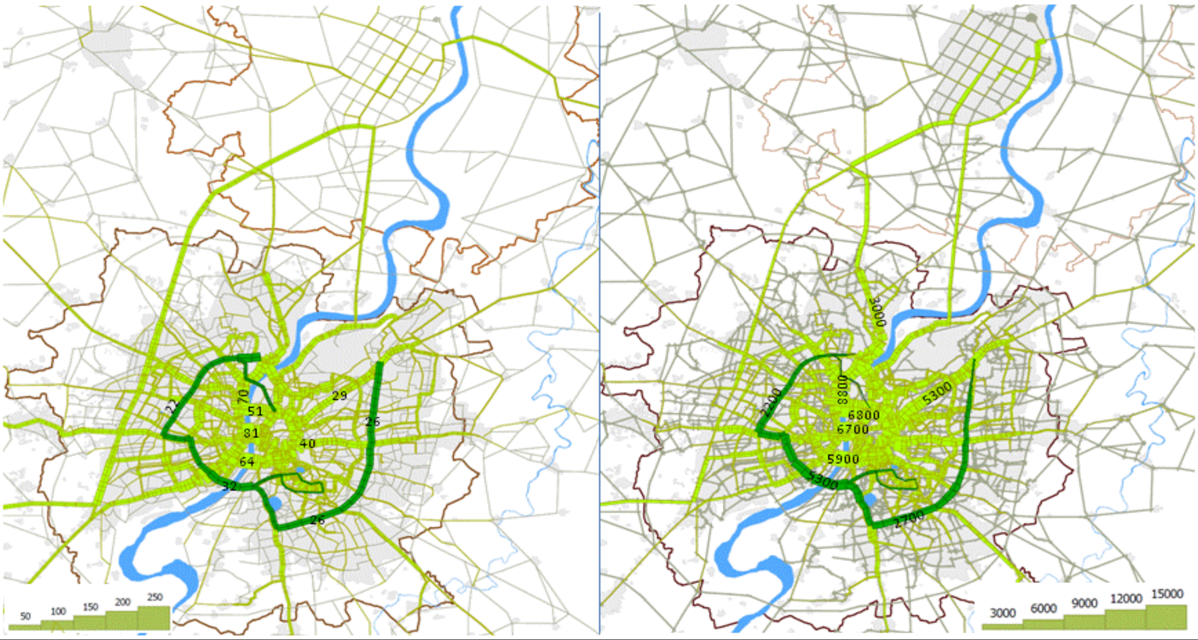
The demand assignment was carried out on various public transport networks (refer section 4.1). The base year AM Peak assignment model was calibrated based on the passenger boardings and passenger volumes on the major public transport network.

Table shows the model outputs for the base year. The average trip length in the base year for public transport is around 11kms.

Table 2.11 PT ridership summary (full day)

Demand full day	**1112036**						
Mode	**Boardings**	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Leg Length (km)**
Bus (AMTS & VTCOS)	1196096	11209446	716156	90%	1167	**1.20**	9.37
BRT	136792	1044206	43796	10%	3040		7.63
Total	**1332888**	**12253653**	**759952**				
PT trip length (km)	**11.02**						

Following Figure shows the public transport frequencies and passenger flows on the public transport network.



PT Supply (Buses per hour) – 2011	**Passenger Demand (Pass. per hour 2011)**
***Passenger flows are for morning peak hour, which gives one direction high flows at some locations**	

Fig. 2.19 Base year bus flows & passenger flows

2.5.2 Business as Usual Scenario

The model outputs of this scenario are presented below:

A. Full Day Ridership on different PT modes (Phase I corridors)

1. Year 2018 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 19%							
PT Demand:	**1161756**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1046007	11964389	715746	52%	1020		11.44
BRT	674016	6038968	253278	33%	5617	**1.73**	8.96
Metro	293172	1997942	62715	15%	8329		6.81
Total	**2013194**	**20001299**	**1031739**				
PT Trip Length	**17.22**	**km**					

2. Year 2021 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 26%							
PT Demand:	**1652010**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1530058	16949789	1014647	53%	1493		11.08
BRT	953003	8581121	359893	33%	7942	**1.76**	9.00
Metro	422749	2903798	91152	15%	12010		6.87
Total	**2905810**	**28434707**	**1465693**				
PT Trip Length	**17.21**	**km**					

3. Year 2031 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 35%							
PT Demand:	**2326209**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	2189882	22577737	1354111	53%	2136		10.31
BRT	1311846	11589869	486073	32%	10932	**1.77**	8.83
Metro	606067	4191908	131593	15%	17218		6.92
Total	**4107795**	**38359514**	**1971777**				
PT Trip Length	**16.49**	**km**					

4. Year 2043 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4724093	44797383	2675716	105%	4609	**1.72**	9.48
BRT	2600786	21122707	885873	58%	21673		8.12
Metro	1243598	8255972	259178	28%	35329		6.64
Total	**8568476**	**74176063**	**3820767**				
PT Trip Length	**14.91**	**km**					

B. Full Day Ridership on different PT modes (Phase I + II corridors)

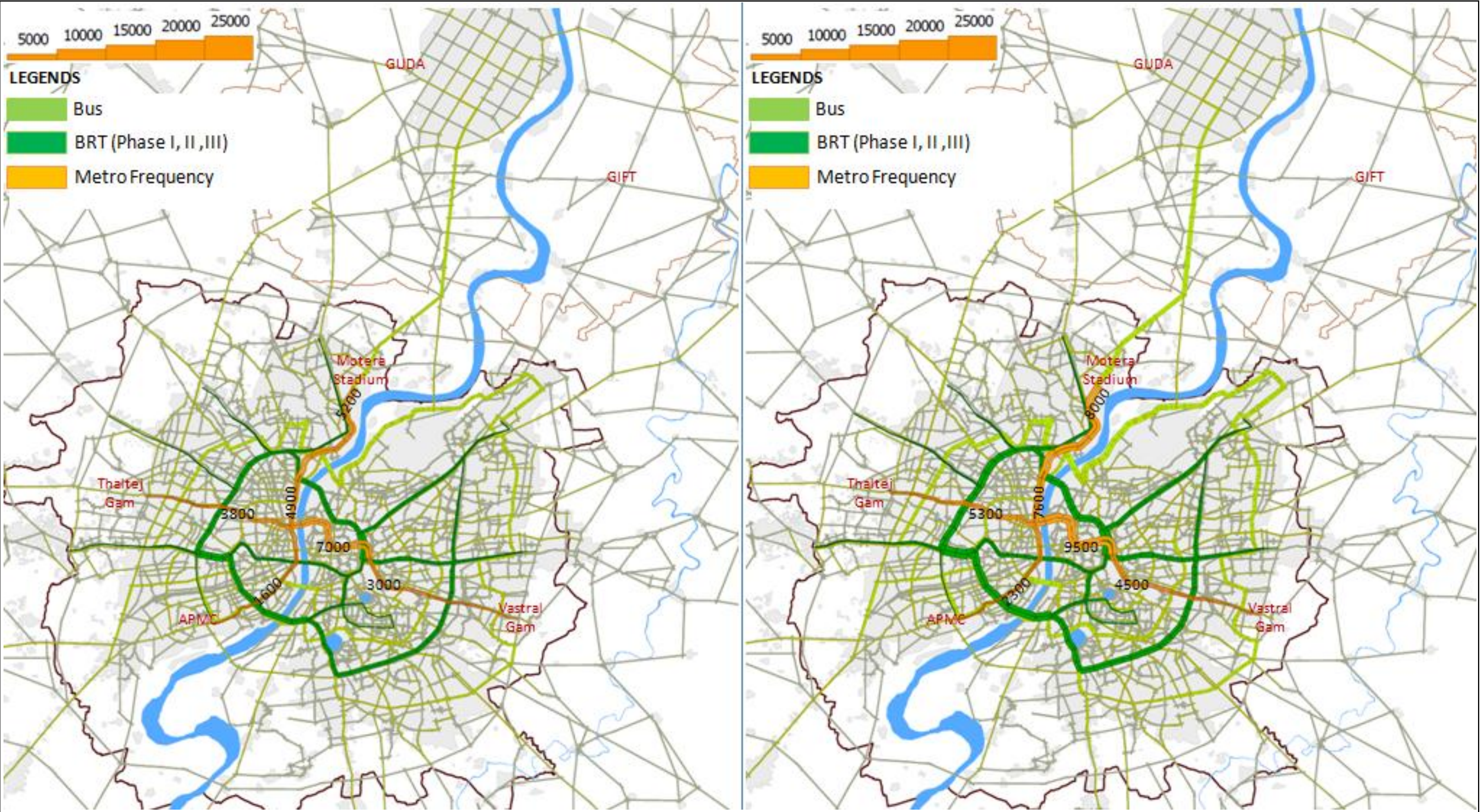
5. Year 2031 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

PT Share in Motorized trips: 35%							
PT Demand:	**2326209**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1955921	20161687	1217900	44%	1908	**1.70**	10.31
BRT	1318921	11863957	497559	29%	10991		9.00
Metro	672336	6157859	193209	15%	11206		9.16
Total	**3947179**	**38183503**	**1908669**				
PT Trip Length	**16.41**	**km**					

6. Year 2043 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

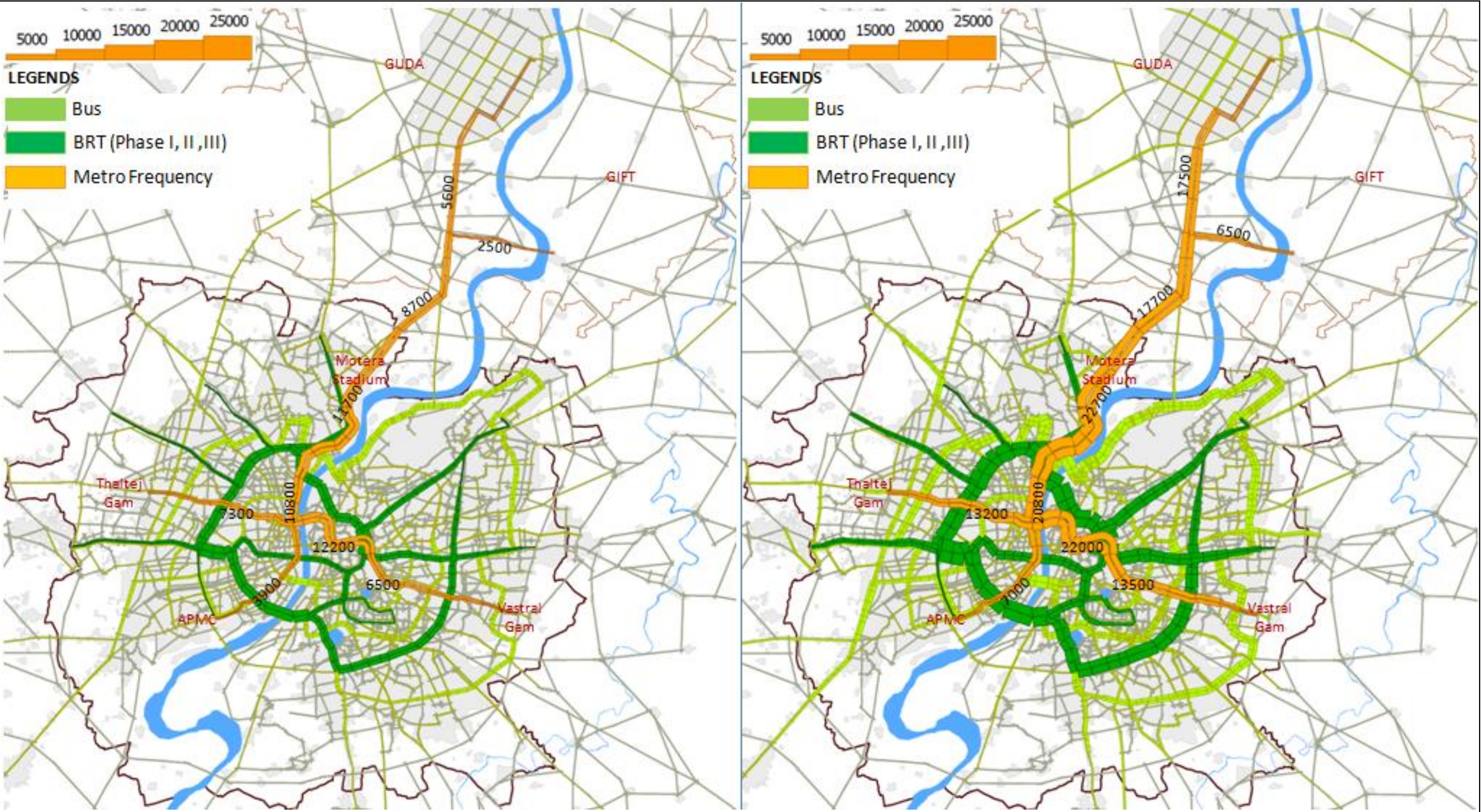
PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4176601	39608708	2381618	93%	4075	**1.67**	9.48
BRT	2671336	21867443	917112	60%	22261		8.19
Metro	1442392	12176899	382053	32%	24040		8.44
Total	**8290329**	**73653051**	**3680784**				
PT Trip Length	**14.81**	**km**					

Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures.



Year 2018 (Phase I Metro)	Year 2021 (Phase I Metro)

Fig. 2.20 BAU - Passenger Flows 2018 & 2021 (Phase I)



Year 2031 (Phase I+II Metro)	Year 2043 (Phase I+II Metro)

Fig. 2.21 BAU - Passenger Flows 2031 & 2043 (Phase I+II)

Peak hour Ridership on Metro - Ph I corridors

C.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	984	984	0	1362	1362	0	1810	1810	0	3248	3248	0
Vasna	1268	283	0	1813	451	0	2666	857	0	5348	2100	0
Anjali	1510	255	12	2151	358	20	3109	480	37	6083	868	132
Paldi	1988	517	40	2924	830	57	4298	1268	80	8532	2597	148
Madalpur	2720	797	64	3940	1106	90	5678	1520	140	11161	2985	355
Nava Gandhigram	3206	512	26	4653	751	37	6702	1085	60	13194	2197	164
Ashram Road	4665	2286	828	6791	3278	1140	9722	4621	1601	19367	9544	3372
Usmanpura	4646	325	344	6764	455	482	9642	587	667	19124	1144	1387
Vadaj	5944	2624	1326	9002	4142	1904	13304	6355	2694	26484	12926	5567
Ranip	5562	113	494	8520	183	666	12743	316	877	25506	721	1698
Sabarmati Rail Stn	5389	4	177	8274	6	251	12348	13	408	24618	54	942
AEC	5312	14	91	8163	22	133	12146	44	246	24143	92	567
Sabarmati	5149	18	181	7946	29	246	11838	54	362	23505	112	750
Motera Stadium	0	0	5149	0	0	7946	0	0	11838	0	0	23505
Line 1R: Motera Stadium to APMC												
Motera Stadium	5328	5328	0	8121	8121	0	12100	12100	0	24261	24261	0
Sabarmati	5287	55	95	8052	79	149	11996	132	236	24135	286	412
AEC	5336	58	9	8124	86	14	12136	171	31	24470	404	68

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Sabarmati Rail Stn	5421	113	28	8246	168	45	12356	301	80	25004	704	171
Ranip	4946	288	763	7398	377	1225	10853	469	1972	21375	956	4585
Vadaj	5266	1784	1464	7656	2604	2346	10959	3752	3645	21959	7873	7290
Usmanpura	4918	0	348	7155	0	501	10300	0	659	20692	0	1267
Ashram Road	2878	0	2040	4199	0	2956	6131	0	4169	12441	0	8251
Nava Gandhigram	2436	0	442	3542	0	656	5170	0	962	10557	0	1884
Madalpur	1909	14	541	2784	20	778	4093	30	1108	8471	80	2166
Paldi	1559	8	359	2260	13	537	3287	21	826	6833	45	1683
Anjali	1222	41	378	1706	61	614	2408	102	982	4926	273	2180
Vasna	918	0	304	1248	0	458	1612	0	796	3012	0	1915
APMC	0	0	918	0	0	1248	0	0	1612	0	0	3012

C.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	765	765	0	1325	1325	0	2446	2446	0	5104	5104	0
Thaltej	1521	760	4	2390	1074	9	3917	1496	25	7846	2864	122
Drive-in Cinema	1935	415	1	2957	569	2	4687	778	8	9155	1365	56
Gurukul Road	2534	618	20	3784	858	30	5802	1168	54	11079	2119	195
Helmet Cross Road	3089	629	73	4504	845	126	6598	1072	275	12352	1945	672
Commerce Six Road	3290	221	21	4777	310	36	6986	463	75	13054	958	256
Stadium	3355	112	47	4863	160	73	7083	242	146	13070	483	467
Ashram Road	6222	3192	325	8757	4415	521	11896	5800	988	21890	11108	2287
Shahpur	6204	327	345	8712	456	500	11755	630	771	21371	1236	1756
Relief Road	5984	502	722	8353	693	1052	11191	922	1486	20294	1764	2842
Kalupur Rly. Stn.	3678	994	3300	5289	1374	4439	7818	2089	5462	15457	5464	10300
Kankaria East	3168	15	525	4575	24	738	6894	51	974	13922	171	1707
New Cotton Mills	2468	72	772	3624	110	1060	5719	202	1378	12135	583	2370
Amraiwadi	2008	95	556	3040	162	746	5086	328	962	11264	974	1845
Rabari Colony	1651	50	407	2551	73	562	4438	154	802	10132	526	1659
Vastral	688	1	963	1216	1	1336	2485	6	1958	5907	37	4262
Nirant Cross Rd.	301	8	395	644	16	587	1408	40	1117	3388	131	2650
Vastral Gam	0	0	301	0	0	644	0	0	1408	0	0	3388

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	166	166	0	373	373	0	852	852	0	1940	1940	0
Nirant Cross Rd.	580	421	6	973	613	13	1960	1136	28	4595	2725	70
Vastral	1526	946	1	2281	1310	1	3886	1931	6	8798	4237	34
Rabari Colony	1964	506	68	2867	685	99	4619	932	199	10165	2021	654
Amraiwadi	2402	510	72	3467	712	112	5394	989	214	11426	1854	592
New Cotton Mills	3091	778	89	4399	1065	132	6528	1370	236	13252	2482	657
Kankaria East	3420	342	13	4864	484	20	7133	650	44	14322	1221	150
Kalupur Rly. Stn.	7038	4426	808	9510	5751	1104	12101	6671	1703	22944	13375	4754
Relief Road	6699	578	917	9158	838	1189	11828	1144	1417	22183	2152	2912
Shahpur	6552	288	436	8976	409	591	11667	604	765	22011	1336	1509
Ashram Road	4472	151	2231	6188	248	3036	8323	502	3845	15609	1212	7614
Stadium	4045	55	482	5636	83	636	7694	150	779	14596	443	1456
Commerce Six Road	3800	19	264	5312	32	356	7268	63	488	13804	196	987
Helmet Cross Road	2728	90	1161	3964	145	1493	5810	292	1751	11002	658	3460
Gurukul Road	2108	14	634	3109	21	876	4658	34	1185	8930	98	2171
Drive-in Cinema	1543	1	565	2344	2	767	3636	8	1030	7112	56	1872
Thaltej	544	0	1000	948	0	1395	1774	0	1862	3557	0	3556
Thaltej Gam	0	0	544	0	0	948	0	0	1774	0	0	3557

C. Full Day Ridership on Metro - Ph I corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

D.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	8364	8364	0	11577	11577	0	15382	15382	0	27608	27608	0
Vasna	10775	2407	0	15412	3835	0	22664	7283	0	45461	17850	0
Anjali	12838	2169	105	18282	3040	170	26428	4077	313	51707	7375	1125
Paldi	16895	4396	340	24851	7052	483	36533	10781	680	72519	22073	1261
Madalpur	23120	6776	547	33487	9404	768	48263	12920	1193	94867	25371	3019
Nava Gandhigram	27254	4355	224	39552	6382	316	56970	9221	513	112149	18676	1397
Ashram Road	39651	19431	7035	57725	27866	9693	82637	39277	13607	164618	81127	28659
Usmanpura	39494	2764	2921	57494	3869	4100	81960	4988	5668	162557	9727	11788
Vadaj	50524	22307	11274	76517	35207	16181	113081	54016	22896	225111	109871	47318
Ranip	47280	959	4202	72417	1554	5658	108314	2686	7453	216798	6127	14436
Sabarmati Rail Stn	45808	31	1506	70326	48	2135	104958	112	3468	209253	459	8007
AEC	45152	116	772	69384	187	1129	103241	374	2094	205214	782	4818
Sabarmati	43768	153	1537	67544	248	2091	100626	459	3074	199791	949	6372
Motera Stadium	0	0	43768	0	0	67544	0	0	100626	0	0	199791
Line 1R: Motera Stadium to APMC												
Motera Stadium	45285	45285	0	69030	69030	0	102850	102850	0	206217	206217	0
Sabarmati	44941	466	809	68439	673	1265	101963	1122	2009	205146	2428	3499

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
AEC	45356	490	75	69051	734	122	103153	1452	262	207995	3431	578
Sabarmati Rail Stn	46080	962	241	70094	1428	384	105026	2557	683	212531	5987	1452
Ranip	42038	2445	6484	62886	3206	10414	92249	3985	16762	181686	8126	38971
Vadaj	44761	15164	12444	65079	22134	19941	93153	31889	30981	186650	66922	61962
Usmanpura	41800	0	2958	60819	0	4260	87550	0	5603	175882	0	10768
Ashram Road	24460	0	17343	35690	0	25129	52115	0	35435	105750	0	70132
Nava Gandhigram	20706	0	3754	30107	0	5579	43942	0	8174	89733	0	16014
Madalpur	16228	122	4600	23664	170	6616	34789	258	9415	72002	680	18411
Paldi	13250	71	3050	19207	109	4563	27941	177	7021	58082	384	14307
Anjali	10384	347	3213	14504	517	5219	20465	870	8347	41874	2322	18530
Vasna	7800	0	2584	10608	0	3896	13699	0	6766	25599	0	16276
APMC	0	0	7800	0	0	10608	0	0	13699	0	0	25599

D.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	6504	6504	0	11261	11261	0	20788	20788	0	43381	43381	0
Thaltej	12927	6463	37	20312	9126	75	33296	12719	211	66688	24344	1037
Drive-in Cinema	16449	3529	7	25133	4838	17	39838	6610	68	77819	11601	473
Gurukul Road	21539	5256	167	32167	7290	255	49314	9931	456	94170	18010	1659
Helmet Cross Road	26258	5345	622	38281	7184	1071	56086	9112	2339	104989	16531	5712
Commerce Six Road	27962	1877	177	40606	2632	306	59384	3937	636	110956	8146	2179
Stadium	28519	955	398	41337	1357	622	60207	2060	1238	111092	4107	3971
Ashram Road	52887	27132	2764	74433	37526	4430	101113	49300	8398	186068	94418	19441
Shahpur	52734	2778	2931	74055	3876	4253	99916	5358	6555	181655	10509	14926
Relief Road	50861	4270	6140	71002	5892	8945	95122	7840	12634	172496	14994	24154
Kalupur Rly. Stn.	31260	8449	28050	44958	11682	37730	66453	17755	46424	131386	46444	87550
Kankaria East	26925	129	4464	38889	204	6270	58602	435	8282	118334	1452	14508
New Cotton Mills	20981	612	6559	30807	932	9013	48613	1720	11710	103149	4957	20142
Amraiwadi	17068	809	4723	25840	1374	6341	43231	2791	8177	95741	8276	15684
Rabari Colony	14032	425	3461	21685	622	4777	37723	1309	6817	86119	4474	14100
Vastral	5851	7	8184	10336	10	11359	21124	48	16643	50208	313	36224
Nirant Cross Rd.	2560	65	3356	5477	133	4991	11971	340	9493	28801	1115	22522
Vastral Gam	0	0	2560	0	0	5477	0	0	11971	0	0	28801

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	1408	1408	0	3169	3169	0	7245	7245	0	16487	16487	0
Nirant Cross Rd.	4930	3577	54	8269	5212	112	16660	9659	241	39056	23164	592
Vastral	12971	8044	7	19387	11132	10	33028	16412	48	74783	36013	286
Rabari Colony	16694	4298	575	24368	5821	840	39260	7922	1690	86404	17177	5556
Amraiwadi	20414	4338	615	29468	6049	952	45846	8405	1816	97124	15759	5035
New Cotton Mills	26272	6616	758	37390	9051	1125	55485	11645	2009	112642	21097	5583
Kankaria East	29073	2910	109	41341	4117	170	60632	5522	371	121740	10377	1278
Kalupur Rly. Stn.	59826	37621	6868	80838	48885	9387	102857	56702	14477	195021	113689	40406
Relief Road	56943	4913	7796	77846	7120	10108	100535	9721	12043	188557	18289	24752
Shahpur	55695	2451	3703	76299	3478	5025	99168	5134	6504	187092	11359	12825
Ashram Road	38012	1282	18965	52601	2105	25806	70744	4264	32684	132675	10299	64716
Stadium	34384	466	4094	47903	707	5406	65396	1275	6623	124066	3767	12379
Commerce Six Road	32297	163	2247	45149	275	3026	61781	534	4148	117337	1663	8391
Helmet Cross Road	23188	762	9870	33691	1231	12689	49385	2485	14882	93517	5590	29410
Gurukul Road	17915	122	5392	26425	180	7443	39596	289	10074	75902	833	18452
Drive-in Cinema	13117	7	4804	19921	17	6521	30909	68	8755	60455	473	15915
Thaltej	4621	0	8500	8061	0	11859	15082	0	15827	30236	0	30223
Thaltej Gam	0	0	4621	0	0	8061	0	0	15082	0	0	30236

D. Peak hour Ridership on Metro - Ph I+II corridors

E.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	984	984	0	1362	1362	0	1770	1770	0	3194	3194	0
Vasna	1268	283	0	1813	451	0	2626	856	0	5312	2118	0
Anjali	1510	255	12	2151	358	20	3916	1327	37	6058	879	132
Paldi	1988	517	40	2924	830	57	5129	1292	80	8517	2606	148
Madalpur	2720	797	64	3940	1106	90	6783	1794	140	11538	3374	353
Nava Gandhigram	3206	512	26	4653	751	37	7822	1098	60	13592	2217	164
Ashram Road	4665	2286	828	6791	3278	1140	10942	4521	1401	19452	8774	2913
Usmanpura	4646	325	344	6764	455	482	10882	606	667	19276	1143	1319
Vadaj	5944	2624	1326	9002	4142	1904	12433	4346	2795	24406	10383	5253
Ranip	5562	113	494	8520	183	666	12659	1029	803	25192	2264	1477
Sabarmati Rail Stn	5389	4	177	8274	6	251	12389	93	363	24529	186	849
AEC	5312	14	91	8163	22	133	12198	48	239	24075	96	551
Sabarmati	5149	18	181	7946	29	246	11966	71	303	23584	139	630
Motera Stadium	0	0	5149	0	0	7946	9490	1414	3890	19386	3840	8038
Motera Gam	-	-	-	-	-	-	8964	226	752	18278	544	1651
Tapovan Ring road	-	-	-	-	-	-	8657	138	444	17774	673	1177
Koba Circle	-	-	-	-	-	-	8290	102	469	16966	449	1257
Koba Village	-	-	-	-	-	-	8025	39	304	16425	188	728
PDPU Approch	-	-	-	-	-	-	6182	498	2342	13036	2098	5487

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Randesan	-	-	-	-	-	-	5993	63	252	12700	296	632
CH-0	-	-	-	-	-	-	4047	0	1946	8374	0	4326
CH-3	-	-	-	-	-	-	1931	0	2116	3892	0	4482
Sachivalay	-	-	-	-	-	-	1412	6	524	3066	20	846
Sector-21	-	-	-	-	-	-	578	0	835	1392	0	1674
Akshardham	-	-	-	-	-	-	0	0	578	0	0	1392
Line 1R: Akshardham to APMC												
Akshardham	-	-	-	-	-	-	742	742	0	1616	1616	0
Sector-21	-	-	-	-	-	-	1222	481	1	2559	949	6
Sachivalay	-	-	-	-	-	-	1733	518	6	3352	816	23
CH-3	-	-	-	-	-	-	4358	2675	50	9000	5804	156
CH-0	-	-	-	-	-	-	5466	1603	496	11150	3832	1682
Randesan	-	-	-	-	-	-	5645	238	58	11463	607	294
PDPU Approch	-	-	-	-	-	-	7525	2308	428	14962	5385	1886
Koba Village	-	-	-	-	-	-	7780	292	37	15481	701	181
Koba Circle	-	-	-	-	-	-	8077	376	79	16077	994	398
Tapovan Ring road	-	-	-	-	-	-	8302	350	125	16377	877	576
Motera Gam	-	-	-	-	-	-	8845	723	180	17570	1571	379
Motera Stadium	5328	5328	0	8121	8121	0	11698	3986	1134	4679	1594	453
Sabarmati	5287	55	95	8052	79	149	11442	122	377	4577	49	151
AEC	5336	58	9	8124	86	14	11573	165	34	4629	66	14
Sabarmati Rail Stn	5421	113	28	8246	168	45	11787	299	85	4715	120	34
Ranip	4946	288	763	7398	377	1225	10601	484	1670	4240	194	668

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Vadaj	5266	1784	1464	7656	2604	2346	10506	3761	3856	4203	1504	1542
Usmanpura	4918	0	348	7155	0	501	9874	0	633	3949	0	253
Ashram Road	2878	0	2040	4199	0	2956	6092	0	3782	2437	0	1513
Nava Gandhigram	2436	0	442	3542	0	656	5231	0	860	2092	0	344
Madalpur	1909	14	541	2784	20	778	4161	0	1070	1664	0	428
Paldi	1559	8	359	2260	13	537	3362	21	820	1345	8	328
Anjali	1222	41	378	1706	61	614	2475	102	988	990	41	395
Vasna	918	0	304	1248	0	458	1672	0	804	669	0	322
APMC	0	0	918	0	0	1248	0	0	1672	0	0	669

E.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	765	765	0	1325	1325	0	2378	2378	0	5042	5042	0
Thaltej	1521	760	4	2390	1074	9	3647	1296	26	7395	2478	125
Drive-in Cinema	1935	415	1	2957	569	2	4362	722	8	8598	1258	56
Gurukul Road	2534	618	20	3784	858	30	5400	1092	54	10399	1996	195
Helmet Cross Road	3089	629	73	4504	845	126	6103	978	276	11520	1749	628
Commerce Six Road	3290	221	21	4777	310	36	6436	407	75	12202	938	256
Stadium	3355	112	47	4863	160	73	6520	230	146	12236	501	467
Ashram Road	6222	3192	325	8757	4415	521	10609	5022	933	19397	9384	2224
Shahpur	6204	327	345	8712	456	500	10443	608	773	18753	1065	1708
Relief Road	5984	502	722	8353	693	1052	9844	874	1474	18785	2840	2808
Kalupur Rly. Stn.	3678	994	3300	5289	1374	4439	7870	2084	4058	15538	4981	8227
Kankaria East	3168	15	525	4575	24	738	6948	51	973	14195	164	1508
New Cotton Mills	2468	72	772	3624	110	1060	5770	202	1381	12444	583	2334
Amraiwadi	2008	95	556	3040	162	746	5128	328	970	11573	974	1844
Rabari Colony	1651	50	407	2551	73	562	4474	154	808	10282	526	1818
Vastral	688	1	963	1216	1	1336	2508	6	1972	6022	37	4296
Nirant Cross Rd.	301	8	395	644	16	587	1420	40	1128	3438	131	2715
Vastral Gam	0	0	301	0	0	644	0	0	1420	0	0	3438

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	166	166	0	373	373	0	869	869	0	1862	1862	0
Nirant Cross Rd.	580	421	6	973	613	13	1988	1148	28	4582	2760	39
Vastral	1526	946	1	2281	1310	1	3918	1936	6	8804	4254	34
Rabari Colony	1964	506	68	2867	685	99	4602	883	199	10220	2017	601
Amraiwadi	2402	510	72	3467	712	112	5337	948	214	11595	1808	432
New Cotton Mills	3091	778	89	4399	1065	132	6416	1315	236	13427	2420	588
Kankaria East	3420	342	13	4864	484	20	7067	695	44	14536	1256	148
Kalupur Rly. Stn.	7038	4426	808	9510	5751	1104	12279	6706	1494	21956	12548	5127
Relief Road	6699	578	917	9158	838	1189	11960	1096	1415	20932	1812	2837
Shahpur	6552	288	436	8976	409	591	11802	605	763	20942	1331	1320
Ashram Road	4472	151	2231	6188	248	3036	8380	504	3926	15083	1220	7079
Stadium	4045	55	482	5636	83	636	7742	143	781	14062	429	1449
Commerce Six Road	3800	19	264	5312	32	356	7318	64	488	13278	198	983
Helmet Cross Road	2728	90	1161	3964	145	1493	5858	293	1752	10808	658	3127
Gurukul Road	2108	14	634	3109	21	876	4721	35	1173	8756	100	2151
Drive-in Cinema	1543	1	565	2344	2	767	3708	8	1020	6992	56	1820
Thaltej	544	0	1000	948	0	1395	1791	0	1917	3583	0	3408
Thaltej Gam	0	0	544	0	0	948	0	0	1791	0	0	3583

E. Full Day Ridership on Metro - Ph I+II Corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

F.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	8364	8364	0	11577	11577	0	15048	15048	0	27149	27149	0
Vasna	10775	2407	0	15412	3835	0	22321	7273	0	45152	18003	0
Anjali	12838	2169	105	18282	3040	170	33289	11281	313	51496	7470	1125
Paldi	16895	4396	340	24851	7052	483	43598	10985	677	72396	22154	1258
Madalpur	23120	6776	547	33487	9404	768	57657	15246	1187	98070	28679	3002
Nava Gandhigram	27254	4355	224	39552	6382	316	66484	9336	510	115529	18846	1391
Ashram Road	39651	19431	7035	57725	27866	9693	93007	38430	11907	165345	74579	24762
Usmanpura	39494	2764	2921	57494	3869	4100	92494	5154	5668	163846	9714	11213
Vadaj	50524	22307	11274	76517	35207	16181	105679	36944	23756	207448	88254	44652
Ranip	47280	959	4202	72417	1554	5658	107600	8745	6824	214135	19244	12556
Sabarmati Rail Stn	45808	31	1506	70326	48	2135	105308	792	3087	208498	1584	7218
AEC	45152	116	772	69384	187	1129	103683	405	2030	204636	816	4682
Sabarmati	43768	153	1537	67544	248	2091	101708	602	2574	200461	1180	5355
Motera Stadium	0	0	43768	0	0	67544	80662	12019	33065	164778	32637	68320
Motera Gam	-	-	-	-	-	-	76194	1921	6389	155366	4624	14035
Tapovan Ring road	-	-	-	-	-	-	73586	1170	3777	151082	5719	10003
Koba Circle	-	-	-	-	-	-	70468	867	3985	144211	3818	10686

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Koba Village	-	-	-	-	-	-	68214	330	2584	139614	1598	6191
PDPU Approch	-	-	-	-	-	-	52544	4233	19904	110809	17836	46641
Randesan	-	-	-	-	-	-	50939	537	2139	107950	2516	5372
CH-0	-	-	-	-	-	-	34398	0	16541	71179	0	36771
CH-3	-	-	-	-	-	-	16412	0	17983	33079	0	38100
Sachivalay	-	-	-	-	-	-	12005	48	4454	26061	173	7194
Sector-21	-	-	-	-	-	-	4910	0	7096	11829	0	14232
Akhardham	-	-	-	-	-	-	0	0	4910	0	0	11829
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	6304	6304	0	13739	13739	0
Sector-21	-	-	-	-	-	-	10387	4087	7	21753	8065	51
Sachivalay	-	-	-	-	-	-	14732	4400	54	28495	6933	194
CH-3	-	-	-	-	-	-	37043	22736	425	76503	49334	1326
CH-0	-	-	-	-	-	-	46458	13627	4216	94775	32572	14300
Randesan	-	-	-	-	-	-	47981	2020	496	97434	5161	2502
PDPU Approch	-	-	-	-	-	-	63961	19615	3635	127174	45771	16034
Koba Village	-	-	-	-	-	-	66130	2482	313	131590	5957	1540
Koba Circle	-	-	-	-	-	-	68656	3199	673	136653	8446	3386
Tapovan Ring road	-	-	-	-	-	-	70570	2978	1064	139206	7456	4899
Motera Gam	-	-	-	-	-	-	75184	6147	1530	149345	13355	3220
Motera Stadium	45285	45285	0	69030	69030	0	99430	33881	9636	193140	69697	25901
Sabarmati	44941	466	809	68439	673	1265	97260	1034	3203	189972	2258	5430

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
AEC	45356	490	75	69051	734	122	98372	1401	289	192630	3288	629
Sabarmati Rail Stn	46080	962	241	70094	1428	384	100188	2543	724	197186	6001	1445
Ranip	42038	2445	6484	62886	3206	10414	90107	4114	14198	180275	8415	25330
Vadaj	44761	15164	12444	65079	22134	19941	89304	31970	32773	177545	67334	70064
Usmanpura	41800	0	2958	60819	0	4260	83926	0	5379	166916	0	10628
Ashram Road	24460	0	17343	35690	0	25129	51779	0	32147	103714	0	63203
Nava Gandhigram	20706	0	3754	30107	0	5579	44465	0	7313	89111	0	14603
Madalpur	16228	122	4600	23664	170	6616	35367	0	9098	71257	0	17853
Paldi	13250	71	3050	19207	109	4563	28574	177	6967	59531	384	12107
Anjali	10384	347	3213	14504	517	5219	21039	870	8401	43095	2322	18761
Vasna	7800	0	2584	10608	0	3896	14209	0	6834	26554	0	16541
APMC	0	0	7800	0	0	10608	0	0	14209	0	0	26554

F.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	6504	6504	0	11261	11261	0	20213	20213	0	42854	42854	0
Thaltej	12927	6463	37	20312	9126	75	31001	11013	224	62859	21066	1061
Drive-in Cinema	16449	3529	7	25133	4838	17	37077	6140	68	73083	10693	473
Gurukul Road	21539	5256	167	32167	7290	255	45903	9282	456	88390	16966	1656
Helmet Cross Road	26258	5345	622	38281	7184	1071	51877	8313	2343	97920	14865	5335
Commerce Six Road	27962	1877	177	40606	2632	306	54703	3458	636	103720	7976	2176
Stadium	28519	955	398	41337	1357	622	55423	1958	1238	104006	4257	3971
Ashram Road	52887	27132	2764	74433	37526	4430	90175	42687	7932	164873	79767	18901
Shahpur	52734	2778	2931	74055	3876	4253	88767	5168	6572	159402	9054	14521
Relief Road	50861	4270	6140	71002	5892	8945	83671	7432	12529	159671	24140	23871
Kalupur Rly. Stn.	31260	8449	28050	44958	11682	37730	66892	17717	34496	132076	42337	69931
Kankaria East	26925	129	4464	38889	204	6270	59061	435	8269	120659	1397	12818
New Cotton Mills	20981	612	6559	30807	932	9013	49042	1720	11740	105771	4957	19842
Amraiwadi	17068	809	4723	25840	1374	6341	43591	2791	8242	98369	8276	15677
Rabari Colony	14032	425	3461	21685	622	4777	38029	1309	6868	87394	4474	15453
Vastral	5851	7	8184	10336	10	11359	21318	48	16762	51190	313	36519
Nirant Cross Rd.	2560	65	3356	5477	133	4991	12067	340	9588	29226	1115	23079
Vastral Gam	0	0	2560	0	0	5477	0	0	12067	0	0	29226

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	1408	1408	0	3169	3169	0	7388	7388	0	15824	15824	0
Nirant Cross Rd.	4930	3577	54	8269	5212	112	16898	9755	241	38950	23463	333
Vastral	12971	8044	7	19387	11132	10	33306	16453	48	74831	36162	286
Rabari Colony	16694	4298	575	24368	5821	840	39120	7507	1690	86867	17143	5107
Amraiwadi	20414	4338	615	29468	6049	952	45366	8061	1816	98559	15368	3672
New Cotton Mills	26272	6616	758	37390	9051	1125	54533	11176	2009	114131	20567	4998
Kankaria East	29073	2910	109	41341	4117	170	60068	5909	371	123556	10679	1255
Kalupur Rly. Stn.	59826	37621	6868	80838	48885	9387	104373	56998	12696	186629	106658	43581
Relief Road	56943	4913	7796	77846	7120	10108	101660	9316	12026	177919	15399	24113
Shahpur	55695	2451	3703	76299	3478	5025	100317	5144	6487	178004	11312	11223
Ashram Road	38012	1282	18965	52601	2105	25806	71230	4281	33368	128204	10373	60173
Stadium	34384	466	4094	47903	707	5406	65807	1214	6637	119527	3645	12318
Commerce Six Road	32297	163	2247	45149	275	3026	62203	547	4151	112860	1686	8357
Helmet Cross Road	23188	762	9870	33691	1231	12689	49796	2489	14892	91868	5590	26581
Gurukul Road	17915	122	5392	26425	180	7443	40127	299	9969	74429	847	18285
Drive-in Cinema	13117	7	4804	19921	17	6521	31521	68	8673	59432	473	15470
Thaltej	4621	0	8500	8061	0	11859	15225	0	16296	30457	0	28971
Thaltej Gam	0	0	4621	0	0	8061	0	0	15225	0	0	30457

2.5.3 Gradual Scenario

A. Full Day Ridership on different PT modes (Phase I corridors)

1. Year 2018 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 22%							
PT Demand:	**1342379**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1203410	13585917	814369	52%	1174	**1.73**	11.29
BRT	785247	7089388	297332	34%	6544		9.03
Metro	339136	2319136	72798	15%	9635		6.84
Total	**2327793**	**22994441**	**1184499**				
PT Trip Length	**17.13**	**km**					

2. Year 2021 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 28%							
PT Demand:	**1759931**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1603284	17550535	1051923	52%	1564	**1.75**	10.95
BRT	1019592	9086922	381107	33%	8497		8.91
Metro	454719	3113277	97729	15%	12918		6.85
Total	**3077595**	**29750733**	**1530759**				
PT Trip Length	**16.90**	**km**					

3. Year 2031 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 37.5%							
PT Demand:	**2553130**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	2379041	25089311	1499272	53%	2321	**1.76**	10.55
BRT	1424542	12427156	521193	32%	11871		8.72
Metro	680105	4663906	146408	15%	19321		6.86
Total	**4483689**	**42180373**	**2166873**				
PT Trip Length	**16.52**	**km**					

4. Year 2043 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4724093	44797383	2675716	105%	4609	**1.72**	9.48
BRT	2600786	21122707	885873	58%	21673		8.12
Metro	1243598	8255972	259178	28%	35329		6.64
Total	**8568476**	**74176063**	**3820767**				
PT Trip Length	**14.91**	**km**					

B. Full Day Ridership on different PT modes (Phase I + II corridors)

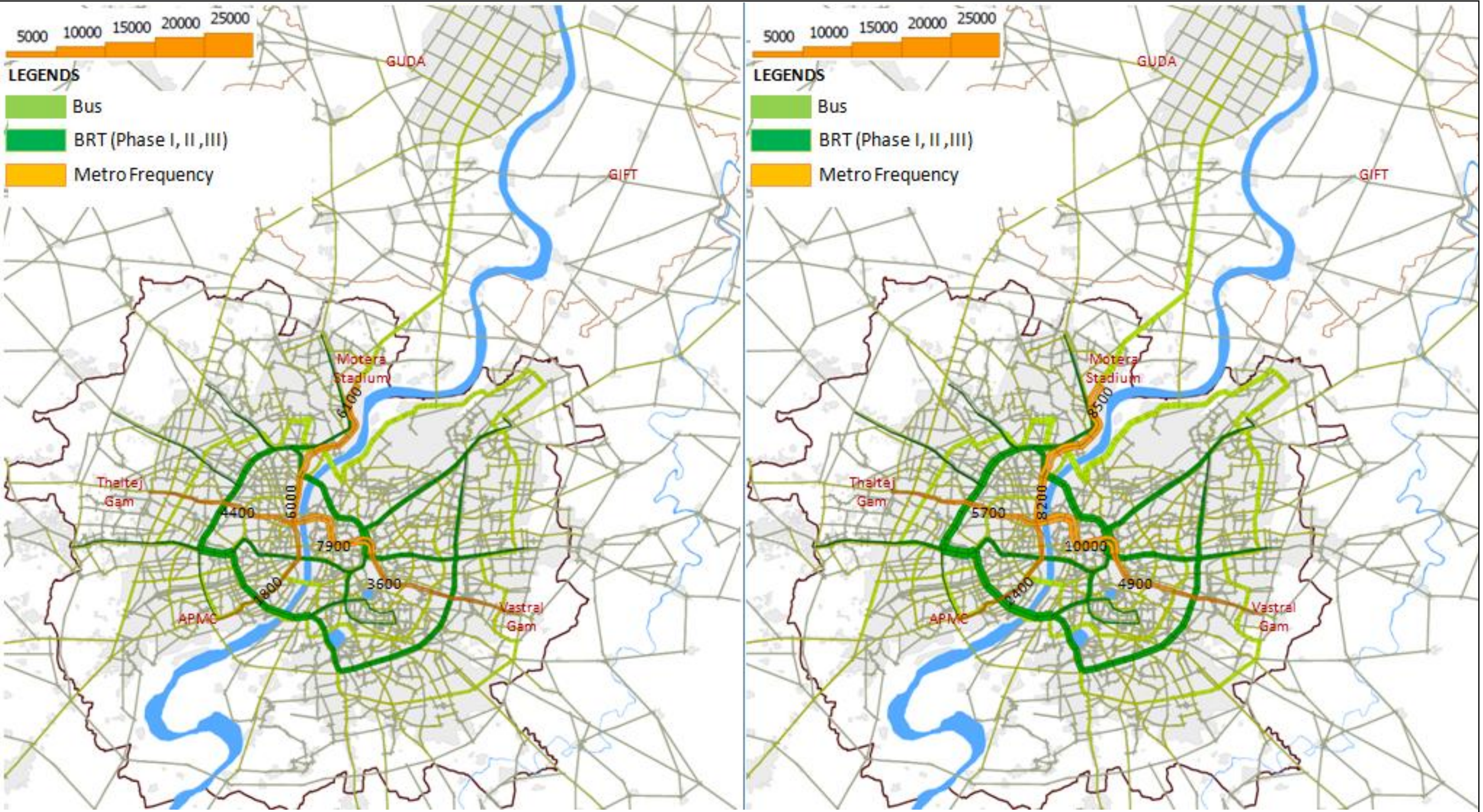
5. Year 2031 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

PT Share in Motorized trips: 37.5%							
PT Demand:	**2553130**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	2118227	22393355	1347574	47%	2067	**1.67**	10.57
BRT	1425079	12679906	531783	32%	11876		8.90
Metro	731214	6572554	206225	16%	12187		8.99
Total	**4274521**	**41645815**	**2085582**				
PT Trip Length	**16.31**	**km**					

6. Year 2043 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

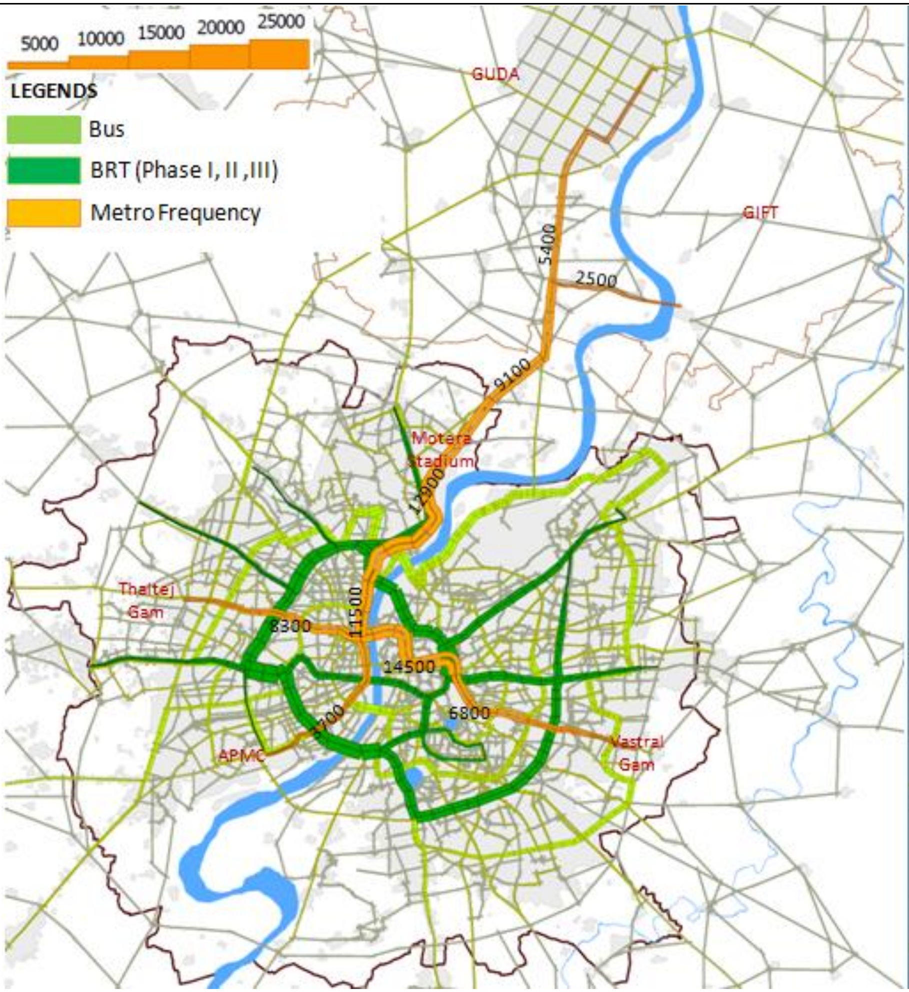
PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4176601	39608708	2381618	93%	4075	**1.67**	9.48
BRT	2671336	21867443	917112	60%	22261		8.19
Metro	1442392	12176899	382053	32%	24040		8.44
Total	**8290329**	**73653051**	**3680784**				
PT Trip Length	**14.81**	**km**					

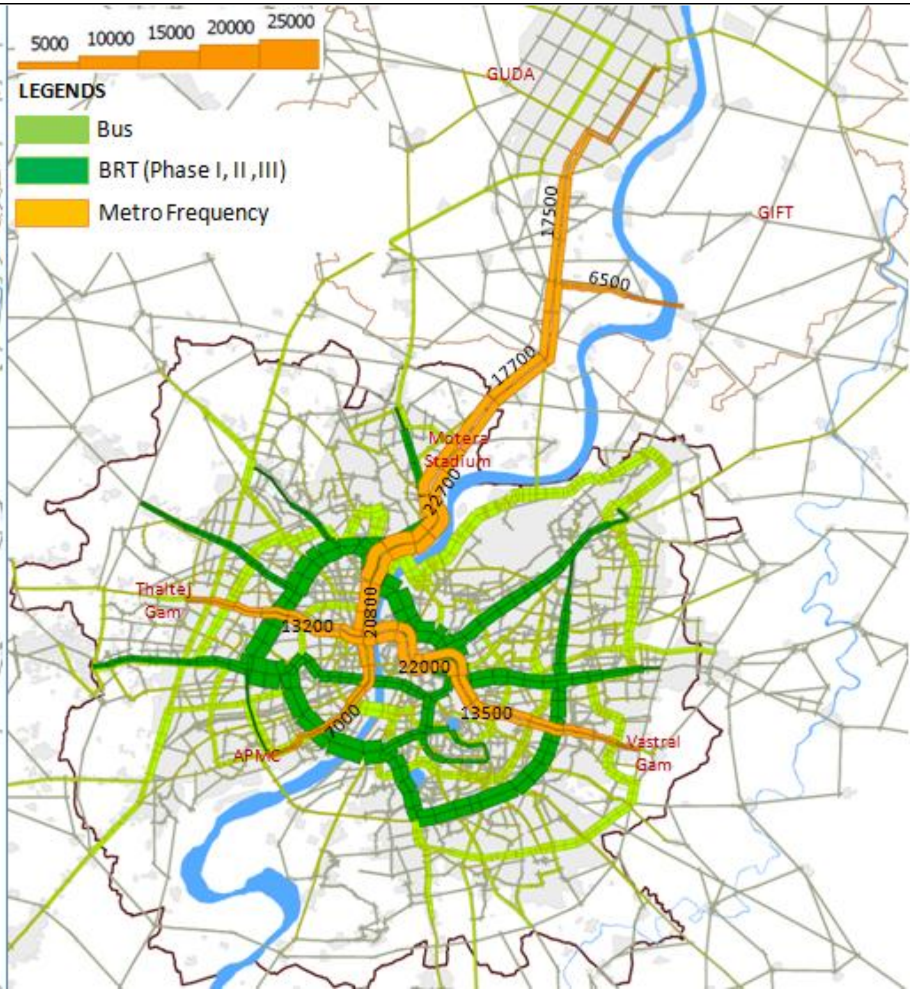
Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures.



Year 2018 (Phase I Metro)	Year 2021 (Phase I Metro)

Fig. 2.22 Gradual - Passenger Flows 2018 & 2021 (Phase I)





Year 2021 (Phase I+II Metro)	Year 2043 (Phase I+II Metro)

Fig. 2.23 Gradual - Passenger Flows 2031 & 2043 (Phase I+II)

C. Peak hour Ridership on Metro - Ph I corridors

C.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	1127	1127	0	1452	1452	0	1938	1938	0	3248	3248	0
Vasna	1479	352	0	1991	539	0	2896	958	0	5348	2100	0
Anjali	1771	308	16	2347	379	22	3368	518	45	6083	868	132
Paldi	2328	606	49	3141	858	64	4667	1383	84	8532	2597	148
Madalpur	3173	921	77	4251	1212	103	6216	1704	154	11161	2985	355
Nava Gandhigram	3749	608	32	5027	816	40	7342	1189	64	13194	2197	164
Ashram Road	5424	2629	954	7305	3540	1262	10883	5378	1837	19367	9544	3372
Usmanpura	5400	378	402	7269	494	530	10811	649	721	19124	1144	1387
Vadaj	6921	3059	1538	9519	4319	2069	14634	6814	2990	26484	12926	5567
Ranip	6472	130	579	8990	195	724	14029	331	936	25506	721	1698
Sabarmati Rail Stn	6268	5	209	8704	6	292	13588	14	455	24618	54	942
AEC	6173	18	113	8568	26	162	13364	44	268	24143	92	567
Sabarmati	5981	22	214	8314	31	285	13016	52	400	23505	112	750
Motera Stadium	0	0	5981	0	0	8314	0	0	13016	0	0	23505
Line 1R: Motera Stadium to APMC												
Motera Stadium	6193	6193	0	8529	8529	0	13333	13333	0	24261	24261	0
Sabarmati	6146	69	116	8463	92	158	13232	142	243	24135	286	412
AEC	6207	73	12	8554	108	17	13383	182	30	24470	404	68

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Sabarmati Rail Stn	6309	138	35	8706	201	48	13626	323	80	25004	704	171
Ranip	5744	325	890	7803	396	1300	12050	540	2117	21375	956	4585
Vadaj	6128	2092	1708	8213	2824	2414	12292	4096	3853	21959	7873	7290
Usmanpura	5713	0	416	7683	0	530	11578	0	715	20692	0	1267
Ashram Road	3352	0	2361	4526	0	3157	6804	0	4774	12441	0	8251
Nava Gandhigram	2823	0	529	3812	0	714	5763	0	1040	10557	0	1884
Madalpur	2202	17	638	2984	23	850	4565	33	1231	8471	80	2166
Paldi	1788	11	426	2421	15	578	3693	22	894	6833	45	1683
Anjali	1390	48	446	1860	71	632	2763	122	1052	4926	273	2180
Vasna	1027	0	362	1324	0	536	1836	0	927	3012	0	1915
APMC	0	0	1027	0	0	1324	0	0	1836	0	0	3012

C.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	914	914	0	1436	1436	0	2576	2576	0	5104	5104	0
Thaltej	1786	877	5	2586	1160	9	4264	1714	27	7846	2864	122
Drive-in Cinema	2282	498	1	3210	626	2	5093	838	9	9155	1365	56
Gurukul Road	3003	743	22	4106	930	34	6283	1252	62	11079	2119	195
Helmet Cross Road	3646	739	97	4860	908	154	7161	1171	293	12352	1945	672
Commerce Six Road	3882	262	26	5165	346	40	7597	521	85	13054	958	256
Stadium	3960	138	59	5261	180	84	7701	265	161	13070	483	467
Ashram Road	7205	3650	405	9376	4727	612	13340	6718	1080	21890	11108	2287
Shahpur	7182	376	400	9319	511	568	13185	694	849	21371	1236	1756
Relief Road	6918	580	843	8900	753	1172	12570	1006	1620	20294	1764	2842
Kalupur Rly. Stn.	4341	1126	3704	5797	1545	4648	8394	2458	6634	15457	5464	10300
Kankaria East	3738	19	623	5037	28	788	7420	55	1028	13922	171	1707
New Cotton Mills	2912	86	911	4026	126	1138	6199	216	1437	12135	583	2370
Amraiwadi	2396	115	631	3410	188	804	5462	352	1089	11264	974	1845
Rabari Colony	1977	59	478	2872	92	630	4766	175	871	10132	526	1659
Vastral	848	1	1130	1406	1	1468	2614	5	2158	5907	37	4262
Nirant Cross Rd.	366	10	492	732	22	694	1487	45	1171	3388	131	2650
Vastral Gam	0	0	366	0	0	732	0	0	1487	0	0	3388

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	208	208	0	430	430	0	888	888	0	1940	1940	0
Nirant Cross Rd.	713	512	8	1137	725	18	2076	1221	33	4595	2725	70
Vastral	1820	1108	1	2589	1453	1	4203	2132	5	8798	4237	34
Rabari Colony	2322	580	78	3215	754	128	5031	1064	236	10165	2021	654
Amraiwadi	2832	602	91	3859	775	131	5863	1060	227	11426	1854	592
New Cotton Mills	3630	904	106	4844	1137	152	7082	1469	251	13252	2482	657
Kankaria East	4017	402	16	5338	517	23	7733	697	46	14322	1221	150
Kalupur Rly. Stn.	7942	4841	916	10082	5998	1253	14319	8596	2010	22944	13375	4754
Relief Road	7608	676	1010	9738	919	1263	13822	1250	1747	22183	2152	2912
Shahpur	7440	330	499	9555	463	646	13614	666	874	22011	1336	1509
Ashram Road	5142	189	2487	6646	296	3205	9522	555	4647	15609	1212	7614
Stadium	4658	68	552	6061	93	678	8775	165	912	14596	443	1456
Commerce Six Road	4375	24	307	5706	36	392	8284	71	563	13804	196	987
Helmet Cross Road	3192	116	1299	4288	173	1590	6441	307	2150	11002	658	3460
Gurukul Road	2453	16	756	3359	23	952	5200	38	1278	8930	98	2171
Drive-in Cinema	1790	1	664	2516	2	845	4062	9	1147	7112	56	1872
Thaltej	654	0	1136	1034	0	1483	1876	0	2186	3557	0	3556
Thaltej Gam	0	0	654	0	0	1034	0	0	1876	0	0	3557

D. Full Day Ridership on Metro – Ph I Corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

D.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	9578	9578	0	12339	12339	0	16470	16470	0	27608	27608	0
Vasna	12570	2992	0	16922	4583	0	24613	8143	0	45461	17850	0
Anjali	15055	2615	133	19948	3220	190	28631	4400	381	51707	7375	1125
Paldi	19791	5154	418	26700	7293	541	39668	11754	717	72519	22073	1261
Madalpur	26969	7830	653	36132	10305	874	52839	14481	1306	94867	25371	3019
Nava Gandhigram	31865	5165	269	42728	6939	343	62404	10105	541	112149	18676	1397
Ashram Road	46104	22345	8109	62091	30087	10724	92507	45716	15616	164618	81127	28659
Usmanpura	45903	3216	3414	61785	4199	4502	91892	5515	6127	162557	9727	11788
Vadaj	58830	26003	13076	80913	36713	17585	124392	57919	25418	225111	109871	47318
Ranip	55009	1102	4923	76415	1656	6151	119248	2815	7959	216798	6127	14436
Sabarmati Rail Stn	53275	41	1775	73987	54	2482	115498	119	3869	209253	459	8007
AEC	52472	153	959	72831	218	1377	113597	374	2275	205214	782	4818
Sabarmati	50837	184	1816	70669	262	2424	110636	439	3400	199791	949	6372
Motera Stadium	0	0	50837	0	0	70669	0	0	110636	0	0	199791
Line 1R: Motera Stadium to APMC												
Motera Stadium	52642	52642	0	72495	72495	0	113332	113332	0	206217	206217	0
Sabarmati	52238	585	989	71937	785	1343	112469	1204	2067	205146	2428	3499

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
AEC	52758	619	99	72709	915	143	113754	1544	258	207995	3431	578
Sabarmati Rail Stn	53628	1170	299	74001	1707	411	115824	2744	677	212531	5987	1452
Ranip	48824	2764	7568	66324	3369	11047	102422	4593	17996	181686	8126	38971
Vadaj	52088	17785	14521	69809	24007	20522	104482	34813	32749	186650	66922	61962
Usmanpura	48559	0	3533	65307	0	4502	98410	0	6076	175882	0	10768
Ashram Road	28492	0	20067	38474	0	26833	57831	0	40579	105750	0	70132
Nava Gandhigram	23994	0	4498	32405	0	6069	48987	0	8843	89733	0	16014
Madalpur	18717	143	5420	25367	194	7228	38804	282	10465	72002	680	18411
Paldi	15195	92	3618	20577	126	4916	31392	187	7596	58082	384	14307
Anjali	11812	408	3788	15810	602	5369	23487	1037	8945	41874	2322	18530
Vasna	8731	0	3080	11257	0	4553	15609	0	7878	25599	0	16276
APMC	0	0	8731	0	0	11257	0	0	15609	0	0	25599

D.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	7766	7766	0	12203	12203	0	21896	21896	0	43381	43381	0
Thaltej	15181	7456	41	21981	9857	75	36244	14572	228	66688	24344	1037
Drive-in Cinema	19400	4230	10	27282	5318	17	43292	7126	75	77819	11601	473
Gurukul Road	25527	6314	187	34898	7902	286	53407	10645	530	94170	18010	1659
Helmet Cross Road	30988	6283	826	41307	7721	1309	60870	9952	2489	104989	16531	5712
Commerce Six Road	32994	2230	224	43904	2938	343	64576	4430	721	110956	8146	2179
Stadium	33660	1173	503	44720	1530	714	65460	2251	1370	111092	4107	3971
Ashram Road	61244	31025	3441	79699	40178	5199	113390	57106	9177	186068	94418	19441
Shahpur	61044	3199	3400	79213	4345	4831	112074	5899	7215	181655	10509	14926
Relief Road	58806	4927	7164	75653	6402	9962	106848	8551	13773	172496	14994	24154
Kalupur Rly. Stn.	36897	9571	31481	49276	13131	39508	71349	20890	56389	131386	46444	87550
Kankaria East	31770	163	5294	42816	238	6695	63073	466	8741	118334	1452	14508
New Cotton Mills	24752	728	7742	34221	1071	9670	52690	1833	12216	103149	4957	20142
Amraiwadi	20366	979	5365	28988	1598	6831	46430	2995	9255	95741	8276	15684
Rabari Colony	16806	503	4063	24412	782	5355	40514	1486	7402	86119	4474	14100
Vastral	7211	7	9602	11948	10	12478	22219	44	18340	50208	313	36224
Nirant Cross Rd.	3108	82	4182	6225	184	5902	12641	381	9955	28801	1115	22522
Vastral Gam	0	0	3108	0	0	6225	0	0	12641	0	0	28801

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	1771	1771	0	3658	3658	0	7551	7551	0	16487	16487	0
Nirant Cross Rd.	6059	4352	65	9663	6161	156	17646	10377	282	39056	23164	592
Vastral	15470	9421	7	22005	12352	10	35724	18119	44	74783	36013	286
Rabari Colony	19734	4930	666	27329	6409	1085	42765	9047	2003	86404	17177	5556
Amraiwadi	24072	5114	775	32803	6589	1115	49837	9007	1931	97124	15759	5035
New Cotton Mills	30858	7684	898	41177	9666	1292	60197	12488	2132	112642	21097	5583
Kankaria East	34146	3420	136	45376	4396	197	65729	5926	394	121740	10377	1278
Kalupur Rly. Stn.	67510	41147	7783	85700	50980	10652	121713	73069	17085	195021	113689	40406
Relief Road	64671	5743	8582	82773	7810	10737	117487	10622	14848	188557	18289	24752
Shahpur	63240	2808	4240	81216	3937	5494	115722	5661	7429	187092	11359	12825
Ashram Road	43707	1608	21141	56488	2516	27244	80940	4716	39498	132675	10299	64716
Stadium	39590	575	4695	51520	792	5760	74589	1404	7755	124066	3767	12379
Commerce Six Road	37186	204	2608	48498	306	3332	70411	605	4787	117337	1663	8391
Helmet Cross Road	27135	989	11040	36448	1472	13518	54747	2611	18275	93517	5590	29410
Gurukul Road	20849	139	6426	28550	197	8095	44203	320	10866	75902	833	18452
Drive-in Cinema	15218	10	5641	21386	17	7181	34527	75	9751	60455	473	15915
Thaltej	5559	0	9659	8786	0	12604	15946	0	18581	30236	0	30223
Thaltej Gam	0	0	5559	0	0	8786	0	0	15946	0	0	30236

E. Peak hour Ridership on Metro - Ph I+II corridors

E.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	1127	1127	0	1452	1452	0	1877	1877	0	3194	3194	0
Vasna	1479	352	0	1991	539	0	2834	958	0	5312	2118	0
Anjali	1771	308	16	2347	379	22	4185	1395	45	6058	879	132
Paldi	2328	606	49	3141	858	64	5498	1398	84	8517	2606	148
Madalpur	3173	921	77	4251	1212	103	7304	1959	153	11538	3374	353
Nava Gandhigram	3749	608	32	5027	816	40	8431	1190	63	13592	2217	164
Ashram Road	5424	2629	954	7305	3540	1262	12140	5212	1504	19452	8774	2913
Usmanpura	5400	378	402	7269	494	530	12087	668	721	19276	1143	1319
Vadaj	6921	3059	1538	9519	4319	2069	13548	4586	3125	24406	10383	5253
Ranip	6472	130	579	8990	195	724	13758	1068	858	25192	2264	1477
Sabarmati Rail Stn	6268	5	209	8704	6	292	13442	93	408	24529	186	849
AEC	6173	18	113	8568	26	162	13229	47	260	24075	96	551
Sabarmati	5981	22	214	8314	31	285	12961	68	335	23584	139	630
Motera Stadium	0	0	5981	0	0	8314	10116	1380	4226	19386	3840	8038
Motera Gam	-	-	-	-	-	-	9516	211	811	18278	544	1651
Tapovan Ring road	-	-	-	-	-	-	9106	136	546	17774	673	1177
Koba Circle	-	-	-	-	-	-	8611	106	602	16966	449	1257
Koba Village	-	-	-	-	-	-	8283	38	366	16425	188	728
PDPU Approch	-	-	-	-	-	-	6310	518	2491	13036	2098	5487
Randesan	-	-	-	-	-	-	6069	64	306	12700	296	632
CH-0	-	-	-	-	-	-	4149	0	1920	8374	0	4326
CH-3	-	-	-	-	-	-	1904	0	2246	3892	0	4482
Sachivalay	-	-	-	-	-	-	1436	6	473	3066	20	846
Sector-21	-	-	-	-	-	-	597	0	840	1392	0	1674

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Akhardham	-	-	-	-	-	-	0	0	597	0	0	1392
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	740	740	0	1616	1616	0
Sector-21	-	-	-	-	-	-	1197	457	1	2559	949	6
Sachivalay	-	-	-	-	-	-	1636	447	7	3352	816	23
CH-3	-	-	-	-	-	-	4246	2667	57	9000	5804	156
CH-0	-	-	-	-	-	-	5263	1538	521	11150	3832	1682
Randesan	-	-	-	-	-	-	5494	290	59	11463	607	294
PDPU Approch	-	-	-	-	-	-	7502	2456	448	14962	5385	1886
Koba Village	-	-	-	-	-	-	7819	352	35	15481	701	181
Koba Circle	-	-	-	-	-	-	8226	486	80	16077	994	398
Tapovan Ring road	-	-	-	-	-	-	8534	431	123	16377	877	576
Motera Gam	-	-	-	-	-	-	9162	792	164	17570	1571	379
Motera Stadium	6193	6193	0	8529	8529	0	12432	4350	1080	4679	1594	453
Sabarmati	6146	69	116	8463	92	158	12193	130	369	4577	49	151
AEC	6207	73	12	8554	108	17	12336	176	33	4629	66	14
Sabarmati Rail Stn	6309	138	35	8706	201	48	12573	321	84	4715	120	34
Ranip	5744	325	890	7803	396	1300	11370	559	1762	4240	194	668
Vadaj	6128	2092	1708	8213	2824	2414	11479	4107	3998	4203	1504	1542
Usmanpura	5713	0	416	7683	0	530	10798	0	681	3949	0	253
Ashram Road	3352	0	2361	4526	0	3157	6749	0	4049	2437	0	1513
Nava Gandhigram	2823	0	529	3812	0	714	5816	0	933	2092	0	344
Madalpur	2202	17	638	2984	23	850	4627	0	1189	1664	0	428
Paldi	1788	11	426	2421	15	578	3770	22	879	1345	8	328
Anjali	1390	48	446	1860	71	632	2827	122	1066	990	41	395
Vasna	1027	0	362	1324	0	536	1893	0	934	669	0	322
APMC	0	0	1027	0	0	1324	0	0	1893	0	0	669

E.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	914	914	0	1436	1436	0	2469	2469	0	5042	5042	0
Thaltej	1786	877	5	2586	1160	9	3826	1385	28	7395	2478	125
Drive-in Cinema	2282	498	1	3210	626	2	4572	755	9	8598	1258	56
Gurukul Road	3003	743	22	4106	930	34	5651	1142	62	10399	1996	195
Helmet Cross Road	3646	739	97	4860	908	154	6371	1013	293	11520	1749	628
Commerce Six Road	3882	262	26	5165	346	40	6721	434	84	12202	938	256
Stadium	3960	138	59	5261	180	84	6805	245	161	12236	501	467
Ashram Road	7205	3650	405	9376	4727	612	11099	5316	1022	19397	9384	2224
Shahpur	7182	376	400	9319	511	568	10906	657	850	18753	1065	1708
Relief Road	6918	580	843	8900	753	1172	10226	926	1606	18785	2840	2808
Kalupur Rly. Stn.	4341	1126	3704	5797	1545	4648	8432	2457	4251	15538	4981	8227
Kankaria East	3738	19	623	5037	28	788	7462	55	1025	14195	164	1508
New Cotton Mills	2912	86	911	4026	126	1138	6238	216	1440	12444	583	2334
Amraiwadi	2396	115	631	3410	188	804	5497	352	1093	11573	974	1844
Rabari Colony	1977	59	478	2872	92	630	4796	175	876	10282	526	1818
Vastral	848	1	1130	1406	1	1468	2632	5	2169	6022	37	4296
Nirant Cross Rd.	366	10	492	732	22	694	1497	45	1180	3438	131	2715
Vastral Gam	0	0	366	0	0	732	0	0	1497	0	0	3438

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	208	208	0	430	430	0	903	903	0	1862	1862	0
Nirant Cross Rd.	713	512	8	1137	725	18	2099	1230	33	4582	2760	39
Vastral	1820	1108	1	2589	1453	1	4214	2120	5	8804	4254	34
Rabari Colony	2322	580	78	3215	754	128	4942	964	236	10220	2017	601
Amraiwadi	2832	602	91	3859	775	131	5706	991	227	11595	1808	432
New Cotton Mills	3630	904	106	4844	1137	152	6832	1376	251	13427	2420	588
Kankaria East	4017	402	16	5338	517	23	7518	733	46	14536	1256	148
Kalupur Rly. Stn.	7942	4841	916	10082	5998	1253	14493	8637	1662	21956	12548	5127
Relief Road	7608	676	1010	9738	919	1263	13946	1199	1746	20932	1812	2837
Shahpur	7440	330	499	9555	463	646	13738	666	874	20942	1331	1320
Ashram Road	5142	189	2487	6646	296	3205	9604	553	4686	15083	1220	7079
Stadium	4658	68	552	6061	93	678	8846	156	914	14062	429	1449
Commerce Six Road	4375	24	307	5706	36	392	8356	73	563	13278	198	983
Helmet Cross Road	3192	116	1299	4288	173	1590	6513	308	2151	10808	658	3127
Gurukul Road	2453	16	756	3359	23	952	5288	39	1264	8756	100	2151
Drive-in Cinema	1790	1	664	2516	2	845	4157	9	1140	6992	56	1820
Thaltej	654	0	1136	1034	0	1483	1891	0	2266	3583	0	3408
Thaltej Gam	0	0	654	0	0	1034	0	0	1891	0	0	3583

F. Full Day Ridership on Metro - Ph I+II corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

F.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	9578	9578	0	12339	12339	0	15956	15956	0	27149	27149	0
Vasna	12570	2992	0	16922	4583	0	24092	8140	0	45152	18003	0
Anjali	15055	2615	133	19948	3220	190	35571	11859	381	51496	7470	1125
Paldi	19791	5154	418	26700	7293	541	46733	11880	714	72396	22154	1258
Madalpur	26969	7830	653	36132	10305	874	62084	16650	1299	98070	28679	3002
Nava Gandhigram	31865	5165	269	42728	6939	343	71665	10118	537	115529	18846	1391
Ashram Road	46104	22345	8109	62091	30087	10724	103190	44305	12781	165345	74579	24762
Usmanpura	45903	3216	3414	61785	4199	4502	102741	5678	6127	163846	9714	11213
Vadaj	58830	26003	13076	80913	36713	17585	115155	38978	26561	207448	88254	44652
Ranip	55009	1102	4923	76415	1656	6151	116940	9078	7293	214135	19244	12556
Sabarmati Rail Stn	53275	41	1775	73987	54	2482	114257	789	3471	208498	1584	7218
AEC	52472	153	959	72831	218	1377	112445	401	2210	204636	816	4682
Sabarmati	50837	184	1816	70669	262	2424	110170	575	2849	200461	1180	5355
Motera Stadium	0	0	50837	0	0	70669	85986	11733	35918	164778	32637	68320
Motera Gam	-	-	-	-	-	-	80883	1792	6895	155366	4624	14035
Tapovan Ring road	-	-	-	-	-	-	77401	1156	4638	151082	5719	10003
Koba Circle	-	-	-	-	-	-	73192	904	5114	144211	3818	10686

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Koba Village	-	-	-	-	-	-	70404	326	3114	139614	1598	6191
PDPU Approch	-	-	-	-	-	-	53638	4406	21172	110809	17836	46641
Randesan	-	-	-	-	-	-	51588	547	2601	107950	2516	5372
CH-0	-	-	-	-	-	-	35268	0	16320	71179	0	36771
CH-3	-	-	-	-	-	-	16181	0	19088	33079	0	38100
Sachivalay	-	-	-	-	-	-	12209	51	4022	26061	173	7194
Sector-21	-	-	-	-	-	-	5073	0	7137	11829	0	14232
Akhardham	-	-	-	-	-	-	0	0	5073	0	0	11829
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	6290	6290	0	13739	13739	0
Sector-21	-	-	-	-	-	-	10173	3886	7	21753	8065	51
Sachivalay	-	-	-	-	-	-	13906	3798	61	28495	6933	194
CH-3	-	-	-	-	-	-	36094	22668	483	76503	49334	1326
CH-0	-	-	-	-	-	-	44737	13073	4430	94775	32572	14300
Randesan	-	-	-	-	-	-	46699	2462	500	97434	5161	2502
PDPU Approch	-	-	-	-	-	-	63767	20876	3808	127174	45771	16034
Koba Village	-	-	-	-	-	-	66463	2995	299	131590	5957	1540
Koba Circle	-	-	-	-	-	-	69921	4134	677	136653	8446	3386
Tapovan Ring road	-	-	-	-	-	-	72542	3662	1044	139206	7456	4899
Motera Gam	-	-	-	-	-	-	77877	6732	1397	149345	13355	3220
Motera Stadium	52642	52642	0	72495	72495	0	105672	36975	9180	193140	69697	25901
Sabarmati	52238	585	989	71937	785	1343	103642	1108	3138	189972	2258	5430

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
AEC	52758	619	99	72709	915	143	104853	1496	282	192630	3288	629
Sabarmati Rail Stn	53628	1170	299	74001	1707	411	106872	2730	711	197186	6001	1445
Ranip	48824	2764	7568	66324	3369	11047	96648	4753	14977	180275	8415	25330
Vadaj	52088	17785	14521	69809	24007	20522	97573	34908	33983	177545	67334	70064
Usmanpura	48559	0	3533	65307	0	4502	91786	0	5787	166916	0	10628
Ashram Road	28492	0	20067	38474	0	26833	57368	0	34418	103714	0	63203
Nava Gandhigram	23994	0	4498	32405	0	6069	49436	0	7932	89111	0	14603
Madalpur	18717	143	5420	25367	194	7228	39331	0	10105	71257	0	17853
Paldi	15195	92	3618	20577	126	4916	32048	187	7470	59531	384	12107
Anjali	11812	408	3788	15810	602	5369	24028	1037	9058	43095	2322	18761
Vasna	8731	0	3080	11257	0	4553	16089	0	7942	26554	0	16541
APMC	0	0	8731	0	0	11257	0	0	16089	0	0	26554

F.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	7766	7766	0	12203	12203	0	20985	20985	0	42854	42854	0
Thaltej	15181	7456	41	21981	9857	75	32521	11771	238	62859	21066	1061
Drive-in Cinema	19400	4230	10	27282	5318	17	38859	6416	75	73083	10693	473
Gurukul Road	25527	6314	187	34898	7902	286	48035	9704	530	88390	16966	1656
Helmet Cross Road	30988	6283	826	41307	7721	1309	54155	8612	2492	97920	14865	5335
Commerce Six Road	32994	2230	224	43904	2938	343	57130	3692	717	103720	7976	2176
Stadium	33660	1173	503	44720	1530	714	57844	2084	1367	104006	4257	3971
Ashram Road	61244	31025	3441	79699	40178	5199	94343	45186	8687	164873	79767	18901
Shahpur	61044	3199	3400	79213	4345	4831	92701	5583	7225	159402	9054	14521
Relief Road	58806	4927	7164	75653	6402	9962	86921	7868	13648	159671	24140	23871
Kalupur Rly. Stn.	36897	9571	31481	49276	13131	39508	71675	20886	36135	132076	42337	69931
Kankaria East	31770	163	5294	42816	238	6695	63430	466	8711	120659	1397	12818
New Cotton Mills	24752	728	7742	34221	1071	9670	53020	1833	12240	105771	4957	19842
Amraiwadi	20366	979	5365	28988	1598	6831	46726	2995	9292	98369	8276	15677
Rabari Colony	16806	503	4063	24412	782	5355	40766	1486	7446	87394	4474	15453
Vastral	7211	7	9602	11948	10	12478	22375	44	18435	51190	313	36519
Nirant Cross Rd.	3108	82	4182	6225	184	5902	12723	381	10030	29226	1115	23079
Vastral Gam	0	0	3108	0	0	6225	0	0	12723	0	0	29226

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	1771	1771	0	3658	3658	0	7674	7674	0	15824	15824	0
Nirant Cross Rd.	6059	4352	65	9663	6161	156	17843	10452	282	38950	23463	333
Vastral	15470	9421	7	22005	12352	10	35816	18017	44	74831	36162	286
Rabari Colony	19734	4930	666	27329	6409	1085	42010	8197	2003	86867	17143	5107
Amraiwadi	24072	5114	775	32803	6589	1115	48504	8425	1931	98559	15368	3672
New Cotton Mills	30858	7684	898	41177	9666	1292	58069	11696	2132	114131	20567	4998
Kankaria East	34146	3420	136	45376	4396	197	63903	6229	394	123556	10679	1255
Kalupur Rly. Stn.	67510	41147	7783	85700	50980	10652	123189	73413	14127	186629	106658	43581
Relief Road	64671	5743	8582	82773	7810	10737	118541	10193	14838	177919	15399	24113
Shahpur	63240	2808	4240	81216	3937	5494	116773	5658	7426	178004	11312	11223
Ashram Road	43707	1608	21141	56488	2516	27244	81637	4699	39834	128204	10373	60173
Stadium	39590	575	4695	51520	792	5760	75194	1329	7772	119527	3645	12318
Commerce Six Road	37186	204	2608	48498	306	3332	71029	622	4787	112860	1686	8357
Helmet Cross Road	27135	989	11040	36448	1472	13518	55359	2615	18282	91868	5590	26581
Gurukul Road	20849	139	6426	28550	197	8095	44945	333	10747	74429	847	18285
Drive-in Cinema	15218	10	5641	21386	17	7181	35333	75	9687	59432	473	15470
Thaltej	5559	0	9659	8786	0	12604	16072	0	19261	30457	0	28971
Thaltej Gam	0	0	5559	0	0	8786	0	0	16072	0	0	30457

2.5.4 Moderate Scenario

A. Full Day Ridership on different PT modes (Phase I corridors)

1. Year 2018 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 22%							
PT Demand:	**1365452**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1183557	13639651	817238	50%	1155	**1.74**	11.52
BRT	791183	7241561	303715	33%	6593		9.15
Metro	397929	2748785	86284	17%	11305		6.91
Total	**2372670**	**23629997**	**1207237**				
PT Trip Length	**17.31**	**km**					

2. Year 2021 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 28%							
PT Demand:	**1728828**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1461643	16107684	964611	49%	1426	**1.73**	11.02
BRT	983137	8628200	361870	33%	8193		8.78
Metro	537792	3634433	114087	18%	15278		6.76
Total	**2982572**	**28370317**	**1440568**				
PT Trip Length	**16.41**	**km**					

3. Year 2031 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 37.5%							
PT Demand:	**2556458**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	2234449	24487585	1464499	50%	2180	**1.75**	10.96
BRT	1437925	12791014	536449	32%	11983		8.90
Metro	811237	5576864	175067	18%	23046		6.87
Total	**4483611**	**42855463**	**2176016**				
PT Trip Length	**16.76**	**km**					

4. Year 2043 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4724093	44797383	2675716	105%	4609	**1.72**	9.48
BRT	2600786	21122707	885873	58%	21673		8.12
Metro	1243598	8255972	259178	28%	35329		6.64
Total	**8568476**	**74176063**	**3820767**				
PT Trip Length	**14.91**	**km**					

B. Full Day Ridership on different PT modes (Phase I + II corridors)

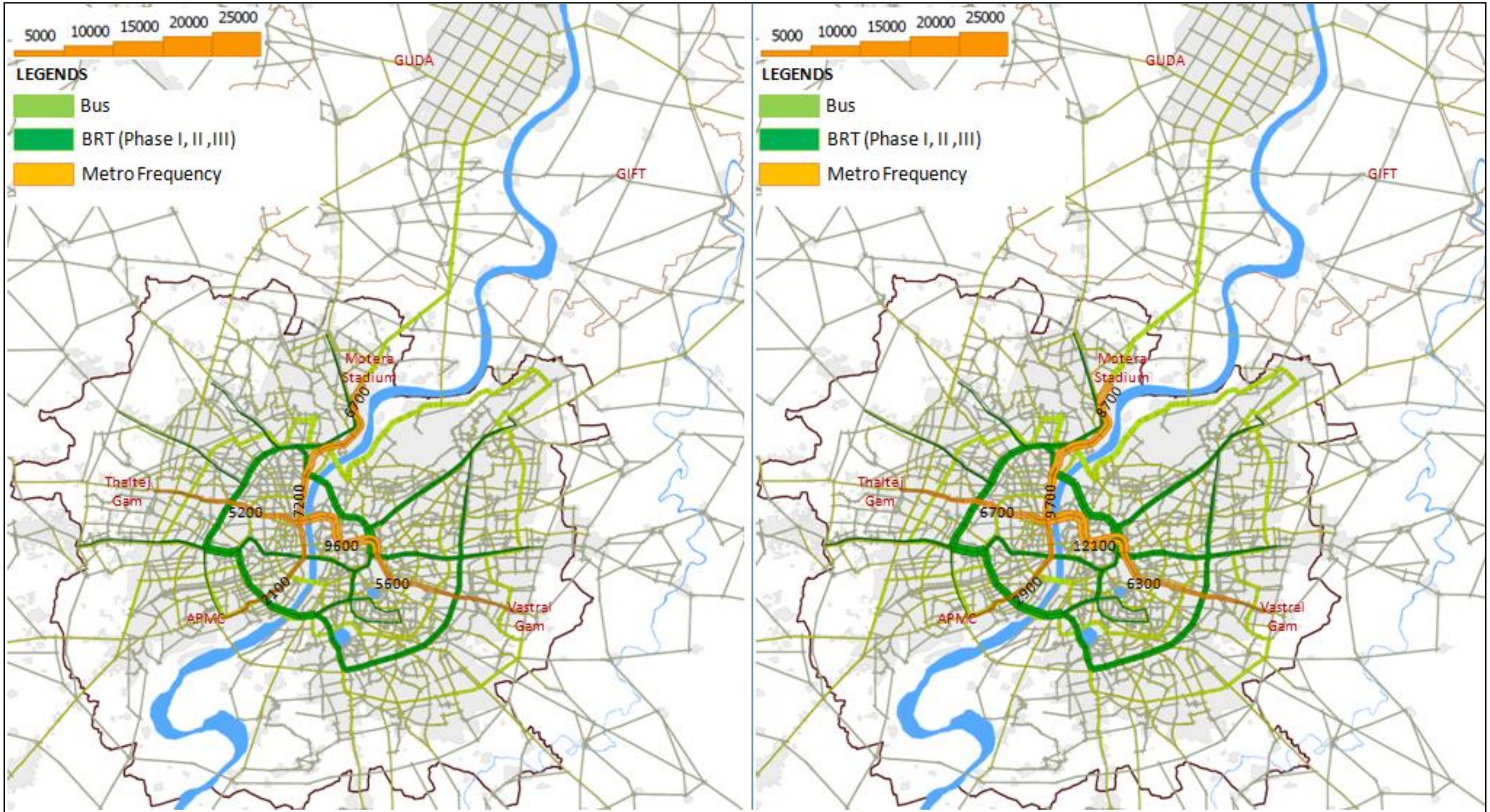
5. Year 2031 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

PT Share in Motorized trips: 37.5%							
PT Demand:	**2556458**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1993325	21859617	1316604	44%	1945	**1.67**	10.97
BRT	1436446	13013792	545782	32%	11970		9.06
Metro	837383	7375263	231430	19%	13956		8.81
Total	**4267153**	**42248672**	**2093816**				
PT Trip Length	**16.53**	**km**					

6. Year 2043 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

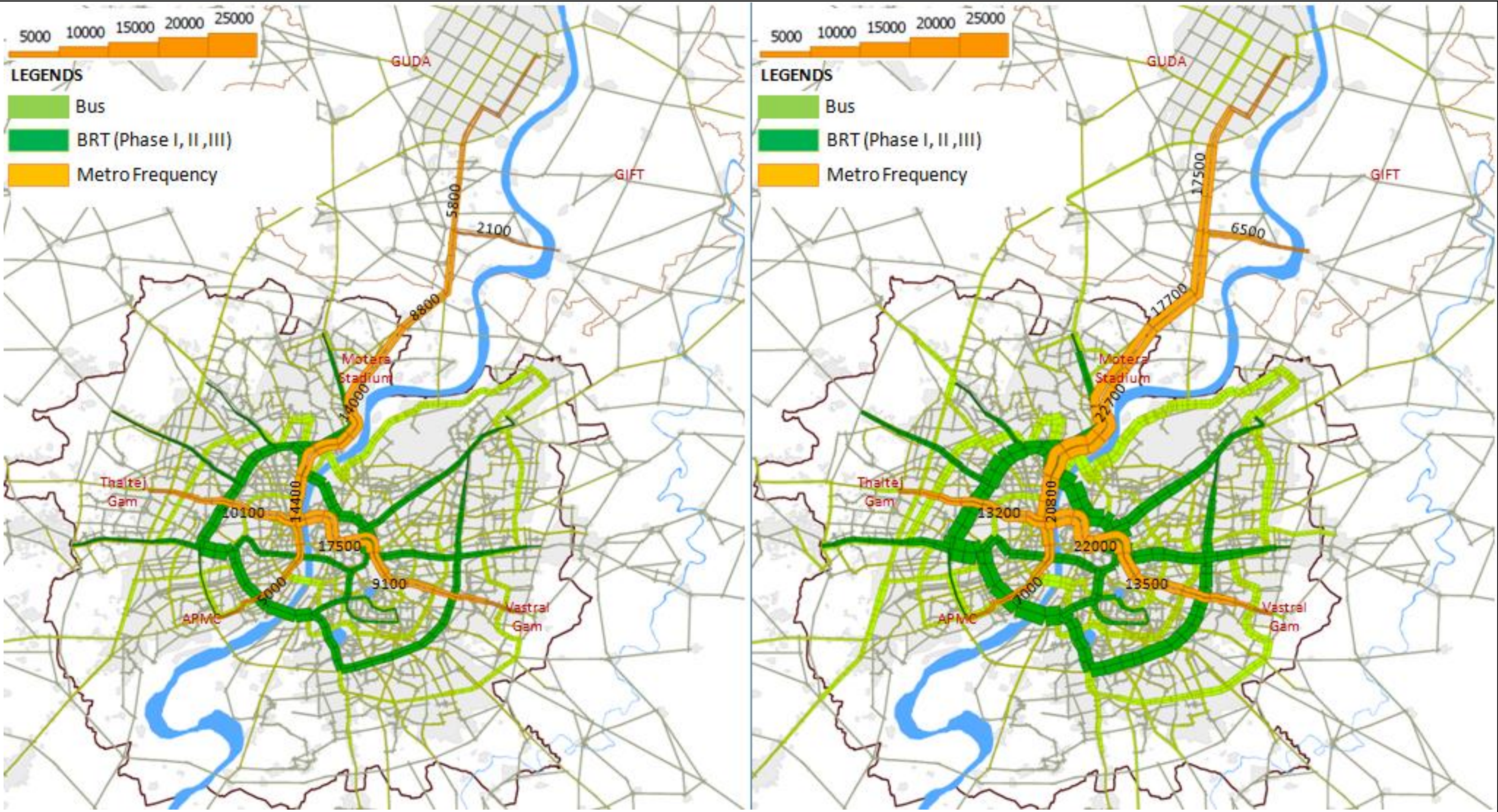
PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4176601	39608708	2381618	93%	4075	**1.67**	9.48
BRT	2671336	21867443	917112	60%	22261		8.19
Metro	1442392	12176899	382053	32%	24040		8.44
Total	**8290329**	**73653051**	**3680784**				
PT Trip Length	**14.81**	**km**					

Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures.



Year 2018 (Phase I Metro)	Year 2021 (Phase I Metro)

Fig. 2.24 Moderate - Passenger Flows 2018 & 2021 (Phase I)



Year 2031 (Phase I+II Metro)	Year 2043 (Phase I+II Metro)

Fig. 2.25 Moderate - Passenger Flows 2031 & 2043 (Phase I+II)

Peak hour Ridership on Metro - Ph I corridors

C.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	1234	1234	0	1624	13804	0	2325	2325	0	3248	3248	0
Vasna	1757	523	0	2416	6729	0	3675	1350	0	5348	2100	0
Anjali	2160	422	19	2915	4522	275	4312	692	56	6083	868	132
Paldi	2818	710	52	3835	8432	615	5850	1634	95	8532	2597	148
Madalpur	3830	1092	80	5190	12672	1159	7719	2068	199	11161	2985	355
Nava Gandhigram	4503	716	43	6116	8544	666	9054	1444	109	13194	2197	164
Ashram Road	6530	3305	1278	8862	38026	14691	13286	6700	2469	19367	9544	3372
Usmanpura	6456	438	511	8744	5294	6290	13129	800	957	19124	1144	1387
Vadaj	7773	3149	1832	10175	34180	22022	16244	6776	3661	26484	12926	5567
Ranip	7214	138	698	9437	1744	8017	15372	352	1224	25506	721	1698
Sabarmati Rail Stn	6923	1	292	9020	95	3645	14764	24	632	24618	54	942
AEC	6801	18	141	8833	252	1839	14463	52	353	24143	92	567
Sabarmati	6540	22	283	8484	286	3250	13989	58	532	23505	112	750
Motera Stadium	0	0	6540	0	0	72117	0	0	13989	0	0	23505
Line 1R: Motera Stadium to APMC												
Motera Stadium	6748	6748	0	8635	73399	0	14113	14113	0	24261	24261	0
Sabarmati	6733	107	122	8622	1224	1336	14034	214	293	24135	286	412
AEC	6815	93	11	8751	1268	170	14244	246	36	24470	404	68

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Sabarmati Rail Stn	6986	206	35	9007	2666	493	14620	473	98	25004	704	171
Ranip	6521	427	892	8466	4685	9289	13550	735	1804	21375	956	4585
Vadaj	7216	2474	1780	9712	30032	19441	14626	4975	3900	21959	7873	7290
Usmanpura	6749	0	467	9065	0	5494	13760	0	866	20692	0	1267
Ashram Road	3961	0	2788	5364	0	31460	8125	0	5635	12441	0	8251
Nava Gandhigram	3368	0	592	4543	0	6980	6917	0	1208	10557	0	1884
Madalpur	2623	18	764	3530	292	8894	5460	47	1504	8471	80	2166
Paldi	2136	12	499	2877	170	5729	4433	28	1054	6833	45	1683
Anjali	1606	53	582	2148	724	6919	3309	145	1268	4926	273	2180
Vasna	1109	0	498	1413	0	6246	2072	0	1237	3012	0	1915
APMC	0	0	1109	0	0	12009	0	0	2072	0	0	3012

C.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	1069	1069	0	1663	14137	0	3257	3257	0	5104	5104	0
Thaltej	2082	1016	4	3003	11461	75	5344	2117	30	7846	2864	122
Drive-in Cinema	2707	625	0	3789	6715	34	6401	1075	18	9155	1365	56
Gurukul Road	3683	996	19	4994	10608	364	7970	1652	82	11079	2119	195
Helmet Cross Road	4405	830	108	5869	9054	1615	8994	1402	378	12352	1945	672
Commerce Six Road	4738	361	28	6290	4097	524	9580	708	122	13054	958	256
Stadium	4843	178	74	6391	2077	1217	9684	354	250	13070	483	467
Ashram Road	8762	4462	542	11232	48253	7103	16307	8056	1433	21890	11108	2287
Shahpur	8778	520	504	11172	6042	6552	16142	936	1101	21371	1236	1756
Relief Road	8419	730	1088	10636	8735	13291	15374	1322	2091	20294	1764	2842
Kalupur Rly. Stn.	5607	1246	4058	7546	16861	43122	11061	3122	7434	15457	5464	10300
Kankaria East	4842	41	806	6577	690	8928	9814	111	1358	13922	171	1707
New Cotton Mills	3718	87	1211	5226	1615	13097	8162	311	1963	12135	583	2370
Amraiwadi	3002	101	818	4390	2115	9224	7160	462	1465	11264	974	1845
Rabari Colony	2420	44	625	3635	972	7381	6177	224	1207	10132	526	1659
Vastral	1034	0	1387	1752	27	16038	3332	10	2855	5907	37	4262
Nirant Cross Rd.	430	7	612	856	207	7817	1794	56	1594	3388	131	2650
Vastral Gam	0	0	430	0	0	7279	0	0	1794	0	0	3388

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	255	255	0	518	4403	0	1103	1103	0	1940	1940	0
Nirant Cross Rd.	879	631	7	1446	8041	156	2709	1639	33	4595	2725	70
Vastral	2242	1362	0	3312	15885	20	5510	2812	10	8798	4237	34
Rabari Colony	2885	708	64	4159	8415	1217	6634	1395	272	10165	2021	654
Amraiwadi	3566	764	83	5012	8867	1615	7742	1439	330	11426	1854	592
New Cotton Mills	4627	1166	105	6306	12859	1856	9348	1958	353	13252	2482	657
Kankaria East	5115	528	40	6941	6045	649	10193	947	102	14322	1221	150
Kalupur Rly. Stn.	9560	5366	922	12091	57348	13573	17272	9663	2584	22944	13375	4754
Relief Road	9206	862	1215	11666	10346	13957	16692	1600	2180	22183	2152	2912
Shahpur	8938	414	682	11377	5199	7657	16376	851	1167	22011	1336	1509
Ashram Road	6165	284	3056	7946	3791	32953	11586	778	5569	15609	1212	7614
Stadium	5556	79	688	7241	1302	7293	10710	256	1131	14596	443	1456
Commerce Six Road	5170	25	411	6759	435	4536	10057	97	750	13804	196	987
Helmet Cross Road	3891	134	1414	5177	1860	15307	8000	407	2465	11002	658	3460
Gurukul Road	2897	15	1009	3936	252	10802	6371	50	1679	8930	98	2171
Drive-in Cinema	2086	0	811	2906	34	8789	4966	18	1422	7112	56	1872
Thaltej	790	0	1296	1222	0	14311	2363	0	2604	3557	0	3556
Thaltej Gam	0	0	790	0	0	10390	0	0	2363	0	0	3557

C. Full Day Ridership on Metro – Ph I Corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

D.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	10489	10489	0	13804	13804	0	19761	19761	0	27608	27608	0
Vasna	14933	4444	0	20533	6729	0	31236	11478	0	45461	17850	0
Anjali	18357	3584	160	24779	4522	275	36649	5885	476	51707	7375	1125
Paldi	23953	6038	442	32599	8432	615	49728	13886	806	72519	22073	1261
Madalpur	32558	9285	680	44112	12672	1159	65610	17578	1693	94867	25371	3019
Nava Gandhigram	38274	6083	367	51989	8544	666	76962	12274	925	112149	18676	1397
Ashram Road	55502	28091	10863	75324	38026	14691	112934	56953	20985	164618	81127	28659
Usmanpura	54879	3723	4345	74327	5294	6290	111595	6797	8133	162557	9727	11788
Vadaj	66072	26765	15572	86486	34180	22022	138074	57599	31120	225111	109871	47318
Ranip	61316	1176	5933	80216	1744	8017	130662	2992	10407	216798	6127	14436
Sabarmati Rail Stn	58847	10	2479	76667	95	3645	125494	207	5375	209253	459	8007
AEC	57807	156	1197	75082	252	1839	122934	439	2999	205214	782	4818
Sabarmati	55590	190	2407	72117	286	3250	118905	490	4522	199791	949	6372
Motera Stadium	0	0	55590	0	0	72117	0	0	118905	0	0	199791
Line 1R: Motera Stadium to APMC												
Motera Stadium	57361	57361	0	73399	73399	0	119959	119959	0	206217	206217	0
Sabarmati	57232	911	1040	73287	1224	1336	119289	1822	2489	205146	2428	3499

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
AEC	57929	792	92	74385	1268	170	121074	2094	309	207995	3431	578
Sabarmati Rail Stn	59381	1748	299	76558	2666	493	124270	4022	830	212531	5987	1452
Ranip	55430	3628	7579	71958	4685	9289	115178	6246	15337	181686	8126	38971
Vadaj	61336	21032	15127	82549	30032	19441	124318	42289	33150	186650	66922	61962
Usmanpura	57368	0	3968	77054	0	5494	116960	0	7358	175882	0	10768
Ashram Road	33670	0	23701	45594	0	31460	69061	0	47899	105750	0	70132
Nava Gandhigram	28631	0	5035	38614	0	6980	58796	0	10268	89733	0	16014
Madalpur	22294	156	6497	30008	292	8894	46407	398	12787	72002	680	18411
Paldi	18156	102	4240	24453	170	5729	37679	238	8962	58082	384	14307
Anjali	13654	452	4950	18255	724	6919	28128	1231	10781	41874	2322	18530
Vasna	9425	0	4233	12009	0	6246	17615	0	10513	25599	0	16276
APMC	0	0	9425	0	0	12009	0	0	17615	0	0	25599

D.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	9085	9085	0	14137	14137	0	27686	27686	0	43381	43381	0
Thaltej	17694	8639	31	25527	11461	75	45424	17996	258	66688	24344	1037
Drive-in Cinema	23008	5314	0	32205	6715	34	54407	9136	153	77819	11601	473
Gurukul Road	31307	8463	163	42449	10608	364	67748	14042	700	94170	18010	1659
Helmet Cross Road	37441	7055	921	49888	9054	1615	76452	11917	3216	104989	16531	5712
Commerce Six Road	40273	3070	241	53465	4097	524	81430	6018	1040	110956	8146	2179
Stadium	41164	1516	626	54325	2077	1217	82317	3006	2122	111092	4107	3971
Ashram Road	74477	37924	4610	95472	48253	7103	138611	68473	12179	186068	94418	19441
Shahpur	74610	4417	4281	94962	6042	6552	137207	7956	9360	181655	10509	14926
Relief Road	71560	6202	9251	90406	8735	13291	130676	11240	17772	172496	14994	24154
Kalupur Rly. Stn.	47661	10594	34493	64144	16861	43122	94017	26534	63192	131386	46444	87550
Kankaria East	41160	350	6851	55903	690	8928	83422	945	11540	118334	1452	14508
New Cotton Mills	31603	738	10292	44424	1615	13097	69380	2642	16684	103149	4957	20142
Amraiwadi	25514	857	6950	37312	2115	9224	60860	3930	12451	95741	8276	15684
Rabari Colony	20573	377	5314	30899	972	7381	52503	1904	10261	86119	4474	14100
Vastral	8786	0	11788	14892	27	16038	28325	85	24266	50208	313	36224
Nirant Cross Rd.	3652	61	5199	7279	207	7817	15252	473	13546	28801	1115	22522
Vastral Gam	0	0	3652	0	0	7279	0	0	15252	0	0	28801

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	2166	2166	0	4403	4403	0	9377	9377	0	16487	16487	0
Nirant Cross Rd.	7473	5365	61	12288	8041	156	23028	13930	282	39056	23164	592
Vastral	19054	11580	0	28152	15885	20	46838	23899	85	74783	36013	286
Rabari Colony	24524	6015	541	35350	8415	1217	56386	11856	2309	86404	17177	5556
Amraiwadi	30308	6491	707	42602	8867	1615	65810	12233	2808	97124	15759	5035
New Cotton Mills	39328	9914	894	53604	12859	1856	79455	16646	3002	112642	21097	5583
Kankaria East	43476	4491	343	59000	6045	649	86642	8051	864	121740	10377	1278
Kalupur Rly. Stn.	81257	45614	7834	102775	57348	13573	146812	82134	21961	195021	113689	40406
Relief Road	78254	7327	10326	99161	10346	13957	141882	13597	18527	188557	18289	24752
Shahpur	75973	3516	5797	96703	5199	7657	139196	7235	9921	187092	11359	12825
Ashram Road	52404	2411	25979	67538	3791	32953	98478	6616	47338	132675	10299	64716
Stadium	47229	673	5848	61547	1302	7293	91038	2173	9612	124066	3767	12379
Commerce Six Road	43948	214	3495	57450	435	4536	85486	826	6378	117337	1663	8391
Helmet Cross Road	33072	1139	12016	44006	1860	15307	68000	3461	20951	93517	5590	29410
Gurukul Road	24623	126	8575	33456	252	10802	54152	422	14270	75902	833	18452
Drive-in Cinema	17731	0	6892	24701	34	8789	42214	153	12090	60455	473	15915
Thaltej	6715	0	11016	10390	0	14311	20084	0	22131	30236	0	30223
Thaltej Gam	0	0	6715	0	0	10390	0	0	20084	0	0	30236

D. Peak hour Ridership on Metro - Ph I+II corridors

E.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	1234	1234	0	1624	13804	0	2263	2263	0	3248	3248	0
Vasna	1757	523	0	2416	6729	0	3612	1350	0	5348	2100	0
Anjali	2160	422	19	2915	4522	275	4966	1410	56	6083	868	132
Paldi	2818	710	52	3835	8432	615	6518	1646	94	8532	2597	148
Madalpur	3830	1092	80	5190	12672	1159	8732	2411	198	11161	2985	355
Nava Gandhigram	4503	716	43	6116	8544	666	10086	1463	108	13194	2197	164
Ashram Road	6530	3305	1278	8862	38026	14691	14514	6564	2135	19367	9544	3372
Usmanpura	6456	438	511	8744	5294	6290	14388	830	957	19124	1144	1387
Vadaj	7773	3149	1832	10175	34180	22022	15299	4712	3801	26484	12926	5567
Ranip	7214	138	698	9437	1744	8017	15110	942	1131	25506	721	1698
Sabarmati Rail Stn	6923	1	292	9020	95	3645	14650	108	567	24618	54	942
AEC	6801	18	141	8833	252	1839	14361	54	344	24143	92	567
Sabarmati	6540	22	283	8484	286	3250	13977	76	461	23505	112	750
Motera Stadium	0	0	6540	0	0	72117	9920	989	5045	0	0	23505
Motera Gam	-	-	-	-	-	-	9347	140	713	155366	4624	14035
Tapovan Ring road	-	-	-	-	-	-	8883	32	496	151082	5719	10003
Koba Circle	-	-	-	-	-	-	8335	25	573	144211	3818	10686
Koba Village	-	-	-	-	-	-	7981	10	364	139614	1598	6191
PDPU Approch	-	-	-	-	-	-	5864	204	2320	110809	17836	46641

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Randesan	-	-	-	-	-	-	5588	22	299	107950	2516	5372
CH-0	-	-	-	-	-	-	3813	0	1775	71179	0	36771
CH-3	-	-	-	-	-	-	1721	0	2092	33079	0	38100
Sachivalay	-	-	-	-	-	-	1308	2	415	26061	173	7194
Sector-21	-	-	-	-	-	-	525	0	783	11829	0	14232
Akhardham	-	-	-	-	-	-	0	0	525	0	0	11829
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	643	643	0	13739	13739	0
Sector-21	-	-	-	-	-	-	1060	417	0	21753	8065	51
Sachivalay	-	-	-	-	-	-	1435	378	3	28495	6933	194
CH-3	-	-	-	-	-	-	3790	2384	30	76503	49334	1326
CH-0	-	-	-	-	-	-	4787	1250	252	94775	32572	14300
Randesan	-	-	-	-	-	-	5046	274	15	97434	5161	2502
PDPU Approch	-	-	-	-	-	-	7157	2278	168	127174	45771	16034
Koba Village	-	-	-	-	-	-	7491	341	7	131590	5957	1540
Koba Circle	-	-	-	-	-	-	7928	452	15	136653	8446	3386
Tapovan Ring road	-	-	-	-	-	-	8292	401	36	139206	7456	4899
Motera Gam	-	-	-	-	-	-	8888	713	117	149345	13355	3220
Motera Stadium	6748	6748	0	8635	73399	0	13392	5221	716	24261	24261	0
Sabarmati	6733	107	122	8622	1224	1336	13168	199	424	24135	286	412
AEC	6815	93	11	8751	1268	170	13368	240	39	24470	404	68
Sabarmati Rail Stn	6986	206	35	9007	2666	493	13742	472	98	25004	704	171
Ranip	6521	427	892	8466	4685	9289	12930	751	1564	21375	956	4585

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Vadaj	7216	2474	1780	9712	30032	19441	13909	4991	4012	21959	7873	7290
Usmanpura	6749	0	467	9065	0	5494	13072	0	837	20692	0	1267
Ashram Road	3961	0	2788	5364	0	31460	8166	0	4905	12441	0	8251
Nava Gandhigram	3368	0	592	4543	0	6980	7051	0	1116	10557	0	1884
Madalpur	2623	18	764	3530	292	8894	5572	0	1478	8471	80	2166
Paldi	2136	12	499	2877	170	5729	4557	28	1044	6833	45	1683
Anjali	1606	53	582	2148	724	6919	3406	145	1295	4926	273	2180
Vasna	1109	0	498	1413	0	6246	2150	0	1256	3012	0	1915
APMC	0	0	1109	0	0	12009	0	0	2150	0	0	3012

E.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	1069	1069	0	1663	14137	0	3152	3152	0	5042	5042	0
Thaltej	2082	1016	4	3003	11461	75	4905	1786	32	7395	2478	125
Drive-in Cinema	2707	625	0	3789	6715	34	5877	990	18	8598	1258	56
Gurukul Road	3683	996	19	4994	10608	364	7340	1545	82	10399	1996	195
Helmet Cross Road	4405	830	108	5869	9054	1615	8208	1246	378	11520	1749	628
Commerce Six Road	4738	361	28	6290	4097	524	8706	620	122	12202	938	256
Stadium	4843	178	74	6391	2077	1217	8791	334	250	12236	501	467
Ashram Road	8762	4462	542	11232	48253	7103	14049	6644	1386	19397	9384	2224
Shahpur	8778	520	504	11172	6042	6552	13844	899	1104	18753	1065	1708
Relief Road	8419	730	1088	10636	8735	13291	13009	1242	2077	18785	2840	2808
Kalupur Rly. Stn.	5607	1246	4058	7546	16861	43122	11100	3119	5029	15538	4981	8227
Kankaria East	4842	41	806	6577	690	8928	9855	111	1356	14195	164	1508
New Cotton Mills	3718	87	1211	5226	1615	13097	8199	311	1967	12444	583	2334
Amraiwadi	3002	101	818	4390	2115	9224	7194	462	1467	11573	974	1844
Rabari Colony	2420	44	625	3635	972	7381	6205	224	1213	10282	526	1818
Vastral	1034	0	1387	1752	27	16038	3350	10	2866	6022	37	4296
Nirant Cross Rd.	430	7	612	856	207	7817	1802	56	1603	3438	131	2715
Vastral Gam	0	0	430	0	0	7279	0	0	1802	0	0	3438

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	255	255	0	518	4403	0	1116	1116	0	1862	1862	0
Nirant Cross Rd.	879	631	7	1446	8041	156	2731	1648	33	4582	2760	39
Vastral	2242	1362	0	3312	15885	20	5522	2801	10	8804	4254	34
Rabari Colony	2885	708	64	4159	8415	1217	6555	1304	272	10220	2017	601
Amraiwadi	3566	764	83	5012	8867	1615	7592	1368	330	11595	1808	432
New Cotton Mills	4627	1166	105	6306	12859	1856	9104	1865	353	13427	2420	588
Kankaria East	5115	528	40	6941	6045	649	10004	1001	102	14536	1256	148
Kalupur Rly. Stn.	9560	5366	922	12091	57348	13573	17466	9698	2236	21956	12548	5127
Relief Road	9206	862	1215	11666	10346	13957	16834	1546	2177	20932	1812	2837
Shahpur	8938	414	682	11377	5199	7657	16520	851	1166	20942	1331	1320
Ashram Road	6165	284	3056	7946	3791	32953	11675	781	5626	15083	1220	7079
Stadium	5556	79	688	7241	1302	7293	10788	246	1133	14062	429	1449
Commerce Six Road	5170	25	411	6759	435	4536	10137	100	751	13278	198	983
Helmet Cross Road	3891	134	1414	5177	1860	15307	8079	408	2466	10808	658	3127
Gurukul Road	2897	15	1009	3936	252	10802	6467	51	1663	8756	100	2151
Drive-in Cinema	2086	0	811	2906	34	8789	5073	18	1412	6992	56	1820
Thaltej	790	0	1296	1222	0	14311	2384	0	2689	3583	0	3408
Thaltej Gam	0	0	790	0	0	10390	0	0	2384	0	0	3583

E. Full Day Ridership on Metro – Ph I+II Corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

F.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	10489	10489	0	13804	13804	0	19234	19234	0	27149	27149	0
Vasna	14933	4444	0	20533	6729	0	30702	11472	0	45152	18003	0
Anjali	18357	3584	160	24779	4522	275	42214	11985	476	51496	7470	1125
Paldi	23953	6038	442	32599	8432	615	55403	13991	802	72396	22154	1258
Madalpur	32558	9285	680	44112	12672	1159	74219	20495	1680	98070	28679	3002
Nava Gandhigram	38274	6083	367	51989	8544	666	85731	12434	921	115529	18846	1391
Ashram Road	55502	28091	10863	75324	38026	14691	123372	55791	18149	165345	74579	24762
Usmanpura	54879	3723	4345	74327	5294	6290	122295	7055	8133	163846	9714	11213
Vadaj	66072	26765	15572	86486	34180	22022	130040	40052	32307	207448	88254	44652
Ranip	61316	1176	5933	80216	1744	8017	128432	8007	9615	214135	19244	12556
Sabarmati Rail Stn	58847	10	2479	76667	95	3645	124528	915	4818	208498	1584	7218
AEC	57807	156	1197	75082	252	1839	122070	462	2921	204636	816	4682
Sabarmati	55590	190	2407	72117	286	3250	118803	649	3917	200461	1180	5355
Motera Stadium	0	0	55590	0	0	72117	84323	8408	42884	164778	32637	68320
Motera Gam	-	-	-	-	-	-	79451	1187	6059	155366	4624	14035
Tapovan Ring road	-	-	-	-	-	-	75504	272	4219	151082	5719	10003
Koba Circle	-	-	-	-	-	-	70846	214	4872	144211	3818	10686
Koba Village	-	-	-	-	-	-	67837	82	3091	139614	1598	6191

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
PDPU Approch	-	-	-	-	-	-	49847	1731	19720	110809	17836	46641
Randesan	-	-	-	-	-	-	47498	190	2540	107950	2516	5372
CH-0	-	-	-	-	-	-	32412	0	15089	71179	0	36771
CH-3	-	-	-	-	-	-	14627	0	17785	33079	0	38100
Sachivalay	-	-	-	-	-	-	11118	17	3526	26061	173	7194
Sector-21	-	-	-	-	-	-	4461	0	6654	11829	0	14232
Akhardham	-	-	-	-	-	-	0	0	4461	0	0	11829
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	5464	5464	0	13739	13739	0
Sector-21	-	-	-	-	-	-	9010	3546	0	21753	8065	51
Sachivalay	-	-	-	-	-	-	12196	3210	24	28495	6933	194
CH-3	-	-	-	-	-	-	32212	20267	252	76503	49334	1326
CH-0	-	-	-	-	-	-	40691	10622	2142	94775	32572	14300
Randesan	-	-	-	-	-	-	42894	2332	129	97434	5161	2502
PDPU Approch	-	-	-	-	-	-	60833	19366	1428	127174	45771	16034
Koba Village	-	-	-	-	-	-	63675	2900	58	131590	5957	1540
Koba Circle	-	-	-	-	-	-	67385	3839	129	136653	8446	3386
Tapovan Ring road	-	-	-	-	-	-	70482	3407	309	139206	7456	4899
Motera Gam	-	-	-	-	-	-	75545	6059	996	149345	13355	3220
Motera Stadium	57361	57361	0	73399	73399	0	113832	44377	6089	193140	69697	25901
Sabarmati	57232	911	1040	73287	1224	1336	111925	1693	3601	189972	2258	5430
AEC	57929	792	92	74385	1268	170	113631	2037	330	192630	3288	629

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Sabarmati Rail Stn	59381	1748	299	76558	2666	493	116810	4015	833	197186	6001	1445
Ranip	55430	3628	7579	71958	4685	9289	109908	6385	13291	180275	8415	25330
Vadaj	61336	21032	15127	82549	30032	19441	118225	42422	34105	177545	67334	70064
Usmanpura	57368	0	3968	77054	0	5494	111112	0	7113	166916	0	10628
Ashram Road	33670	0	23701	45594	0	31460	69414	0	41694	103714	0	63203
Nava Gandhigram	28631	0	5035	38614	0	6980	59932	0	9486	89111	0	14603
Madalpur	22294	156	6497	30008	292	8894	47365	0	12566	71257	0	17853
Paldi	18156	102	4240	24453	170	5729	38733	238	8871	59531	384	12107
Anjali	13654	452	4950	18255	724	6919	28954	1231	11006	43095	2322	18761
Vasna	9425	0	4233	12009	0	6246	18275	0	10679	26554	0	16541
APMC	0	0	9425	0	0	12009	0	0	18275	0	0	26554

F.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	9085	9085	0	14137	14137	0	26789	26789	0	42854	42854	0
Thaltej	17694	8639	31	25527	11461	75	41694	15181	272	62859	21066	1061
Drive-in Cinema	23008	5314	0	32205	6715	34	49956	8418	153	73083	10693	473
Gurukul Road	31307	8463	163	42449	10608	364	62390	13131	697	88390	16966	1656
Helmet Cross Road	37441	7055	921	49888	9054	1615	69768	10594	3216	97920	14865	5335
Commerce Six Road	40273	3070	241	53465	4097	524	74004	5273	1037	103720	7976	2176
Stadium	41164	1516	626	54325	2077	1217	74722	2839	2122	104006	4257	3971
Ashram Road	74477	37924	4610	95472	48253	7103	119415	56474	11781	164873	79767	18901
Shahpur	74610	4417	4281	94962	6042	6552	117674	7640	9381	159402	9054	14521
Relief Road	71560	6202	9251	90406	8735	13291	110578	10557	17656	159671	24140	23871
Kalupur Rly. Stn.	47661	10594	34493	64144	16861	43122	94347	26513	42745	132076	42337	69931
Kankaria East	41160	350	6851	55903	690	8928	83769	945	11526	120659	1397	12818
New Cotton Mills	31603	738	10292	44424	1615	13097	69690	2642	16718	105771	4957	19842
Amraiwadi	25514	857	6950	37312	2115	9224	61149	3930	12471	98369	8276	15677
Rabari Colony	20573	377	5314	30899	972	7381	52741	1904	10312	87394	4474	15453
Vastral	8786	0	11788	14892	27	16038	28472	85	24358	51190	313	36519
Nirant Cross Rd.	3652	61	5199	7279	207	7817	15317	473	13627	29226	1115	23079
Vastral Gam	0	0	3652	0	0	7279	0	0	15317	0	0	29226

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	2166	2166	0	4403	4403	0	9486	9486	0	15824	15824	0
Nirant Cross Rd.	7473	5365	61	12288	8041	156	23215	14011	282	38950	23463	333
Vastral	19054	11580	0	28152	15885	20	46937	23807	85	74831	36162	286
Rabari Colony	24524	6015	541	35350	8415	1217	55716	11087	2309	86867	17143	5107
Amraiwadi	30308	6491	707	42602	8867	1615	64535	11631	2808	98559	15368	3672
New Cotton Mills	39328	9914	894	53604	12859	1856	77384	15851	3002	114131	20567	4998
Kankaria East	43476	4491	343	59000	6045	649	85034	8510	864	123556	10679	1255
Kalupur Rly. Stn.	81257	45614	7834	102775	57348	13573	148461	82430	19003	186629	106658	43581
Relief Road	78254	7327	10326	99161	10346	13957	143092	13138	18506	177919	15399	24113
Shahpur	75973	3516	5797	96703	5199	7657	140417	7235	9908	178004	11312	11223
Ashram Road	52404	2411	25979	67538	3791	32953	99239	6640	47821	128204	10373	60173
Stadium	47229	673	5848	61547	1302	7293	91698	2088	9629	119527	3645	12318
Commerce Six Road	43948	214	3495	57450	435	4536	86166	847	6382	112860	1686	8357
Helmet Cross Road	33072	1139	12016	44006	1860	15307	68670	3465	20961	91868	5590	26581
Gurukul Road	24623	126	8575	33456	252	10802	54968	435	14137	74429	847	18285
Drive-in Cinema	17731	0	6892	24701	34	8789	43122	153	11999	59432	473	15470
Thaltej	6715	0	11016	10390	0	14311	20264	0	22858	30457	0	28971
Thaltej Gam	0	0	6715	0	0	10390	0	0	20264	0	0	30457

2.5.5 Rapid Scenario

A. Full Day Ridership on different PT modes (Phase I corridors)

1. Year 2018 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 25%							
PT Demand:	**1511944**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1265657	14147165	848142	49%	1235	**1.72**	11.18
BRT	871287	7679532	322086	34%	7261		8.81
Metro	457664	3059188	96028	18%	13002		6.68
Total	**2594608**	**24885886**	**1266256**				
PT Trip Length	**16.46**	**km**					

2. Year 2021 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 30%							
PT Demand:	**1855670**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	1508492	16421164	984111	47%	1472	**1.72**	10.89
BRT	1019952	8920104	374109	32%	8500		8.75
Metro	661606	4432152	139125	21%	18796		6.70
Total	**3190050**	**29773419**	**1497344**				
PT Trip Length	**16.04**	**km**					

3. Year 2031 – Phase I Metro Corridors (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 40%							
PT Demand:	**2705958**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	2247040	24079072	1441307	50%	2192	**1.73**	10.72
BRT	1499431	13029915	546469	33%	12495		8.69
Metro	922855	6294893	197609	21%	26217		6.82
Total	**4669325**	**43403880**	**2185385**				
PT Trip Length	**16.04**	**km**					

4. Year 2043 – Phase I Metro Corridor (Motera-APMC, Thaltej Gam - Vastral Gam)

PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4724093	44797383	2675716	105%	4609	**1.72**	9.48
BRT	2600786	21122707	885873	58%	21673		8.12
Metro	1243598	8255972	259178	28%	35329		6.64
Total	**8568476**	**74176063**	**3820767**				
PT Trip Length	**14.91**	**km**					

B. Full Day Ridership on different PT modes (Phase I + II corridors)

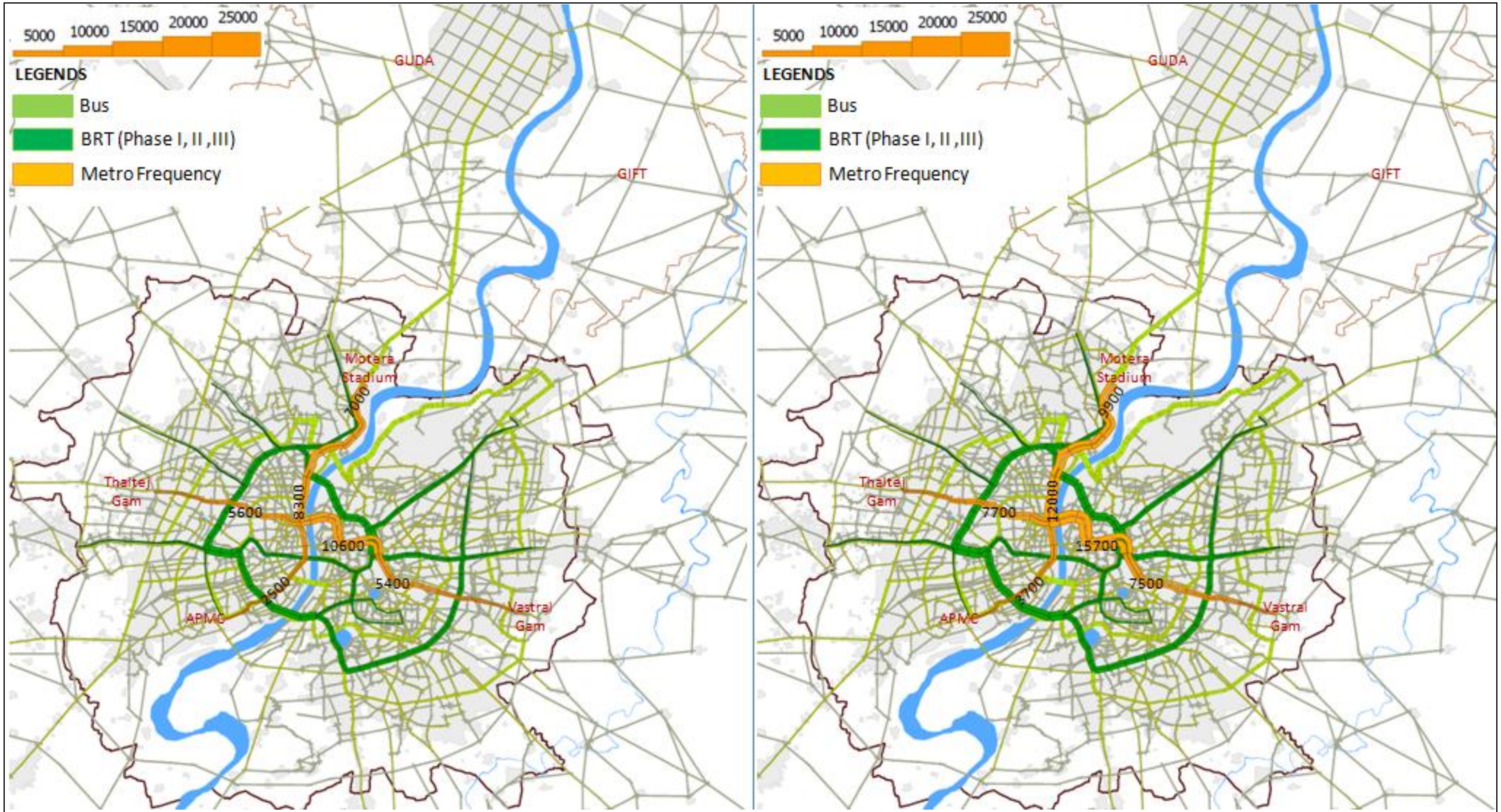
5. Year 2031 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

PT Share in Motorized trips: 40%							
PT Demand:	**2705958**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	2013494	21656198	1304883	45%	1964	**1.64**	10.76
BRT	1498927	13281332	557002	33%	12491		8.86
Metro	930294	7834402	245853	21%	15505		8.42
Total	**4442715**	**42771932**	**2107739**				
PT Trip Length	**15.81**	**km**					

6. Year 2043 – Phase I (Motera-APMC, Thaltej Gam - Vastral Gam) + Phase II Metro Corridors (Motera-Gandhinagar Akshardham, Koba-GIFT city)

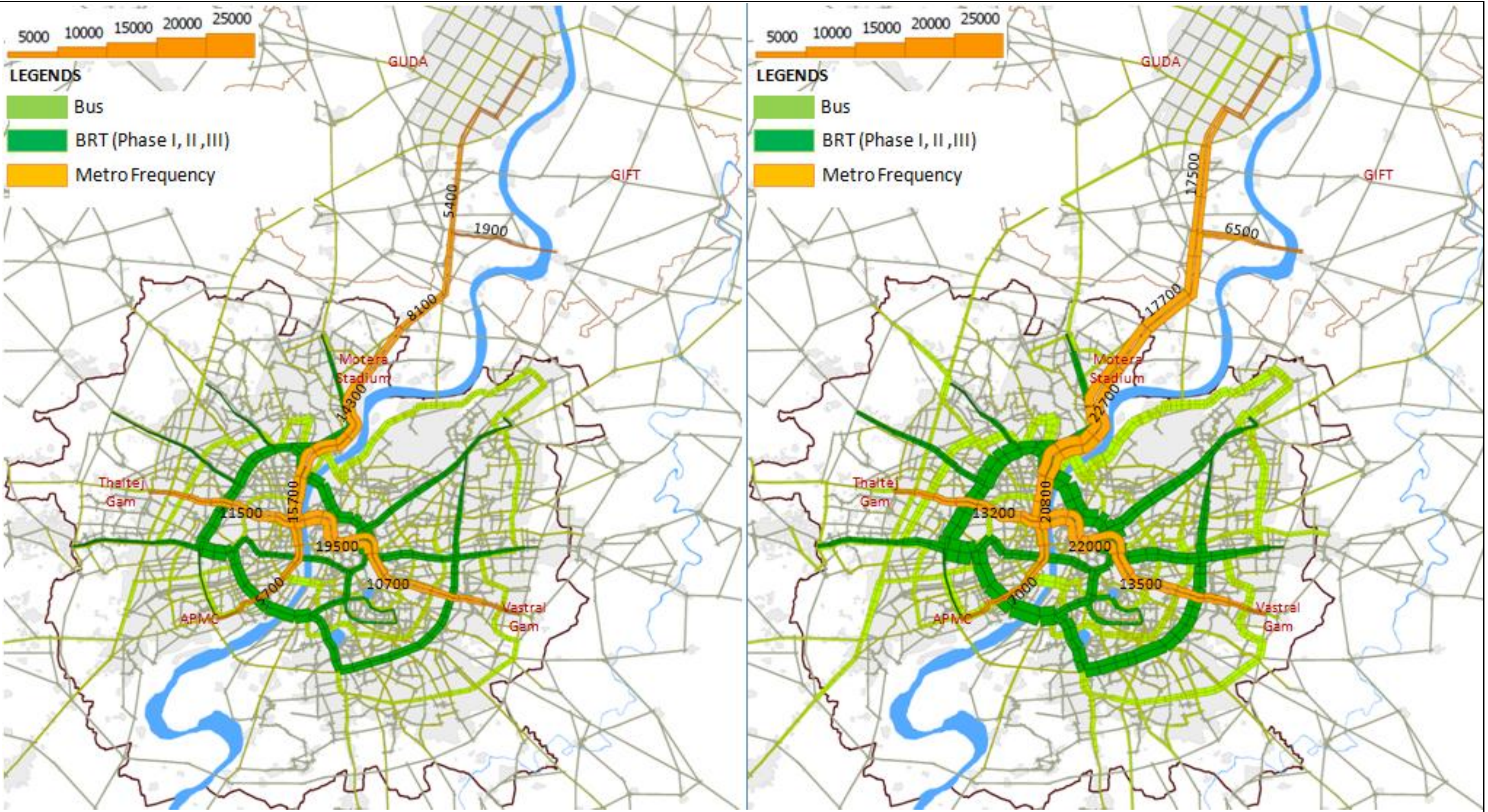
PT Share in Motorized trips: 50%							
PT Demand:	**4974805**						
	Boardings	**Pass. Km**	**Pass. Hr.**	**% Boardings**	**Metro Bo. per km**	**Trans. Rate**	**Trip Leg Length**
Bus	4176601	39608708	2381618	93%	4075	**1.67**	9.48
BRT	2671336	21867443	917112	60%	22261		8.19
Metro	1442392	12176899	382053	32%	24040		8.44
Total	**8290329**	**73653051**	**3680784**				
PT Trip Length	**14.81**	**km**					

Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures.



Year 2018 (Phase I Metro)	Year 2021 (Phase I Metro)

Fig. 2.26 Rapid - Passenger Flows 2018 & 2021 (Phase I)



Year 2031 (Phase I+II Metro)	Year 2043 (Phase I+II Metro)

Fig. 2.27 Rapid - Passenger Flows 2031 & 2043 (Phase I+II)

Peak hour Ridership on Metro - Ph I corridors

C.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	1468	1468	0	1831	1831	0	2490	2490	0	3248	3248	0
Vasna	2088	619	0	2884	1054	0	4286	1796	0	5348	2100	0
Anjali	2564	502	25	3450	605	39	5050	834	70	6083	868	132
Paldi	3335	836	65	4576	1208	81	6685	1746	111	8532	2597	148
Madalpur	4548	1329	116	6189	1775	162	8872	2431	244	11161	2985	355
Nava Gandhigram	5359	878	67	7221	1132	100	10382	1648	139	13194	2197	164
Ashram Road	7597	3780	1542	12096	7337	2462	15242	7908	3047	19367	9544	3372
Usmanpura	7472	564	688	11884	701	912	15016	918	1145	19124	1144	1387
Vadaj	8476	3300	2296	12097	3542	3329	17778	6948	4186	26484	12926	5567
Ranip	7772	162	866	11180	222	1138	16735	380	1423	25506	721	1698
Sabarmati Rail Stn	7411	5	366	10621	13	572	15896	30	869	24618	54	942
AEC	7266	21	165	10359	34	296	15443	62	514	24143	92	567
Sabarmati	6944	28	350	9786	36	608	14818	62	687	23505	112	750
Motera Stadium	0	0	6944	0	0	9786	0	0	14818	0	0	23505
Line 1R Motera Stadium to : APMC												
Motera Stadium	7085	7085	0	9915	9915	0	15127	15127	0	24261	24261	0
Sabarmati	7086	126	125	9932	187	171	15105	291	313	24135	286	412
AEC	7186	113	13	10122	214	23	15430	367	42	24470	404	68

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Sabarmati Rail Stn	7406	263	43	10500	440	62	15999	676	107	25004	704	171
Ranip	7017	501	890	10038	667	1128	14964	855	1889	21375	956	4585
Vadaj	8286	3127	1858	11964	4188	2262	16616	5647	3996	21959	7873	7290
Usmanpura	7721	0	565	11256	0	709	15658	0	958	20692	0	1267
Ashram Road	4638	0	3083	6656	0	4599	9263	0	6395	12441	0	8251
Nava Gandhigram	3928	0	710	5715	0	942	7912	0	1352	10557	0	1884
Madalpur	3042	29	915	4510	50	1254	6213	58	1757	8471	80	2166
Paldi	2484	16	573	3715	24	820	5033	34	1214	6833	45	1683
Anjali	1835	62	712	2715	100	1100	3811	172	1394	4926	273	2180
Vasna	1260	0	574	1738	0	978	2209	0	1602	3012	0	1915
APMC	0	0	1260	0	0	1738	0	0	2209	0	0	3012

C.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	1130	1130	0	1832	1832	0	3726	3726	0	5104	5104	0
Thaltej	2185	1060	5	3359	1535	8	6145	2450	31	7846	2864	122
Drive-in Cinema	2871	688	1	4245	890	4	7410	1283	18	9155	1365	56
Gurukul Road	3994	1153	30	5725	1528	48	9285	1968	93	11079	2119	195
Helmet Cross Road	4841	961	114	6628	1115	212	10346	1573	511	12352	1945	672
Commerce Six Road	5220	419	40	7168	619	78	11090	903	159	13054	958	256
Stadium	5319	204	105	7263	289	194	11188	448	350	13070	483	467
Ashram Road	9720	5038	637	14265	8350	1349	18388	9131	1932	21890	11108	2287
Shahpur	9720	668	669	14099	882	1048	18102	1087	1373	21371	1236	1756
Relief Road	9284	968	1403	13346	1287	2040	17122	1520	2500	20294	1764	2842
Kalupur Rly. Stn.	6543	1643	4384	9042	2080	6383	12862	3690	7950	15457	5464	10300
Kankaria East	5624	65	984	7878	119	1284	11476	168	1554	13922	171	1707
New Cotton Mills	4303	140	1461	6287	234	1826	9629	384	2232	12135	583	2370
Amraiwadi	3465	150	988	5334	302	1254	8545	579	1662	11264	974	1845
Rabari Colony	2757	76	784	4396	142	1080	7404	288	1429	10132	526	1659
Vastral	1151	1	1606	2196	3	2204	4127	12	3288	5907	37	4262
Nirant Cross Rd.	456	11	707	1068	32	1160	2154	74	2048	3388	131	2650
Vastral Gam	0	0	456	0	0	1068	0	0	2154	0	0	3388

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	265	265	0	658	658	0	1336	1336	0	1940	1940	0
Nirant Cross Rd.	984	728	10	1828	1195	25	3397	2104	43	4595	2725	70
Vastral	2578	1594	1	4016	2190	2	6659	3272	10	8798	4237	34
Rabari Colony	3362	886	101	5021	1184	179	7912	1602	349	10165	2021	654
Amraiwadi	4168	927	122	6018	1234	237	9136	1640	417	11426	1854	592
New Cotton Mills	5420	1418	166	7488	1757	287	10898	2194	432	13252	2482	657
Kankaria East	6016	658	62	8330	958	116	11816	1079	160	14322	1221	150
Kalupur Rly. Stn.	10593	5882	1304	15659	9196	1868	19251	10474	3040	22944	13375	4754
Relief Road	10183	1104	1513	15479	1604	1784	18678	1884	2456	22183	2152	2912
Shahpur	9870	546	858	15144	782	1116	18384	1050	1344	22011	1336	1509
Ashram Road	6797	337	3410	9202	0	5942	13249	1097	6232	15609	1212	7614
Stadium	6120	116	792	8369	190	1023	12284	339	1304	14596	443	1456
Commerce Six Road	5678	34	475	7745	62	687	11475	124	933	13804	196	987
Helmet Cross Road	4212	137	1602	6100	275	1920	9291	538	2722	11002	658	3460
Gurukul Road	3056	22	1179	4586	33	1546	7348	56	1999	8930	98	2171
Drive-in Cinema	2161	1	896	3362	4	1228	5678	18	1688	7112	56	1872
Thaltej	818	0	1343	1480	0	1882	2746	0	2933	3557	0	3556
Thaltej Gam	0	0	818	0	0	1480	0	0	2746	0	0	3557

C. Full Day Ridership on Metro – Ph I Corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

D.1. North – South Line (APMC to Motera stadium)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Motera Stadium												
APMC	12481	12481	0	15562	15562	0	21162	21162	0	27608	27608	0
Vasna	17745	5263	0	24517	8956	0	36431	15266	0	45461	17850	0
Anjali	21791	4264	214	29322	5141	333	42925	7086	592	51707	7375	1125
Paldi	28346	7106	551	38899	10265	690	56821	14841	945	72519	22073	1261
Madalpur	38658	11298	986	52605	15086	1380	75415	20662	2071	94867	25371	3019
Nava Gandhigram	45553	7466	571	61377	9625	853	88244	14008	1180	112149	18676	1397
Ashram Road	64576	32133	13110	102813	62366	20927	129560	67218	25898	164618	81127	28659
Usmanpura	63515	4791	5851	101017	5957	7752	127633	7800	9731	162557	9727	11788
Vadaj	72049	28053	19519	102823	30107	28298	151113	59058	35578	225111	109871	47318
Ranip	66059	1374	7364	95033	1884	9676	142249	3230	12097	216798	6127	14436
Sabarmati Rail Stn	62992	44	3114	90280	109	4862	135113	252	7388	209253	459	8007
AEC	61764	180	1404	88050	292	2519	131264	524	4372	205214	782	4818
Sabarmati	59027	235	2975	83181	303	5171	125953	527	5838	199791	949	6372
Motera Stadium	0	0	59027	0	0	83181	0	0	125953	0	0	199791
Line 1R: Motera Stadium to APMC												
Motera Stadium	60221	60221	0	84279	84279	0	128581	128581	0	206217	206217	0
Sabarmati	60234	1074	1061	84419	1588	1452	128394	2472	2659	205146	2428	3499

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
AEC	61084	962	112	86037	1816	194	131155	3121	360	207995	3431	578
Sabarmati Rail Stn	62951	2234	364	89247	3737	527	135990	5746	908	212531	5987	1452
Ranip	59643	4260	7568	85326	5668	9585	127197	7266	16058	181686	8126	38971
Vadaj	70428	26578	15790	101697	35601	19230	141233	48001	33966	186650	66922	61962
Usmanpura	65627	0	4801	95673	0	6025	133093	0	8140	175882	0	10768
Ashram Road	39420	0	26207	56579	0	39093	78734	0	54359	105750	0	70132
Nava Gandhigram	33385	0	6035	48576	0	8004	67249	0	11489	89733	0	16014
Madalpur	25854	245	7776	38335	425	10662	52809	496	14936	72002	680	18411
Paldi	21117	136	4869	31576	207	6967	42782	292	10319	58082	384	14307
Anjali	15596	530	6052	23079	850	9347	32395	1465	11849	41874	2322	18530
Vasna	10713	0	4882	14773	0	8310	18778	0	13617	25599	0	16276
APMC	0	0	10713	0	0	14773	0	0	18778	0	0	25599

D.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	9605	9605	0	15575	15575	0	31671	31671	0	43381	43381	0
Thaltej	18571	9007	41	28550	13046	68	52231	20822	262	66688	24344	1037
Drive-in Cinema	24402	5845	10	36081	7565	34	62985	10907	153	77819	11601	473
Gurukul Road	33946	9799	258	48664	12988	405	78921	16725	789	94170	18010	1659
Helmet Cross Road	41147	8167	966	56335	9476	1805	87944	13369	4345	104989	16531	5712
Commerce Six Road	44370	3560	337	60931	5260	663	94265	7674	1350	110956	8146	2179
Stadium	45213	1737	894	61737	2458	1652	95098	3805	2972	111092	4107	3971
Ashram Road	82620	42826	5416	121251	70978	11465	156295	77615	16419	186068	94418	19441
Shahpur	82617	5678	5685	119840	7500	8911	153864	9238	11669	181655	10509	14926
Relief Road	78914	8225	11927	113438	10938	17340	145537	12920	21247	172496	14994	24154
Kalupur Rly. Stn.	55614	13964	37261	76860	17680	54254	109330	31368	67575	131386	46444	87550
Kankaria East	47801	551	8367	66960	1010	10911	97546	1431	13212	118334	1452	14508
New Cotton Mills	36574	1190	12417	53438	1992	15518	81845	3267	18969	103149	4957	20142
Amraiwadi	29451	1278	8398	45342	2564	10656	72631	4920	14130	95741	8276	15684
Rabari Colony	23433	646	6667	37366	1207	9183	62931	2445	12148	86119	4474	14100
Vastral	9785	7	13651	18663	27	18731	35081	102	27951	50208	313	36224
Nirant Cross Rd.	3873	95	6011	9078	275	9860	18306	632	17405	28801	1115	22522
Vastral Gam	0	0	3873	0	0	9078	0	0	18306	0	0	28801

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	2254	2254	0	5593	5593	0	11353	11353	0	16487	16487	0
Nirant Cross Rd.	8364	6191	82	15541	10156	211	28873	17887	367	39056	23164	592
Vastral	21910	13552	7	34133	18612	20	56603	27815	85	74783	36013	286
Rabari Colony	28580	7528	857	42680	10064	1520	67252	13620	2968	86404	17177	5556
Amraiwadi	35428	7881	1034	51150	10486	2016	77653	13940	3543	97124	15759	5035
New Cotton Mills	46073	12056	1411	63645	14933	2441	92630	18652	3675	112642	21097	5583
Kankaria East	51133	5590	527	70805	8146	983	100439	9170	1357	121740	10377	1278
Kalupur Rly. Stn.	90039	49994	11087	133103	78169	15875	163635	89032	25840	195021	113689	40406
Relief Road	86557	9381	12862	131570	13634	15167	158763	16011	20879	188557	18289	24752
Shahpur	83895	4638	7296	128727	6647	9489	156261	8925	11427	187092	11359	12825
Ashram Road	57773	2866	28988	78217	0	50510	112615	9326	52972	132675	10299	64716
Stadium	52020	983	6735	71138	1615	8694	104411	2880	11084	124066	3767	12379
Commerce Six Road	48266	286	4039	65834	530	5838	97539	1057	7932	117337	1663	8391
Helmet Cross Road	35805	1163	13620	51847	2336	16320	78975	4570	23134	93517	5590	29410
Gurukul Road	25979	190	10020	38981	282	13144	62461	479	16993	75902	833	18452
Drive-in Cinema	18370	10	7619	28577	34	10441	48266	153	14351	60455	473	15915
Thaltej	6956	0	11414	12583	0	15994	23338	0	24929	30236	0	30223
Thaltej Gam	0	0	6956	0	0	12583	0	0	23338	0	0	30236

D. Peak hour Ridership on Metro - Ph I+II corridors

E.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	1468	1468	0	1831	1831	0	2429	2429	0	3194	3194	0
Vasna	2088	619	0	2884	1054	0	4223	1794	0	5312	2118	0
Anjali	2564	502	25	3450	605	39	5680	1527	70	6058	879	132
Paldi	3335	836	65	4576	1208	81	7309	1739	110	8517	2606	148
Madalpur	4548	1329	116	6189	1775	162	9805	2737	241	11538	3374	353
Nava Gandhigram	5359	878	67	7221	1132	100	11324	1657	138	13592	2217	164
Ashram Road	7597	3780	1542	12096	7337	2462	16334	7723	2714	19452	8774	2913
Usmanpura	7472	564	688	11884	701	912	16134	945	1145	19276	1143	1319
Vadaj	8476	3300	2296	12097	3542	3329	16335	4518	4317	24406	10383	5253
Ranip	7772	162	866	11180	222	1138	15930	916	1320	25192	2264	1477
Sabarmati Rail Stn	7411	5	366	10621	13	572	15262	115	783	24529	186	849
AEC	7266	21	165	10359	34	296	14823	64	504	24075	96	551
Sabarmati	6944	28	350	9786	36	608	14299	77	601	23584	139	630
Motera Stadium	0	0	6944	0	0	9786	9150	955	6103	19386	3840	8038
Motera Gam	-	-	-	-	-	-	8519	124	755	18278	544	1651
Tapovan Ring road	-	-	-	-	-	-	8025	28	522	17774	673	1177
Koba Circle	-	-	-	-	-	-	7532	23	516	16966	449	1257
Koba Village	-	-	-	-	-	-	7202	8	338	16425	188	728
PDPU Approch	-	-	-	-	-	-	5391	174	1986	13036	2098	5487

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Randesan	-	-	-	-	-	-	5128	19	282	12700	296	632
CH-0	-	-	-	-	-	-	3525	0	1603	8374	0	4326
CH-3	-	-	-	-	-	-	1583	0	1942	3892	0	4482
Sachivalay	-	-	-	-	-	-	1211	2	374	3066	20	846
Sector-21	-	-	-	-	-	-	482	0	729	1392	0	1674
Akhardham	-	-	-	-	-	-	0	0	482	0	0	1392
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	589	589	0	1616	1616	0
Sector-21	-	-	-	-	-	-	970	382	0	2559	949	6
Sachivalay	-	-	-	-	-	-	1319	352	3	3352	816	23
CH-3	-	-	-	-	-	-	3482	2196	33	9000	5804	156
CH-0	-	-	-	-	-	-	4330	1082	234	11150	3832	1682
Randesan	-	-	-	-	-	-	4578	262	12	11463	607	294
PDPU Approch	-	-	-	-	-	-	6398	1965	146	14962	5385	1886
Koba Village	-	-	-	-	-	-	6711	318	6	15481	701	181
Koba Circle	-	-	-	-	-	-	7109	412	13	16077	994	398
Tapovan Ring road	-	-	-	-	-	-	7511	435	34	16377	877	576
Motera Gam	-	-	-	-	-	-	8160	754	105	17570	1571	379
Motera Stadium	7085	7085	0	9915	9915	0	13708	6250	702	4679	1594	453
Sabarmati	7086	126	125	9932	187	171	13567	272	414	4577	49	151
AEC	7186	113	13	10122	214	23	13881	359	45	4629	66	14
Sabarmati Rail Stn	7406	263	43	10500	440	62	14451	674	104	4715	120	34
Ranip	7017	501	890	10038	667	1128	13778	878	1550	4240	194	668

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Vadaj	8286	3127	1858	11964	4188	2262	15664	5662	3776	4203	1504	1542
Usmanpura	7721	0	565	11256	0	709	14760	0	904	3949	0	253
Ashram Road	4638	0	3083	6656	0	4599	9226	0	5534	2437	0	1513
Nava Gandhigram	3928	0	710	5715	0	942	8004	0	1221	2092	0	344
Madalpur	3042	29	915	4510	50	1254	6305	0	1700	1664	0	428
Paldi	2484	16	573	3715	24	820	5168	34	1171	1345	8	328
Anjali	1835	62	712	2715	100	1100	3908	172	1432	990	41	395
Vasna	1260	0	574	1738	0	978	2271	0	1637	669	0	322
APMC	0	0	1260	0	0	1738	0	0	2271	0	0	669

E.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	1130	1130	0	1832	1832	0	3621	3621	0	5042	5042	0
Thaltej	2185	1060	5	3359	1535	8	5707	2118	32	7395	2478	125
Drive-in Cinema	2871	688	1	4245	890	4	6883	1194	18	8598	1258	56
Gurukul Road	3994	1153	30	5725	1528	48	8644	1853	92	10399	1996	195
Helmet Cross Road	4841	961	114	6628	1115	212	9550	1418	511	11520	1749	628
Commerce Six Road	5220	419	40	7168	619	78	10204	813	158	12202	938	256
Stadium	5319	204	105	7263	289	194	10282	428	350	12236	501	467
Ashram Road	9720	5038	637	14265	8350	1349	16064	7663	1881	19397	9384	2224
Shahpur	9720	668	669	14099	882	1048	15740	1050	1374	18753	1065	1708
Relief Road	9284	968	1403	13346	1287	2040	14705	1440	2474	18785	2840	2808
Kalupur Rly. Stn.	6543	1643	4384	9042	2080	6383	12870	3690	5525	15538	4981	8227
Kankaria East	5624	65	984	7878	119	1284	11492	168	1546	14195	164	1508
New Cotton Mills	4303	140	1461	6287	234	1826	9642	384	2235	12444	583	2334
Amraiwadi	3465	150	988	5334	302	1254	8567	579	1653	11573	974	1844
Rabari Colony	2757	76	784	4396	142	1080	7424	288	1431	10282	526	1818
Vastral	1151	1	1606	2196	3	2204	4140	12	3297	6022	37	4296
Nirant Cross Rd.	456	11	707	1068	32	1160	2158	74	2056	3438	131	2715
Vastral Gam	0	0	456	0	0	1068	0	0	2158	0	0	3438

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	265	265	0	658	658	0	1347	1347	0	1862	1862	0
Nirant Cross Rd.	984	728	10	1828	1195	25	3416	2112	43	4582	2760	39
Vastral	2578	1594	1	4016	2190	2	6662	3255	10	8804	4254	34
Rabari Colony	3362	886	101	5021	1184	179	7825	1513	349	10220	2017	601
Amraiwadi	4168	927	122	6018	1234	237	8976	1567	417	11595	1808	432
New Cotton Mills	5420	1418	166	7488	1757	287	10643	2100	432	13427	2420	588
Kankaria East	6016	658	62	8330	958	116	11618	1134	160	14536	1256	148
Kalupur Rly. Stn.	10593	5882	1304	15659	9196	1868	19428	10503	2692	21956	12548	5127
Relief Road	10183	1104	1513	15479	1604	1784	18790	1817	2455	20932	1812	2837
Shahpur	9870	546	858	15144	782	1116	18495	1049	1344	20942	1331	1320
Ashram Road	6797	337	3410	9202	0	5942	13327	1085	6253	15083	1220	7079
Stadium	6120	116	792	8369	190	1023	12350	330	1306	14062	429	1449
Commerce Six Road	5678	34	475	7745	62	687	11544	128	933	13278	198	983
Helmet Cross Road	4212	137	1602	6100	275	1920	9360	538	2722	10808	658	3127
Gurukul Road	3056	22	1179	4586	33	1546	7448	58	1971	8756	100	2151
Drive-in Cinema	2161	1	896	3362	4	1228	5785	18	1681	6992	56	1820
Thaltej	818	0	1343	1480	0	1882	2762	0	3023	3583	0	3408
Thaltej Gam	0	0	818	0	0	1480	0	0	2762	0	0	3583

E. Full Day Ridership on Metro – Ph I+II Corridors

(Note: Outputs based on 3hr AM peak model. An expansion factor of 3.4 has been applied to convert 3hr figures to full day figures)

F.1. North – South Line (APMC to Akshardham)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 1: APMC to Akshardham												
APMC	12481	12481	0	15562	15562	0	20648	20648	0	27149	27149	0
Vasna	17745	5263	0	24517	8956	0	35894	15246	0	45152	18003	0
Anjali	21791	4264	214	29322	5141	333	48283	12981	592	51496	7470	1125
Paldi	28346	7106	551	38899	10265	690	62125	14780	938	72396	22154	1258
Madalpur	38658	11298	986	52605	15086	1380	83341	23266	2050	98070	28679	3002
Nava Gandhigram	45553	7466	571	61377	9625	853	96251	14086	1176	115529	18846	1391
Ashram Road	64576	32133	13110	102813	62366	20927	138836	65647	23066	165345	74579	24762
Usmanpura	63515	4791	5851	101017	5957	7752	137139	8034	9731	163846	9714	11213
Vadaj	72049	28053	19519	102823	30107	28298	138849	38406	36696	207448	88254	44652
Ranip	66059	1374	7364	95033	1884	9676	135408	7783	11223	214135	19244	12556
Sabarmati Rail Stn	62992	44	3114	90280	109	4862	129730	976	6654	208498	1584	7218
AEC	61764	180	1404	88050	292	2519	125997	547	4281	204636	816	4682
Sabarmati	59027	235	2975	83181	303	5171	121543	656	5110	200461	1180	5355
Motera Stadium	0	0	59027	0	0	83181	77778	8116	51877	164778	32637	68320
Motera Gam	-	-	-	-	-	-	72413	1051	6419	155366	4624	14035
Tapovan Ring road	-	-	-	-	-	-	68214	238	4434	151082	5719	10003
Koba Circle	-	-	-	-	-	-	64025	194	4386	144211	3818	10686
Koba Village	-	-	-	-	-	-	61220	68	2870	139614	1598	6191

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
PDPU Approch	-	-	-	-	-	-	45825	1482	16878	110809	17836	46641
Randesan	-	-	-	-	-	-	43591	160	2394	107950	2516	5372
CH-0	-	-	-	-	-	-	29964	0	13627	71179	0	36771
CH-3	-	-	-	-	-	-	13454	0	16510	33079	0	38100
Sachivalay	-	-	-	-	-	-	10292	17	3179	26061	173	7194
Sector-21	-	-	-	-	-	-	4094	0	6198	11829	0	14232
Akhardham	-	-	-	-	-	-	0	0	4094	0	0	11829
Line 1R: Akshardham to APMC												
Akhardham	-	-	-	-	-	-	5005	5005	0	13739	13739	0
Sector-21	-	-	-	-	-	-	8248	3244	0	21753	8065	51
Sachivalay	-	-	-	-	-	-	11210	2989	27	28495	6933	194
CH-3	-	-	-	-	-	-	29594	18666	282	76503	49334	1326
CH-0	-	-	-	-	-	-	36802	9200	1992	94775	32572	14300
Randesan	-	-	-	-	-	-	38916	2224	105	97434	5161	2502
PDPU Approch	-	-	-	-	-	-	54380	16704	1241	127174	45771	16034
Koba Village	-	-	-	-	-	-	57042	2706	48	131590	5957	1540
Koba Circle	-	-	-	-	-	-	60428	3499	109	136653	8446	3386
Tapovan Ring road	-	-	-	-	-	-	63845	3699	286	139206	7456	4899
Motera Gam	-	-	-	-	-	-	69360	6409	891	149345	13355	3220
Motera Stadium	60221	60221	0	84279	84279	0	116518	53125	5964	193140	69697	25901
Sabarmati	60234	1074	1061	84419	1588	1452	115318	2315	3516	189972	2258	5430
AEC	61084	962	112	86037	1816	194	117987	3053	381	192630	3288	629
Sabarmati Rail Stn	62951	2234	364	89247	3737	527	122832	5726	884	197186	6001	1445

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Ranip	59643	4260	7568	85326	5668	9585	117113	7463	13178	180275	8415	25330
Vadaj	70428	26578	15790	101697	35601	19230	133144	48124	32093	177545	67334	70064
Usmanpura	65627	0	4801	95673	0	6025	125460	0	7687	166916	0	10628
Ashram Road	39420	0	26207	56579	0	39093	78418	0	47042	103714	0	63203
Nava Gandhigram	33385	0	6035	48576	0	8004	68037	0	10377	89111	0	14603
Madalpur	25854	245	7776	38335	425	10662	53591	0	14450	71257	0	17853
Paldi	21117	136	4869	31576	207	6967	43928	292	9955	59531	384	12107
Anjali	15596	530	6052	23079	850	9347	33218	1465	12172	43095	2322	18761
Vasna	10713	0	4882	14773	0	8310	19302	0	13916	26554	0	16541
APMC	0	0	10713	0	0	14773	0	0	19302	0	0	26554

F.2. East – West Line (Thaltej Gam to Vastral Gam)

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2: Thaltej Gam to Vastral Gam												
Thaltej Gam	9605	9605	0	15575	15575	0	30780	30780	0	42854	42854	0
Thaltej	18571	9007	41	28550	13046	68	48511	18000	272	62859	21066	1061
Drive-in Cinema	24402	5845	10	36081	7565	34	58507	10152	153	73083	10693	473
Gurukul Road	33946	9799	258	48664	12988	405	73471	15749	785	88390	16966	1656
Helmet Cross Road	41147	8167	966	56335	9476	1805	81178	12050	4345	97920	14865	5335
Commerce Six Road	44370	3560	337	60931	5260	663	86737	6909	1346	103720	7976	2176
Stadium	45213	1737	894	61737	2458	1652	87397	3635	2972	104006	4257	3971
Ashram Road	82620	42826	5416	121251	70978	11465	136541	65134	15990	164873	79767	18901
Shahpur	82617	5678	5685	119840	7500	8911	133787	8922	11676	159402	9054	14521
Relief Road	78914	8225	11927	113438	10938	17340	124991	12237	21032	159671	24140	23871
Kalupur Rly. Stn.	55614	13964	37261	76860	17680	54254	109395	31362	46961	132076	42337	69931
Kankaria East	47801	551	8367	66960	1010	10911	97685	1431	13141	120659	1397	12818
New Cotton Mills	36574	1190	12417	53438	1992	15518	81954	3267	18996	105771	4957	19842
Amraiwadi	29451	1278	8398	45342	2564	10656	72821	4920	14052	98369	8276	15677
Rabari Colony	23433	646	6667	37366	1207	9183	63107	2445	12162	87394	4474	15453
Vastral	9785	7	13651	18663	27	18731	35187	102	28023	51190	313	36519
Nirant Cross Rd.	3873	95	6011	9078	275	9860	18343	632	17476	29226	1115	23079
Vastral Gam	0	0	3873	0	0	9078	0	0	18343	0	0	29226

Stop Name	2018			2021			2031			2043		
	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight	Link Load	Board	Alight
Line 2R: Vastral Gam to Thaltej Gam												
Vastral Gam	2254	2254	0	5593	5593	0	11451	11451	0	15824	15824	0
Nirant Cross Rd.	8364	6191	82	15541	10156	211	29039	17955	367	38950	23463	333
Vastral	21910	13552	7	34133	18612	20	56624	27669	85	74831	36162	286
Rabari Colony	28580	7528	857	42680	10064	1520	66514	12859	2968	86867	17143	5107
Amraiwadi	35428	7881	1034	51150	10486	2016	76293	13321	3543	98559	15368	3672
New Cotton Mills	46073	12056	1411	63645	14933	2441	90467	17850	3675	114131	20567	4998
Kankaria East	51133	5590	527	70805	8146	983	98750	9639	1357	123556	10679	1255
Kalupur Rly. Stn.	90039	49994	11087	133103	78169	15875	165138	89274	22882	186629	106658	43581
Relief Road	86557	9381	12862	131570	13634	15167	159718	15443	20866	177919	15399	24113
Shahpur	83895	4638	7296	128727	6647	9489	157206	8915	11427	178004	11312	11223
Ashram Road	57773	2866	28988	78217	0	50510	113278	9221	53149	128204	10373	60173
Stadium	52020	983	6735	71138	1615	8694	104975	2802	11104	119527	3645	12318
Commerce Six Road	48266	286	4039	65834	530	5838	98127	1085	7932	112860	1686	8357
Helmet Cross Road	35805	1163	13620	51847	2336	16320	79560	4570	23137	91868	5590	26581
Gurukul Road	25979	190	10020	38981	282	13144	63305	496	16752	74429	847	18285
Drive-in Cinema	18370	10	7619	28577	34	10441	49171	153	14290	59432	473	15470
Thaltej	6956	0	11414	12583	0	15994	23477	0	25694	30457	0	28971
Thaltej Gam	0	0	6956	0	0	12583	0	0	23477	0	0	30457

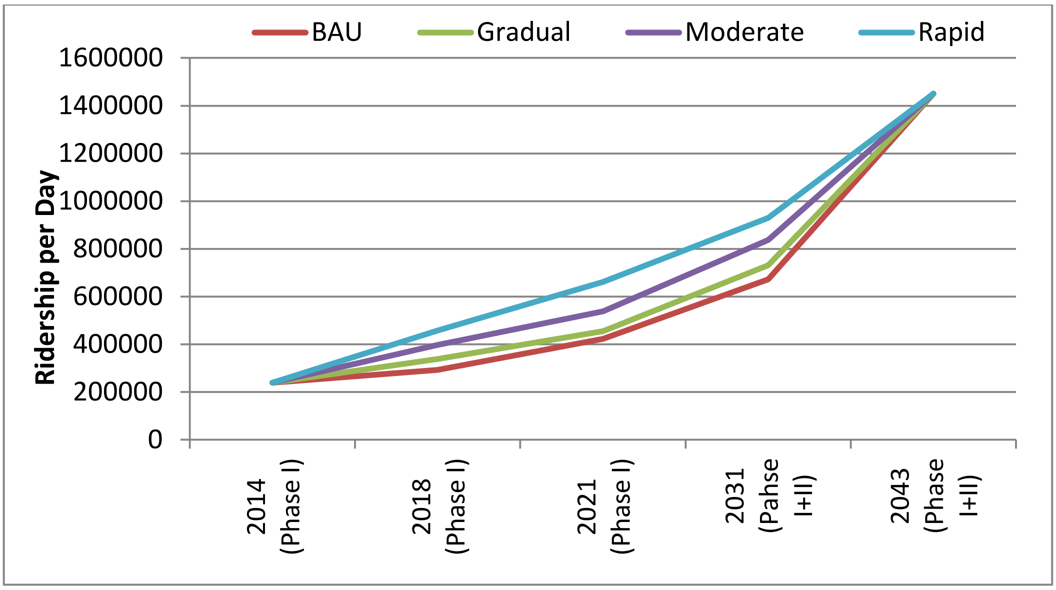
2.6 Summary

The demand forecasting exercise was carried out for four scenarios depending on different land use growth alternatives and build up public transport ridership.

The following table summarises the metro boarding in different scenarios and for different forecast years. It can be seen that by the horizon year of 2043, around 14.4 lakh boardings on metro is expected.

Scenarios	Year					
	2018 (Phase I)	2021 (Phase I)	2031 (Phase I)	2043 (Phase I)	2031 (Phase I+II)	2043 (Phase I+II)
Business As Usual	293172	422749	606067	1243598	672336	1442392
Gradual	339136	454719	680105	1243598	731214	1442392
Moderate	397929	537792	811237	1243598	837383	1442392
Rapid	457664	661606	922855	1243598	930294	1442392

The Figure below shows the buildup of metro ridership under different scenarios, from commissioning year to horizon year.



In terms of metro boarding/s per km, it is expected that by the horizon year it would have 24000 boardings/km, which is quite high in comparison to other metro cities across the world.

Metro boardings/km

Scenarios	Year					
	2018 (Phase I)	2021 (Phase I)	2031 (Phase I)	2043 (Phase I)	2031 (Phase I+II)	2043 (Phase I+II)
Business As Usual	8329	12010	17218	35329	11206	24040
Gradual	9635	12918	19321	35329	12187	24040
Moderate	11305	15278	23046	35329	13956	24040
Rapid	13002	18796	26217	35329	15505	24040

The major stations on Phase I metro corridors are presented in the tables hereabove. It can be seen that stations at Kalupur, Ashram road on East West Line and Ashram road, Vadaj and Motera on North-South line will have very high boarding levels.

Chapter - 3

System Selection

Chapter - 3

SYSTEM SELECTION

3.1 OPTIONS FOR PUBLIC TRANSPORT SYSTEM

The following systems are mainly available for Urban Mass Transit:

i) **High Capacity Metro System:** Metro system is a grade separated dedicated system for high peak hour traffic densities exceeding 40,000 PHPDT. It is characterized by short distances of stations spaced at 1 km, high acceleration and declaration and average speeds of 30-35 kmph.

ii) **Light Capacity Metro System:** This is a dedicated metro rail system for moderate peak hour traffic densities exceeding 8000 PHPDT.

iii) **Light Rail Transit:** Modern trams-Street Cars running on Rails at grade or elevated with sharp curves of 24m radius. These are extremely popular and operating in large number of European countries. Generally the stations are spaced at 500m to 1 km and have high acceleration and deceleration characteristics. In most of the countries, they are operating at-grade with prioritized signaling at road inter-section.

iv) **Sky Train:** This is an experimental rail based system under development by Konkan Railway.

v) **Other Rail Based Systems:** A number of options are available but have not been introduced in India. Some of these are very briefly mentioned below:

(a) Maglev

This is an advanced Rail based transit system in which Magnetic Levitation is used to raise the vehicles above the rail surface. Rail wheel interaction is thus avoided and very high speeds are attainable. Maglev Levitation can either be due to attractive force or due to repulsive forces.

(b) Linear Induction Motor (LIM) Train

This is also an advanced Rail based transit system in which propulsion is through a Linear Induction Motor whose stator is spread along the track. The rotor is a magnetic material provided in the under frame of train. In the technology the tractive force is not transmitted through rail-wheel interaction, and so there is no limitation on account of adhesion. This technology is most appropriate for turnouts, as the height of the tunnel can be reduced to lower height of cars.

(c) Monorail

Monorail trains operate on grade separated dedicated corridors with sharp curves of up to 50m radius. This is a rubber tyred based rolling stock, electrically propelled on concrete beams known as guide-ways. The system is extremely suitable in narrow corridors as it requires minimum right of way on existing roads and permits light and air and is more environmental friendly. This is prevalent in several countries for traffic densities of over 20,000 PHPDT.

(d) Bus Rapid Transit System

This system involves operation of buses on a dedicated corridor (except of traffic integration) at a high frequency to achieve PHPDT. For providing a very high transport capacity say 20,000 PHPDT, about 200 buses shall be required per hour *i.e.,* at headway of 20 seconds. Such a high PHPDT can be achieved by providing two lanes of traffic in each direction and elimination of traffic intersection on the route.

(e) Automated Guide way Transit System

The term is used for systems other than conventional rail based system on grade separated guide ways. The system can be rail based or rubber tire based but fully automated guided systems with driver less operation.

The salient features of the various Transit Systems are summarized as under**:-**

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
Exterior of Vehicle	 It is a transport system that runs on the exclusive beam slab track mainly built over highways.	 It is a new transport system that runs on the exclusive track built on elevated structure with lightweight vehicle.	 It is a new transport system that runs straddling on the exclusive beam track mainly built over highways.
Rolling stock			
Length (m)	30.0 (articulated type)		
Width (m)	2.5		
Height (m)	3.7		
Number of doors	3		
Wheel arrangement	2-2-2		
Weight (tare) (ton)	44		
Axle load (max)	10tf		
Type of car load	Concentrated load	Concentrated load	Concentrated load
Running gear and track structure			
Traction system	Rotary Motor and steel wheel	Rotary Motor and rubber tire	Rotary Motor and rubber tire
Brake system	Electric brake and hydraulic brake	Electric brake and air brake	Electric brake and air brake
Guidance System	Steel rail	Lateral pinched Guidance	Guide Wheel (Rubber)
Power collector	Catenary	Conductor rail	Conductor rail
Voltage	D.C. 750 V	A.C. 750 V (three phase)	D.C. 1,500 V
Track	Steel rail	Concrete slab	Track beam
Switch			
constitution	Switch and crossing	Lateral pinched switch	Flexure track beam
The Operation Characteristics			
Maximum speed	80 km/h	80 km/h	80 km/h
Schedule speed	30 km/h	30 km/h	30 km/h
Minimum curve radius	30m	30m	70m
Maximum gradient	4 %	6 %	6 %

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
Acceleration	3.5km/h/s	3.5km/h/s	3.5km/h/s
Deceleration Service brake	3.5km/h/s	4.8km/h/s	4.0km/h/s
Emergency brake	4.5km/h/s	6.0km/h/s	4.5km/h/s
Automatic Train operation	There is few example of it.	It has been developed aiming for automated operation. There are many examples of automated operation including driverless operation.	There are three cases of ATO operation in Japan.
Transportation capacity			
1 car seat	60		45
standing	90		60
total	150 (30m)	60 (L=9m)	105 (L=15m)
4 car seat	120		180
standing	180		240
total	300 (30m+30m)	360 (6 car L=54m)	420 (L=60m)
8 car seat	240		360
standing	360		480
total	600 (30m+30m+30m+30m)	720 (12 car L=108m)	840 (L=120m)
8 car PHPDT (170% , headway 2.5 min)	24,480	17,300 (100%)	34,300
	It is possible to deal with over 24,480 PHPDT of demand. (train length 120m)	It is possible to deal with up to 11,600 PHPDT of demand. (train length 108m)	It is possible to deal with over 34,300 PHPDT of demand. (train length 120m)
Structure			
Superstructure	Concrete slab	Concrete slab	Track beam
Pier and foundation	Concrete	Concrete	Concrete
Maintainability & cost			
Track	In addition to grinding of surface of rails, track maintenance work will require much time.	It has small maintenance of track.	It has small maintenance of track.
Vehicle	Maintenance of rotary motor and grinding of steel wheels shall be necessary.	Maintenance of rotary motor and exchange of rubber tires after every 120,000 km running shall be necessary.	Maintenance of rotary motor and exchange of rubber tires after every 120,000 km running shall be necessary.
Effect on ambient			

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
surrounding and harmony with urban landscape			
Effect on ambient surrounding	Its noiseproof wheels make as small noise as rubber tires make.	Level Crossing between AGT and road is not available. This system, with rubber tires, makes small noise and vibration. Because its running surfaces are made of concrete slab, there remain problems like inhibition of sunshine or radio disturbance.	This system, with rubber tires, makes small noise and vibration.
urban landscape	This system is inferior to other systems in terms of landscape because overhead wires for power collection must be installed.	Because its superstructure is made of concrete slab, oppressing feeling of view is an issue.	This system is superior to AGT or LIM Train in terms of landscape because its superstructure consists of only track beams that have small section.
Emergency evacuation			
	Evacuation other train (end to end or side by side)	Evacuation other train (end to end or side by side)	Evacuation other train (end to end or side by side)
	Walk way	Walk way	Evacuation device
	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	In this system, supporting vehicles are needed for passengers' emergency evacuation, which is of no matter because this straddle type system have many actual performances of running in Japan and has a established method for rescue.
Operation cost			
Electric energy			2.2kwh/car-km
Rolling stock cost			
/ car			7.5 Crors

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
Exterior of Vehicle	 **It is a new transport system that runs on the exclusive beam slab track mainly built over highways.**	 **It is Medium to Heavy Rail Transit (HRT) is a specialized electrically powered rail system carrying passengers within urban areas,**	 **It is a bus operation generally characterized by use of exclusive or reserved rights-of-way (bus ways) that permit higher speeds and avoidance of delays from general traffic flows.**
Rolling stock			
Length (m)			18 (articulated type)
Width (m)			2.0
Height (m)			3.5
Number of doors			2
Wheel arrangement	5 module / car	2-2 or 3-3	Independent Axles
Weight (tare) (ton)	15.0	41	12 to 16
Axle load (max)	2.3tf/m	17tfm	9tf to 15.3tf
Type of car load	Uniform load	Concentrated l.oad	Concentrated load
Running gear and track structure			
Traction system	Linear Induction Motor and Electromagnetic levitation system	Rotary Motor and steel wheel	Rubber tyre
Brake system	Electric brake and air brake	Electric brake and hydraulic brake and Regenerative brakes	Hydraulic Brakes
Guidance System	Electromagnetic levitation system	Steel Rail	None/ special guide wheels on kerbs
Power collector	Conductor rail	Catenary or Conductor rail	Not applicable
Voltage	D.C. 1,500 V	D.C. 1500 V, A.C. 25kv	None
Track	Steel rail (Electromagnetic levitation system)	Steel rail	Road
Switch			
constitution	Flexure track beam	Switch and crossing	Road Crossings
The Operation Characteristics			

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
Maximum speed	80 km/h	80 to 100 km/h	80 km/h
Schedule speed	30 km/h	35 km/h	20 km/h
Minimum curve radius	50m	100m	12m
Maximum gradient	6 %	6 %	
Acceleration	3.5km/h/s	3.5km/h/s	
Deceleration Service brake	3.5km/h/s	3.5km/h/s	
Emergency brake	4.5km/h/s	4.5km/h/s	
Automatic Train operation	There are cases of ATO operation in Nagoya Japan.	Automatic Train operation	No
Transportation capacity			
1 car seat	32	75	70
standing	42	125	40
total	74 (L=14m)	200(L=24m)	110(L=18)
4 car seat	128	300	
standing	172	500	
total	300 (L=56m)	800(L=96m)	
8 car seat	256	600	
standing	344	1000	
total	600 (L=112m)	1600(L=192m)	
8 car PHPDT (170%, headway 2.5 min)	23,100 (max 160%)	50,000	
	It is possible to deal with over 23,100 PHPDT of demand. (train length 112m)	It is possible to deal with over 50,000 PHPDT of demand. (train length 112m)	It is possible to deal with max 6,000 PHPDT of demand.
Structure			
Superstructure	Concrete slab	Concrete slab	Roads
Pier and foundation	Concrete	Concrete	
Maintainability & cost			
Track	It has less maintenance of track as there is less physical movement.	It has less maintenance of track.	It requires maintenance of roads.
Vehicle	As it has no rotary motor, it is excellent on maintenance.	Maintenance of rotary motor and grinding of steel wheels shall be necessary.	Maintenance of engine and rubber tyres shall be necessary.
Effect on ambient surrounding and			

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
harmony with urban landscape			
Effect on ambient surrounding	There remain problems like inhibition of sunshine or radio disturbance, because its running surfaces are made of concrete slab.	This system is noisy due to steel wheel arrangement	Noise and Pollution Problems
urban landscape	This system is inferior to other systems in terms of landscape because overhead wires for power collection must be installed.	Because its superstructure is made of concrete slab, oppressing feeling of view is an issue. This system is inferior to other systems in terms of landscape because overhead wires for power collection must be installed.	No such issues
Emergency evacuation			
	Evacuation other train (end to end or side by side)	Evacuation other train (end to end or side by side)	No problems
	Walk way	Walk way	
	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	
Operation cost			
Electric energy	2.5kwh/car-km		
Rolling stock cost			
/ car		6 to 9 Crores	Few Lakhs

3.2 CAPACITY OF VARIOUS MODES (as per the recommendations of Working Group on Urban Transport for 12th Five Year Plan)

In their report **on Urban Transport for 12th Five Year Plan**, the Working Group has set the guidelines for the choice of different modes are as follows:

Table 3.1

SYSTEM	PHPDT IN 2021	POPULATION IN 2011	AVG. TRIP LENGTH
Metro Rail #	>=15000 for at least 5km continuous length	More than 20 Lakhs	More than 7 Km
LRT primarily at grade	=<10,000	More than 10 Lakhs	More than 7 Km
Monorail @@	=<10,000	More than 20 Lakhs	About 5-6 Km
Bus Rapid Transit System	>=4,000 and upto 20000	More than 10 Lakhs	>5 Km
Organised City Bus Service as per urban bus specifications		>1 lac, >50,000 in case of hilly towns	>2 to 3 Km

 # for having Metro Rail, the city should have a ridership of at least 1 million on organized public transport (any mode)

@@ Monorail is desirable only as a feeder system or where the narrow roads are flanked on either side by high rise buildings. In monorail while the cost of construction, operation and maintenance is almost the same as elevated metro rail, the carrying capacity is much lesser.

3.2 Selection of a particular mode for any pre-determined traffic corridor depends mainly on demand level of a corridor, Right of Way (ROW) on the road and the capacity of the mode. The demand forecast is estimated considering the traffic growth for about 30 years. Other considerations in mode choice are location of building lines, possibility of increasing ROW. Cost of some mode may vary depending up on the location in view of engineering constraints. Therefore final choice of mode to be adopted for a particular corridor is based on techno economic considerations. As regards the location of a particular mode like at-grade, elevated and underground depends up on the ROW. If ROW is 20m or more, elevated alignment is preferred over underground as the cost of underground alignment is 2- 2½ times of elevated alignment

3.3 DAILY RIDERSHIP ON AHMEDABAD METRO CORRIDORS IN HORIZON YEARS

Daily ridership on the Ahmedabad metro rail network in 2021 is expected to be 4.6 lakh passengers. The average trip length will be 6.68km in year 2021. Corridor wise total daily ridership for the years 2021, 2031 and 2043 and PHPDT are shown in **Table 3.2.**

Table 3.2 - Corridor wise Daily Ridership and PHPDT

Daily ridership				
Corridor/Year	**2018**	**2021**	**2031**	**2043**
North South Corridor	210928	299824	429074	624492
East West Corridor	246743	361780	493781	619118
Total	**457671**	**661604**	**922855**	**1243610**
PHPDT				
Corridor/Year	**2018**	**2021**	**2031**	**2043**
North South Corridor	8476	12097	17778	26484
East West Corridor	10593	15659	19251	22944

3.5 MODE SELECTION

Road-based transit systems can optimally carry up to a maximum of 8,000 PHPDT. With an aim of reduction in road traffic and with the PHPDT of more than 8000 assumed on the above corridors, there can be two options namely 1) Mono Rail and 2) Light Capacity Metro. Mono rail can carry the PHPDT projected but this technology is not a tested one. The operation and maintenance cost is much higher that Light metro. The capital cost of Mono rail is also almost same as that of Light Metro with no experience of Mono rail in India. Even in the other countries, the Mono rail is being adopted only for small lengths and as feeder to Metro. Further part of the East West corridor is underground as there is not sufficient ROW to accommodated elevated transit system and underground monorail is more costlier than metro rail as it requires larger diameter of tunnel.

Moreover, if metro system is in place by 2018, the daily and peak hourly traffic on various sections of roads are expected to be reduced considerably. Reduction in v/c ratio due to metro has been discussed in detail in traffic chapter. It may be seen that with the proposed metro corridor, the road traffic will be reduced not only on these roads but also in the surrounding road network in its influence area.

Hence, keeping in view the above points, it is recommended to adopt a stable, tested and reliable Metro technology i.e. **Light Capacity Metro** System to cater PHPDT 15000 to 25000.

Chapter - 4

Geometric Designing Parameters and Alignment Description

Chapter - 4

GEOMETRIC DESIGNING PARAMETERS AND ALIGNMENT DESCRIPTION

4.1 GENERAL

This chapter deals with geometrical standards adopted for horizontal and vertical alignments, route description, etc. The proposed corridors under Ahmadabad Metro Rail network will consist of Standard Gauge (SG) lines. For underground corridors, track centres are governed by spacing of tunnels and box design.

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80kmph. Planning for any higher speed is not desirable as the average inter-station distance is about 1.06 km and trains will not be able to achieve higher speed.

The elevated tracks will be carried on box-shaped elevated decking supported by single circular piers, generally spaced at 25-m centres and located on the median of the road to extent possible. The horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road and ground levels followed by the alignment.

The underground tracks will be carried in separate tunnels to be drilled by Tunnel Boring Machine. Stations will, however, be constructed by cut and cover method except one station which has been proposed by NATM.

4.2 GEOMETRIC DESIGN PARAMETERS

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

4.2.1 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 300 m or more is 80 km/h. On elevated sections minimum radius of 175m has been used at two locations having speed potential upto 50 km/h. However in underground section desirable minimum radius of curve shall be 300 m for ease of working of Tunnel Boring Machine (TBM). For maximum permissible speed on curve with various radii, Table 4.2 may be referred.

4.2.2 Horizontal Curves

Table 4.1

Description	Underground Section	Elevated Section
Desirable Minimum radius	300 m	200 m
Absolute minimum radius	200 m (only c/c)	120 m
Minimum curve radius at stations	1000 m	1000 m
Maximum permissible cant (Ca)	125 mm	125 mm
Maximum desirable cant	110 mm	110 mm
Maximum cant deficiency (Cd)	85 mm	85 mm

4.2.3 Transition Curves

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

- Length of Transitions of Horizontal curves (m)

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

  Desirable : 0.72 times actual cant or cant deficiency, (in mm), whichever is higher.

- Overlap between transition curves and vertical curves not allowed.
- Minimum straight between two Transition curves (in case of reverse curves): either 25 m or Nil.
- Minimum straight between two Transition curves (in case of same flexure curves): either 25 m or both curves should be converted in to the compound curve by introducing single transition between the two circulars.
- Minimum curve length between two transition curves: 25 m

4.2.4 Vertical Alignment and Track Centre

(a) Elevated Sections

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

The track center on the elevated section is kept as 4.1 m uniform throughout the corridor to standardize the superstructure, except at few locations, wherever scissors crossovers are planned, it is kept 4.5 meter.

(b) Underground sections

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level. At stations, the desirable depth of rail below ground level is 13.5 m, so that station concourse can be located above the platforms.

Track center in underground sections are follows:

Track center in underground sections are follows: Sections where stations are to be constructed by cut & cover and running section by TBM to Accommodate 13 m wide platform	16.04 m (for lesser width of platform, track center to be reduced)
Sections where stations are to be constructed by NATM and running section by TBM to facilitate Construction of stations	23.04 m
Sections where stations as well as running section both are to be constructed by cut and cover method	4.50 m

(c) Gradients

Normally the stations shall be on level stretch. In exceptional cases, station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 3.0 %. However, where existing road gradients are steeper than 2% or for Switch Over Ramps gradient up to 4% (compensated) can be provided in short stretches on the main line.

(d) Vertical Curves

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

(e) Radius of vertical curves:

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

4.2.5 Design Speed

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

Table 4.2 - Cant, Permitted Speed & Minimum Transition Length for Curves

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
			UNDERGROUND	ELEVATED AND AT-GRADE
meters	mm	kmph	mm	Mm
3000	15	80	3500	3650
2800	15	80	3500	3650
2400	20	80	3500	3650
2000	20	80	3500	3650
1600	25	80	3500	3650
1500	30	80	3500	3650
1200	35	80	3500	3650
1000	45	80	3500	3700
800	55	80	3550	3700
600	70	80	3550	3750
500	85	80	3600	3750
450	95	80	3600	3800
400	105	80	3650	3800
350	110	75	3650	3800
300	110	70	3700	3850

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
			UNDERGROUND	ELEVATED AND AT-GRADE
meters	mm	kmph	mm	Mm
200	110	55	3800	3950
150*	110	45	4000	4050
150*	0	30	4000	4050
120*	110	40	4000	4150
120*	0	25	4000	4150

*The curves of 120 and 150 meters radii are used in depot and depot connections.

Notes:
(a) The track spacing is without any column/structure between two tracks and is with equal cant for both outer and inner tracks.
(b) Track spacing shown is not applicable to stations which should be calculated depending on specific requirement.
(c) Figures for any intermediate radius of curvature may be obtained by interpolating between two adjacent radii. For higher radii, values may be extrapolated.

4.2.6 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However effort has also been made to propose station locations, such that inter station distances are as uniform as possible. The average spacing of stations is close to 1.35km.

4.3 TRACK STRUCTURE

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The track structure has been proposed keeping the above philosophy in view.
Two types of track structures are proposed for the corridors under Delhi Metro Rail Project network. The normal ballasted track in Depot (except inside the Workshops, inspection lines and washing plant lines). The ballastless track is recommended on Viaducts and inside tunnels as the regular cleaning and replacement of ballast at such locations will not be possible.

For the depots, ballasted track is recommended as ballastless track on formation is not suitable due to settlement of formations. Ballastless track in depot is required inside the workshop, on inspection lines and washing plant lines.

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

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

4.4 RAIL SECTION

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

4.5 BALLASTLESS TRACK ON MAIN LINES

On the viaducts, it is proposed to adopt plinth type ballastless track structure with RCC derailment guards integrated with the plinths. Further, it is proposed to adopt fastening system complying to performance criteria laid down by Indian Railways on ballastless track structures, with a base-plate spacing of 60 cm. on viaducts.

In the underground sections, similar track structure with a base plate spacing of 70 cm is proposed on slab after 1st stage concrete.

4.6 BALLASTLESS/BALLASTED TRACK IN DEPOT

The ballast less track in Depot may be of the following types:

- Supported on steel pedestal for inspection lines.
- Embedded rail type inside the Workshop.
- Plinth type for Washing line.
- Track is to be laid on PRC sleepers with sleeper spacing of 65 cm. All the rails are to be converted into rail panels by doing flash butt/Thermit welding.

4.7 TURNOUTS

All turn-outs/crossovers on the main lines and other running lines shall be as under:

Table 4.3 – Turn-Outs

S. No.	Description	Turn out Type
01	Main Line	1 in 9
02	Depot/Yard Lines	1 in 7

4.8 BUFFER STOPS

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

4.9 RAIL STRUCTURE INTERACTION

For continuing LWR/CWR on Viaducts, the elevated structures will be adequately designed for the additional longitudinal forces likely to be transmitted as a result of Rail-Structure interaction. Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) required to be provided.

4.10 ROUTE ALIGNMENT

Two Corridors have been identified for implementation in Ahmadabad Metro Rail Project network (Phase 1).

Table 4.4

S. No.	Corridors	Total (km)
i)	North South Corridor : APMC to Motera Stadium	15.420
ii)	East West Corridor : Thaltej Gam To Vastral Gam	20.536
	Total	**35.956**

4.11 NORTH SOUTH CORRIDOR: APMC TO MOTERA STADIUM

The features of North South Corridor: APMC to Motera Stadium along with the details of route alignment have been described below:-

4.11.1 References

(a) Chainages

Chainage at the centre line of Thaltejgam Station has been reckoned as '0' and it increases towards Vastragam.

(b) Coordinates

Coordinates system adopted for topographical survey is WGS 84 for Northing and Easting. However ground elevations are with respect to GTS bench mark of survey of India.

(c) Directions

Direction from Thaltejgam to Vastral has been named as 'Down line' and 'up line' is converse of it.

4.11.2 Description of the Route Alignment of the Corridor

This corridor originates from western side of Thltejgam; leads towards East. Road width from km 0.500 to km 0.960 is very narrow; width of the road is no sufficient to accommodate elevated metro structure. Hence it involves a large number of buildings on both side of the road. Perhaps these building are made in the ROW of the road. As road on the both ends of this 400m stretch is more than 20m which is required to accommodate elevated metro structure. Hence forth alignment further leads eastward and crosses Sarkhej Gandhinagar Road (NH8C) at km 1.2 and aligns along the median of Drive In Road and runs along it up to commerce six road junction. Hereafter it moves further along the centre line of the road up to stadium road crossing; it turns right and aligns along the stadium road and follows it up to km 6.5; hereafter it further turns left; crosses railway lines and Ashram Road and reaches Sabarmati River front. It crosses Sabarmati river between km7.142and km 7.433. After crossing Sabarmati river alignment movers further eastward and attains underground position. First Switch over Ramp has been provided from km 7.510 to km7.700.

After attaining underground position alignment runs for a short distance of 570m under the Kasturba Gandhi Road. First underground station Shahpur has been proposed under Kasturba Gandhi Marg. Beyond Shahpur station it turns towards south and under old court premise another underground station named Relief road has been proposed by NATM. Hence forth alignment turns left and through a reverse curve it aligns along the relief road and passes under it. Further it moves eastward and crosses railway tracks in underground position; it turns right once again and moves south ward up to new Cotton mill; here it turns left; emerges out from underground position to elevated position; switch over ramp has been planned in New Cotton mill area; alignment in New Cotton Mill area is planned off the road. It moves further eastward to Vastragam; beyond New Cotton Mill Area it has been placed in the middle of the road.

4.11.3 Switch Over Ramp (SOR)

Vertical alignment of this corridor changes from underground to elevated or *vise versa* at two locations, as described below:-

Table 4.5 - Details of Switch over Ramps

Sr. No.	Chainage (m)		Length (m)	Remarks
	From	to		
	7510	7700	190	On the eastern bank of Sabarmati River. Presently a hutment area.
	13760	14120	360	In the New Cotton mill area. On open land.

4.11.4 Critical Locations

Few locations along the alignment are critical from alignment point of view. These locations are:

- Km0.440 to km 0.960- Buildings are affecting demolition required.
- Km 6.650 to km7.050 - Buildings are affecting demolition required.

4.11.5 Archeological Survey of India (ASI) protected monuments along the corridor

(a) Kazi Mohmed Chisti's Masjid

Alignment passes by the side of Kazi Mohmed Chisti's Masjid at the distance of 168m in underground position. Construction will be done by TBM.

(b) Delhi Gate

Alignment passes by the side of Delhi Gate and its distance Delhi Gate is 248m Alignment in this area also is underground and construction is proposed by TBM in this stretch.

(c) Qutubudin Shah's Mosque

Alignment passes by the side of Kazi Qutubudin Shah's Mosque at the distance of 119m in underground position. Construction will be done by TBM.

(d) Rani Rupavati's Mosque

Alignment passes by the side of Rani Rupavati's Mosque at the distance of 193m in underground position. Construction will be done by TBM.

(e) Kalupur Gate

Alignment passes by the side of Kalupur Gateat the distance of 110m in underground position. Construction will be done by TBM.

(f) Brick Minar

Alignment passes by the side of brick Minar the distance of 197m in underground position. Construction will be done by TBM.

4.11.6 Alignment Underground Verses Elevated

Construction cost of underground metro line is almost two to three times of that elevated one. Therefore efforts have made to keep alignment elevated as far as it is technically possible. However there is a stretch along the corridor which is underground due to inadequate road width, heavily built-up area and crossing of railway yard. The underground stretch is from km 7.700 to km 13.760.

4.11.7 Stations integrating with different modes of Transport

While deciding station locations efforts have been made to make integration of metro system with other mode of transport such as existing BRTS and railways as far as possible. The details of stations which will have integration with other mode of transport are given in the Table 4.6

Table 4.6 - Details of Integrating Stations

S. No.	Station	Remarks
1.	Ashram Road	Integration with existing BRTS Corridor and proposed metro station on North south corridor.
2.	Kalupur	Integration with existing Indian Railways network.
3.	Rabari Colony	Integration with existing BRTS Corridor.

4.11.8 Depot

Land for depot location for this line has been identified in New Cotton mill area. This land is open and plan. Moreover it is very close to the alignment, so there will be no dead run of the trains. Depot connectivity has been planned from Apparel Park Station.

4.11.9 Other Main Features of the Corridor

a) This corridor provides metro connectivity to Thaltej, Jai Ambe Nagar, Nilmani Society, Gkurukul, Sushil Nagar Society, Saurabh Society, Lion Sharad Mehta

Garden, Sarvottam Nagar Society, Navrangpura, Swastik Society, Ahmedabad, Shah Colony, Kalal Nagar, Parabadi Ni Pole, Mirzapur, Bhadra, Zaveriwad, Revdi Bazar, Laxmi Bazar, Partabgad, Sanrangpur, Rajpur GIDC Apparel Park, Janta Nagar, Satyam Nagar, Rabari Colony, Rita Nagar, Krupalu Nagar Society, Devikrup Society, Mahadev Nagar and Vastral.

b) Corridor is integrated with North South corridor. This integration provides metro connectivity to northern as well as Southern parts of Ahmadabad.

c) Corridor is integrated with Sabarmati river front also.

d) About 29.0% length of the corridor is underground.

e) Total 18 stations have been proposed on this corridor; out of these 04 stations are underground and remaining 14 stations are elevated.

4.11.10 Technical Features

(a) Route Length

The total route length from dead end to dead end is 20.536km as per the break-up details given hereunder:

- Underground
  - i) Cut & Cover : 0.429km
  - ii) TBM : 5.631km
  - iii) Ramp : 0.550km
- Elevated : 13.926km

Total : <u>20.536km</u>

(b) Horizontal Curves

There are total 51 curves on the alignment of this corridor. Sharpest radius is 220m which has been used at one location in the elevated section whereas largest radius is 2000m which has been used at three locations. Total length of alignment on curves is nearly 24.38% (including transition length of curves). Details of curves are given in the Table 4.7 below:-

Table 4.7 – Statement of Horizontal Curves

Curve No.	Direction of curve	Radius (m)	Included angle	Tangent Length (m)	Transition Length (m)		Circular Length (m)	Total Curve Length (m)	Straight between two curves	Remarks
			D M S		L1	L2			142.383	
1	Left	1200	10 24 57.842	109.378	25	25	218.154	268.154	154.535	
2	Right	1010	16 20 01.874	144.948	30	30	287.930	347.930	0.000	
3	Left	500	04 04 25.912	17.783	50	50	35.551	135.551	47.064	

Curve No.	Direction of curve	Radius (m)	Included angle	Tangent Length (m)	Transition Length (m)		Circular Length (m)	Total Curve Length (m)	Straight between two curves	Remarks
			D M S		L1	L2			142.383	
4	Right	300	08 02 45.885	21.099	55	55	42.129	152.129	0.000	
5	Left	210	10 03 47.090	18.489	55	55	36.883	146.883	123.483	
6	Right	1200	09 52 35.130	103.683	30	50	206.851	286.851		Compound curve
7	Right	693.285	13 32 12.101	82.281		40	163.796	203.796	84.901	
8	Left	1010	10 01 47.023	88.628	35	35	176.802	246.802	182.595	
9	Right	550	16 10 43.249	78.172	45	45	155.304	245.304	91.977	
10	Left	275	13 40 43.451	32.983	60	60	65.653	185.653	175.297	
11	Left	1020	05 20 19.380	47.555	30	30	95.042	155.042	92.975	
12	Right	2000	00 52 25.966	15.252	20	20	30.504	70.504	441.053	
13	Right	300	13 13 42.796	34.787	60	60	69.265	189.265	0.000	
14	Left	500	08 16 20.381	36.158	40	40	72.190	152.190	143.839	
15	Left	575	02 36 07.590	13.059	40	40	26.114	106.114	0.000	
16	Right	375	20 09 39.942	66.666	60	60	131.954	251.954	156.581	
17	Left	1200	06 49 24.649	71.540	30	30	142.911	202.911	156.169	
18	Right	1500	06 16 17.870	82.178	25	25	164.191	214.191	0.000	
19	Left	220	22 26 12.106	43.634	60	60	86.151	206.151	143.318	
20	Right	1010	05 02 04.427	44.403	35	35	88.748	158.748	358.605	
21	Right	550	08 18 25.053	39.941	40	50	79.741	169.741		Compound curve
22	Right	220	15 40 00.730	30.267		60	60.156	120.156	48.964	
23	Left	310	28 34 39.148	78.953	60	60	154.619	274.619	61.039	
24	Left	1010	15 16 34.768	135.448	30	30	269.288	329.288	399.436	
25	Left	400	07 38 20.539	26.705	60	60	53.331	173.331	35.961	
26	Right	450	26 27 44.400	105.805	50	50	207.835	307.835	277.829	
27	Right	400	77 12 49.529	319.394	55	55	539.054	649.054	217.955	
28	Left	1015	33 12 56.994	302.737	30	50	588.422	668.422		Compound curve
29	Left	315	96 40 07.784	353.976		55	531.465	586.465	30.035	
30	Right	310	26 56 23.530	74.252	55	55	145.759	255.759	448.682	
31	Right	310	92 12 52.676	322.220	60	60	498.929	618.929	387.428	
32	Left	310	35 32 25.056	99.352	55	55	192.291	302.291	240.408	
33	Right	310	34 58 30.727	97.669	55	55	189.234	299.234	398.360	
34	Left	310	79 46 40.542	259.099	60	60	431.640	551.640	769.453	
35	Right	300	08 18 22.872	21.784	55	55	43.492	153.492	92.021	
36	Right	800	02 44 56.173	19.195	40	40	38.382	118.382	234.908	
37	Left	350	07 46 03.096	23.761	60	60	47.449	167.449	0.000	
38	Right	500	12 42 34.332	55.684	50	50	110.912	210.912	238.233	
39	Left	2000	05 47 32.363	101.181	20	20	202.190	242.190	174.582	
40	Right	4500	03 34 02.044	140.130	20	20	280.170	320.170	115.266	
41	Left	220	12 42 53.157	24.511	60	60	48.821	168.821	85.858	

Curve No.	Direction of curve	Radius (m)	Included angle	Tangent Length (m)	Transition Length (m)		Circular Length (m)	Total Curve Length (m)	Straight between two curves	Remarks
			D M S		L1	L2			142.383	
42	Right	1010	03 35 32.530	31.673	35	35	63.326	133.326	58.142	
43	Right	220	10 51 19.350	20.903	60	60	41.682	161.682	53.235	
44	Left	220	07 08 47.741	13.738	50	50	27.441	127.441	25.470	
45	Right	450	03 31 01.466	13.816	50	50	27.623	127.623	240.701	
46	Right	1010	04 28 23.058	39.445	35	35	78.851	148.851	44.608	
47	Left	1010	01 47 46.430	15.833	35	35	31.664	101.664	341.820	
48	Right	1010	02 47 14.589	24.573	35	35	49.136	119.136	137.952	
49	Right	2000	03 41 17.118	64.392	20	20	128.739	168.739	206.408	
50	Left	650	10 51 40.184	61.793	40	40	123.216	203.216	49.858	
51	Right	2000	01 11 33.852	20.818	20	20	41.634	81.634	634.548	
									5007.976	

(c) Gradient

Change of grade takes place at 59 locations along this corridor. Flattest grade is level which has been provided at the stations Steepest gradient on the route is 3.70% which has been provided on the ramp. While designing the vertical alignment efforts have been made to pace stations on higher altitude than the running section to get benefit of gravitational force for the acceleration and retardation of the trains. Average depth of underground station has been kept in the range of 14.5m and average height of elevated stations' is in the rage of 13.5m. A statement showing details of gradients provide along the corridor is given in the following Table 4.8.

Table 4.8 – Statement of Gradients

S. No.	Chainage(m)		Length(m)	Rail Level(m)		Gradient	Remarks
	From	To		From	To		
1	-405.000	210.000	615.000	61.500	61.500	0.00%	Level
2	210.000	436.956	226.956	61.500	60.100	-0.62%	Fall
3	436.956	916.182	479.226	60.100	68.700	1.79%	Rise
4	916.182	1331.956	415.774	68.700	68.700	0.00%	Level
5	1331.956	1636.956	305.000	68.700	69.600	0.30%	Rise
6	1636.956	1866.956	230.000	69.600	65.600	-1.74%	Fall
7	1866.956	2096.956	230.000	65.600	65.600	0.00%	Level
8	2096.956	2546.956	450.000	65.600	60.300	-1.18%	Fall
9	2546.956	2916.956	370.000	60.300	63.500	0.86%	Rise
10	2916.956	3156.956	240.000	63.500	63.500	0.00%	Level

S. No.	Chainage(m)		Length(m)	Rail Level(m)		Gradient	Remarks
	From	To		From	To		
11	3156.956	3406.956	250.000	63.500	59.100	-1.76%	Fall
12	3406.956	3536.956	130.000	59.100	59.300	0.15%	Rise
13	3536.956	3846.956	310.000	59.300	65.000	1.84%	Rise
14	3846.956	4113.842	266.886	65.000	65.000	0.00%	Level
15	4113.842	4496.956	383.114	65.000	59.000	-1.57%	Fall
16	4496.956	4896.956	400.000	59.000	62.700	0.93%	Rise
17	4896.956	5236.956	340.000	62.700	62.700	0.00%	Level
18	5236.956	5566.956	330.000	62.700	59.100	-1.09%	Fall
19	5566.956	5826.956	260.000	59.100	62.600	1.35%	Rise
20	5826.956	6076.956	250.000	62.600	62.600	0.00%	Level
21	6076.956	6450.000	373.044	62.600	57.700	-1.31%	Fall
22	6450.000	6660.000	210.000	57.700	62.100	2.10%	Rise
23	6660.000	7130.000	470.000	62.100	62.100	0.00%	Level
24	7130.000	8006.956	876.956	62.100	34.500	-3.15%	Fall
25	8006.956	8286.956	280.000	34.500	34.500	0.00%	Level
26	8286.956	8776.956	490.000	34.500	33.030	-0.30%	Fall
27	8776.956	9116.956	340.000	33.030	34.010	0.29%	Rise
28	9116.956	9500.000	383.044	34.010	28.000	-1.57%	Fall
29	9500.000	9800.000	300.000	28.000	28.000	0.00%	Level
30	9800.000	10120.000	320.000	28.000	33.604	1.75%	Rise
31	10120.000	10450.000	330.000	33.604	32.736	-0.26%	Fall
32	10450.000	10834.394	384.394	32.736	30.000	-0.71%	Fall
33	10834.394	11314.394	480.000	30.000	32.000	0.42%	Rise
34	11314.394	11594.394	280.000	32.000	37.500	1.96%	Rise
35	11594.394	11884.394	290.000	37.500	37.500	0.00%	Level
36	11884.394	12344.394	460.000	37.500	32.000	-1.20%	Fall
37	12344.394	12724.394	380.000	32.000	33.500	0.39%	Rise
38	12724.394	12980.000	255.606	33.500	33.000	-0.20%	Fall
39	12980.000	13220.000	240.000	33.000	33.000	0.00%	Level
40	13220.000	13750.000	530.000	33.000	40.000	1.32%	Rise
41	13750.000	14255.989	505.989	40.000	58.722	3.70%	Rise
42	14255.989	14475.989	220.000	58.722	58.722	0.00%	Level
43	14475.989	14840.000	364.011	58.722	57.200	-0.42%	Fall
44	14840.000	15200.000	360.000	57.200	58.000	0.22%	Rise
45	15200.000	15650.000	450.000	58.000	60.500	0.56%	Rise
46	15650.000	15910.000	260.000	60.500	60.500	0.00%	Level

S. No.	Chainage(m)		Length(m)	Rail Level(m)		Gradient	Remarks
	From	To		From	To		
47	15910.000	16155.989	245.989	60.500	57.500	-1.22%	Fall
48	16155.989	16490.000	334.011	57.500	61.200	1.11%	Rise
49	16490.000	16790.000	300.000	61.200	61.200	0.00%	Level
50	16790.000	17120.000	330.000	61.200	57.500	-1.12%	Fall
51	17120.000	17340.000	220.000	57.500	58.600	0.50%	Rise
52	17340.000	17680.000	340.000	58.600	59.300	0.21%	Rise
53	17680.000	17955.000	275.000	59.300	69.500	3.71%	Rise
54	17955.000	18250.000	295.000	69.500	69.500	0.00%	Level
55	18250.000	18580.000	330.000	69.500	66.100	-1.03%	Fall
56	18580.000	18900.000	320.000	66.100	66.740	0.20%	Rise
57	18900.000	19230.000	330.000	66.740	66.740	0.00%	Level
58	19230.000	19520.000	290.000	66.740	64.600	-0.74%	Fall
59	19520.000	20126.647	606.647	64.600	64.600	0.00%	Level

4.12 APMC TO MOTERA STADIUM CORRIDOR

4.12.1 References

(a) Chainages

Chainage at Centre line of proposed APMC Station has been reckoned as ‘0’ and it increases towards Saket G Block.

(b) Coordinates

Coordinates system adopted for topographical survey is WGS 84 for Northing and Easting. However ground elevations are with respect to GTS bench mark of survey of India.

(c) Directions

Direction from APMC to Motera Stadium has been named as ‘Up line’ and ‘Down line’ is converse of it.

4.12.2 Description of the Route Alignment of the Corridor

APMC to Motera stadium start from the APMC and leads towards north on Jawahar Lal Nehru road up to km 0.860; turns left; passes over Vasana Bus Stand; where Vsana metro station has been proposed over the existing Vasana bus stand. Hereafter alignment turns right through a reverse curve passes over Gupta Nagar Area; it further turns left and aligns along the centre of the road at Anjali. This 0.490km long length of the off the road alignment has been proposed to keep more than 100m distance from the Archeological protected monument *'Azam Muazzam Dargah'.* Anjali onward alignment further follows along the centre of the road up to Ellis Bridge flyover. Here alignment has been panned on the right footpath of the road due to flyover. After crossing of the flyover it again comes on the central median of the road and follows it upto Vadaj. After Vadaj Station alignment passes through the open land and hutment area; it is further brought to the right side of the road at Ranip to have integration with the BRTS and Ranip bus stand. It moves forward further and crosses the road and runs by the northern side of the road; Sabarmati Railway Station has been proposed north to the Chiman Bhai Bridge in the off road position. After Sabarmati Station it crosses railway tracks and passes by the side of railway's cricket stadium and again aligns along the median of the road at AEC. It crosses road at km 12.550 and comes from the western side of the road to eastern side of the; runs on the already earmarked location for the metro on the BRTS corridor and it runs along it upto km 13.676. Here it turns towards Motera Stadium along the Motera Stadium road centre line. Alignment terminates near Motera Stadium at km 15.015.

4.12.3 Critical Locations

a. Alignment from 1.035km to km 1.627.

b. Alignment from km 4.688 to km 4.785.

4.12.4 Stations integrating with different modes of Transport

While deciding station locations efforts have been made to make integration of metro system with other mode of transport such as existing metro system, BRTS and railways as far as possible. The details of stations which will have integration with other mode of transport are given in the Table No. 4.9.

Table 4.9 – Details of integrating stations

S. No.	Name of Station	Remarks
(a)	Vasana	Integration with existing AMTS Bus Station
(b)	Ashram Road	Integration with proposed with proposed East west metro Corridor.
(c)	Vadaj	Integration with existing AMTS Vadaj Bus Terminus.
(d)	Ranip	Integration with existing GSRTS Bus Terminal and BRTS.
(e)	Sabarmati Railway Station	Integration with Indian Railways.

4.12.5 Archeological Survey of India (ASI) protected monuments along the corridor

Azam Muazzam Dargah

Alignment passes by the side of *Azam Muazzam Dargah* ASI protected monument. Alignment has been taken off road to maintain prescribed distance by the ASI.

Siyed Usman's Mosque & tomb

Alignment passes by the side of Siyed Usman's Mosque & tomb ASI protected monument. It is 120m away from the alignment.

4.12.6 Depot

The depot identified in Depot has been proposed at Vasana in the beginning of the alignment.

4.12.7 Other Main Features of the Corridor

a. This corridor provides metro connectivity to Vasana, Sanklit Nagar, Kalpur, Gupta Nagar, Someshwar Nagar, BH. Jawahar Nagar, Pravin Nagar, Pankaj Society, Bhatta, Fatehpura Gam, Dungar Shinagar, Paldi, Paldi Gam, Kocharab, Madalpur Gam, Maharashtra Society, Vishalpur, Muslim Society, Mill Officer's Colony, Navarangpura Gam, Sattar Taluka Society, Soni Ni Chal, Usman Pura, Shanti Nagar, Sorabji Compound, Parikshit Nagar, Nava Vadaj, Ramapir Thekra, Keshavbag Wadi, Gayatri Kunj Society, Nijripunj Society Part-2, Dharm Nagar-II, Krishna Nagar, Sidhachal Vatika, Abu Street Society, Hirajain Society, Sabarmati, Ambica Nagar, Keshavbag Colony, Parvati Nagar and Motera

b. Corridor is integrated with East west corridor. This integration provides metro connectivity to Sabarmati River front, Gujarat University, Kalupur Railway Station and so many other important destinations.

c. This corridor is fully elevated.

d. Total 14 stations have been proposed on this corridor; all stations are elevated.

4.12.8 Technical Features

(a) Route Length

The total route length from dead end to dead end is 15.420km as per the break-up details given hereunder:

• Elevated	:	15.420km

Total	**:**	**15.420km**

(b) Horizontal Curves

There are total 48 curves on the alignment of this corridor. Sharpest radius is 175 m which has been used at two locations whereas largest radius is 6000m. Radius more than 1000m has been used at 20 locations. Total length of alignment on curves is nearly 27% (including transition length of curves). Details of curves are given in the Table 4.10 below:

Table 4.10– Statement of Horizontal Curves

Curve No.	Direction of curve	Radius (m)	Included angle	Tangent Length (m)	Transition Length(m)		Circular Length (m)	Total Curve Length (m)	Straight between two curves	Remarks
			D M S		L1	L2			335.003	
1	Left	1200	09 31 27.042	99.967	25	25	199.474	249.474	360.626	
2	Left	1500	06 32 33.826	85.737	25	25	171.288	221.288	108.27	
3	Left	180	17 49 36.830	28.231	60	60	56.005	176.005	0	
4	Right	1005	06 51 13.795	60.182	30	45	120.22	195.22	0	Compound curve
5	Right	175	54 45 52.221	90.643		45	167.269	212.269	0	
6	Left	205	33 15 34.636	61.229	55	55	119	229	119.068	
7	Right	400	03 40 18.367	12.821	50	50	25.634	125.634	114.731	
8	Right	1200	01 37 53.851	17.087	25	25	34.173	84.173	0	
9	Left	210	09 10 37.807	16.854	60	60	33.636	153.636	0	
10	Right	300	19 51 04.791	52.497	60	60	103.941	223.941	46.71	
11	Left	400	05 33 15.929	19.404	60	60	38.777	158.777	91.964	
12	Left	175	14 24 53.599	22.131	60	60	44.028	164.028	164.454	
13	Right	800	06 25 03.304	44.85	40	40	89.606	169.606	133.381	
14	Right	2000	04 00 01.157	69.847	20	20	139.638	179.638	145.706	
15	Left	3000	00 34 33.913	15.082	20	20	30.164	70.164	221.869	
16	Right	2500	01 46 33.815	38.751	20	20	77.495	117.495	309.95	
17	Left	210	24 56 45.119	46.452	60	60	91.431	211.431	27.377	
18	Left	800	02 07 23.490	14.824	40	40	29.645	109.645	0	
19	Right	1010	02 20 26.499	20.634	30	30	41.261	101.261	131.526	
20	Left	1010	02 22 10.325	20.888	30	30	41.77	101.77	25.945	
21	Left	425	03 33 18.975	13.19	50	50	26.372	126.372	50.331	
22	Right	210	07 21 27.908	13.502	60	60	26.968	146.968	35.212	
23	Left	250	14 36 44.714	32.053	60	60	63.759	183.759	300.957	
24	Right	400	19 24 28.138	68.401	50	50	135.492	235.492	42.934	
25	Right	1200	01 48 07.096	18.872	25	25	37.74	87.74	217.521	
26	Left	1500	02 01 17.937	26.466	25	25	52.927	102.927	0	
27	Right	1020	01 35 34.633	14.18	30	30	28.358	88.358	86.363	
28	Right	3000	00 48 16.912	21.067	20	20	42.134	82.134	334.516	
29	Right	260	07 03 59.856	16.054	60	60	32.067	152.067	0	
30	Left	220	08 21 46.907	16.084	60	60	32.112	152.112	149.893	
31	Left	3000	01 07 19.023	29.374	20	20	58.745	98.745	315.909	
32	Left	1750	01 07 17.025	17.126	25	25	34.251	84.251	0	
33	Right	1010	09 22 40.106	82.84	30	60	165.31	255.31	0	Compound curve
34	Right	175	31 49 50.385	49.901		60	97.221	157.221	0	

35	Left	210	61 17 14.469	124.41	60	60	224.63	344.63	533.793	
36	Right	210	86 03 26.639	196.025	60	60	315.417	435.417	141.136	
37	Left	300	13 07 27.577	34.510	60	60	68.719	188.719	292.215	
38	Right	350	06 09 22.265	18.821	55	55	37.606	147.606	105.872	
39	Right	1010	08 33 19.057	75.546	30	30	150.811	210.811	103.662	
40	Left	300	40 25 21.634	110.446	55	55	211.653	321.653	531.656	
41	Left	1500	02 16 15.817	29.732	25	25	59.456	109.456	198.454	
42	Left	225	53 11 57.931	112.670	60	60	208.914	328.914	75.032	
43	Right	500	10 19 15.982	45.156	45	45	90.069	180.069	180.139	
44	Left	5000	00 22 41.207	16.498	20	20	32.997	72.997	305.367	
45	Right	2000	01 09 38.882	20.260	20	20	40.520	80.52	60.294	
46	Right	210	31 26 44.653	59.119	55	55	115.255	225.255	400.186	
47	Left	6000	00 17 22.539	15.163	15	15	30.326	60.326	500.709	
48	Right	450	07 45 58.486	30.545	50	50	60.996	160.996	185.309	

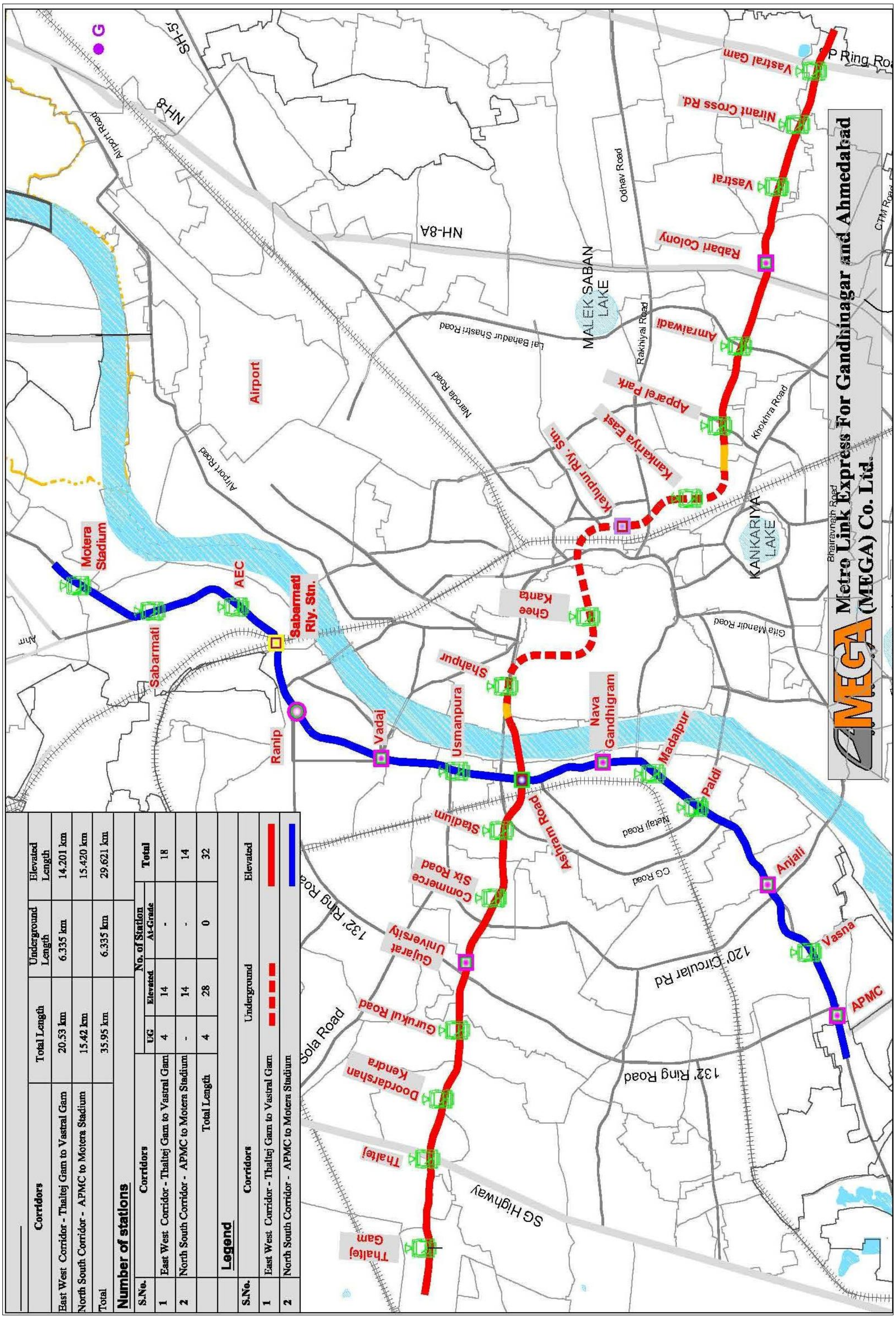
(c) Gradient

Change of grade takes place at 45 locations along this corridor. Flattest grade is level which has been provided at the stations. Level gradient has been provided at all stations. Steepest gradient on the route is 3.0%. While designing the vertical alignment efforts have been made to pace stations on higher altitude than the running section to get benefit of gravitational force for the acceleration and retardation of the trains. Average height of elevated stations' is in the rage of 13.5m. A statement showing details of gradients provide along the corridor is given in the following Table 4.11.

Table 4.11– Statement of Gradients

S. No.	Chainage(m)		Length(m)	Rail Level(m)		Gradient	Remarks
	From	To		From	To		
1	-405.000	260.000	665.000	56.500	56.500	0.00%	level
2	260.000	480.000	220.000	56.500	53.000	-1.59%	fall
3	480.000	950.000	470.000	53.000	56.300	0.70%	rise
4	950.000	1280.000	330.000	56.300	56.300	0.00%	level
5	1280.000	1540.000	260.000	56.300	57.500	0.46%	rise
6	1540.000	1864.000	324.000	57.500	60.500	0.93%	rise
7	1864.000	2202.600	338.600	60.500	60.500	0.00%	level
8	2202.600	2750.000	547.400	60.500	56.300	-0.77%	fall
9	2750.000	3220.000	470.000	56.300	60.100	0.81%	rise
10	3220.000	3510.000	290.000	60.100	60.100	0.00%	level
11	3510.000	3680.000	170.000	60.100	56.900	-1.88%	fall
12	3680.000	4020.000	340.000	56.900	62.000	1.50%	rise

S. No.	Chainage(m)		Length(m)	Rail Level(m)		Gradient	Remarks
	From	To		From	To		
13	4020.000	4430.000	410.000	62.000	62.000	0.00%	level
14	4430.000	4580.000	150.000	62.000	65.500	2.33%	rise
15	4580.000	4876.200	296.200	65.500	63.000	-0.84%	fall
16	4876.200	5109.200	233.000	63.000	63.000	0.00%	level
17	5109.200	5527.300	418.100	63.000	57.800	-1.24%	fall
18	5527.300	5765.000	237.700	57.800	59.400	0.67%	rise
19	5765.000	6286.600	521.600	59.400	70.350	2.10%	rise
20	6286.600	6560.000	273.400	70.350	70.350	0.00%	level
21	6560.000	6850.000	290.000	70.350	61.700	-2.98%	fall
22	6850.000	7110.000	260.000	61.700	65.200	1.35%	rise
23	7110.000	7383.600	273.600	65.200	65.200	0.00%	level
24	7383.600	7690.000	306.400	65.200	61.700	-1.14%	fall
25	7690.000	7960.000	270.000	61.700	62.000	0.11%	rise
26	7960.000	8220.000	260.000	62.000	64.000	0.77%	rise
27	8220.000	8550.000	330.000	64.000	64.000	0.00%	level
28	8550.000	8850.000	300.000	64.000	55.000	-3.00%	fall
29	8850.000	9200.000	350.000	55.000	57.000	0.57%	rise
30	9200.000	9500.000	300.000	57.000	60.000	1.00%	rise
31	9500.000	9890.000	390.000	60.000	66.000	1.54%	rise
32	9890.000	10220.000	330.000	66.000	66.000	0.00%	level
33	10220.000	10545.000	325.000	66.000	63.500	-0.77%	fall
34	10545.000	10980.000	435.000	63.500	64.000	0.11%	rise
35	10980.000	11255.000	275.000	64.000	64.000	0.00%	level
36	11255.000	11550.000	295.000	64.000	61.500	-0.85%	fall
37	11550.000	11840.000	290.000	61.500	66.700	1.79%	rise
38	11840.000	12240.000	400.000	66.700	66.700	0.00%	level
39	12240.000	12580.000	340.000	66.700	62.800	-1.15%	fall
40	12580.000	12850.000	270.000	62.800	66.400	1.33%	rise
41	12850.000	13280.000	430.000	66.400	69.500	0.72%	rise
42	13280.000	13520.000	240.000	69.500	69.500	0.00%	level
43	13520.000	13900.000	380.000	69.500	67.200	-0.61%	fall
44	13900.000	14210.000	310.000	67.200	71.100	1.26%	rise
45	14210.000	15154.320	944.320	71.100	71.100	0.00%	level



Corridors	Total Length	Underground Length	Elevated Length
East West Corridor - Thaltej Gam to Vastral Gam	20.53 km	6.335 km	14.201 km
North South Corridor - APMC to Motera Stadium	15.42 km		15.420 km
Total	35.95 km	6.335 km	29.621 km

Number of stations

S.No.	Corridors	No. of Station UG	Elevated	At-Grade	Total
1	East West Corridor - Thaltej Gam to Vastral Gam	4	14	-	18
2	North South Corridor - APMC to Motera Stadium	-	14	-	14
	Total Length	4	28	0	32

Legend

S.No.	Corridors	Underground	Elevated
1	East West Corridor - Thaltej Gam to Vastral Gam		
2	North South Corridor - APMC to Motera Stadium		

Chapter - 5

Civil Engineering

Chapter - 5

CIVIL ENGINEERING

5.1 GENERAL

This chapter deals with civil underground and elevated structure, Geotechnical investigation, construction methods, land requirements, Utility services and Traffic diversion during construction etc.

5.2 CIVIL STRUCTURES

5.2.1 Underground Construction

The most of the underground section passing under the road, cut and cover method of the underground construction easily can be employed for the construction of the underground sections. However keeping in view obstruction of traffic movement and inconvenience to the general public; during the construction as an open cut around 10.00m wide required to be cut through entire length of underground section it is proposed to tunnel through Tunnel Boring Machine (TBM) or New Austrian Tunneling Method (NATM) in the overburden soil mass. This will reduce substantially inconvenience to general public during construction. Tunnel excavation for a major part of this underground section is expected to be carried out by Tunnel Boring Machines. There is some smaller section along the underground part of the alignment where Cut & Cover method has been considered for construction after Switch Over Ramp (SOR). Tunnel boring machines (TBMs) capable of drilling in soft soil with a finished internal diameter of 5.2 m. can be successfully employed for boring tunnels through this stratum. The tunnels are proposed with a minimum soil cover of 6.0m.

5.2.2 Underground Stations

Total 4 underground stations have been proposed out of which 3 will be constructed by cut and cover with top-down method and 1 by NATM with through tunnels TBM. The diaphragm walls for such station constructions would be 80 to 100 cm. thick and will function as a permanent side wall of the station. It is, therefore, necessary to construct the diaphragm walls absolutely watertight and with the required concrete strength as has been done in the Delhi Metro station constructions. By resorting to top-down method the surface could be restored quickly and further excavations and construction of the station will not hamper the surface activity.

5.2.3 Cut and Cover Method of Construction of Underground Stations

Cut and Cover mainly consists of following steps:

1. Diversion of utilities
2. Construction of support walls
3. Excavation between the support walls along with the installation of struts between the two walls to keep them in position.
4. Construction of tunnel/structure and removal of temporary struts.
5. Back filling and restoration of the surface

5.2.4 Utility Diversion:

It is suggested that all utilities falling within excavation area are diverted away in advance to avoid damage to such utilities during the excavation/ construction phase. The cross utilities, however has to be kept supported. It is suggested that pressure water pipelines crossing the proposed cut area are provided with valves on both sides of the cut so that the cut area can be isolated in case of any leakage to the pipeline to avoid flooding of the cut/damage to the works.

5.2.5 Support Walls:

Most commonly used support wall is RCC Diaphragm Wall. The advantage of diaphragm wall is that the same can be used as part of permanent structure. The modern techniques are now available where water-stop can be inserted at the joints of two diaphragm wall panels to avoid seepage through the joints. It is also now possible to ensure the verticality of the diaphragm wall panels to avoid any infringement problem later on. Typically the diaphragm wall of 80 cm to 1 meter thickness is sufficient to do the cut and cover construction. The various advantages of diaphragm wall are as follows.

It is rigid type of support system and therefore ensures the maximum safety against settlement to the adjacent structures.
Can be used as part of the permanent structure and, therefore, considered economical.
With diaphragm wall it is possible to construct an underground structure by top down method. In this method top slab is cast once the excavation is reached to the top slab level with rigid connections to the diaphragm wall which can be achieved by leaving couplers in the diaphragm wall reinforcement at appropriate level. This top slab then acts as strut between the two support walls and gives much more rigidity and safety to the construction. Excavation thereafter can be completed. This also helps in restoration of the surface faster without waiting for full structure to be completed.
The other support walls which can be used depending on the site conditions are as follows:

(a) Sheet Piles : ‘Z’/ ‘U’ sheet piles cane be used as temporary support wall. This can be advantageous where it is possible to re-use the sheet pile again and again and therefore, economy can be achieved However the main concern remains, driving of sheet piles causes vibrations/noise to the adjacent buildings. This may sometimes lead to damage to the building and most of the time causes inconvenience to the occupants of the building. Situation becomes more critical if sensitive buildings are adjacent to the alignment like hospitals, schools, laboratories, etc. Silent pile driving equipments however are now available and can be used where such problems are anticipated.

(b) Retaining Casing Piles: This is suitable for situation where the cut and cover is to be done in partly soil and partly rock. The top soil retaining structure can be done with the help ofCasing pile which is then grouted with cement slurry. This is considered suitable in case of shallow level, non-uniform, uneven nature of rock head surface which render the construction of sheet piles/diaphragm wall impracticable. These are suitable up to 7-meter depth. The common diameter used for such casing pile is 2.00-2.50 m dia.

(c) Soldier Piles and Lagging: Steel piles (H Section or I section) are driven into the ground at suitable interval (normally 1-1.5 m) centre-to-centre depending on the section and depth of excavation. The gap between two piles is covered with suitable lagging of timber planks/shot-creting /steel sheets/GI sheets during the process of excavation.

(d) Secant Piles: are cast-in-situ bored piles constructed contiguously to each other so that it forms a rigid continuous wall. This is considered an alternative to diaphragm wall where due to soil conditions it is not advisable to construct diaphragm wall from the consideration of settlement during the trenching operation. 800 to 1000 mm dia piles are commonly used. Two alternate soft piles are driven and cast in such a way that the new pile partly cuts into earlier constructed piles. This new pile is constructed with suitable reinforcement. With this, alternate soft and hard pile is constructed. This has got all the advantages of diaphragm wall. However, this wall cannot be used as part of permanent structure and permanent structure has to be constructed in- side of this temporary wall.

5.2.6 Anchors:

As an alternative to the struts, soil/rock anchors can be used to keep these support walls in position. This gives additional advantage as clear space is available between two support walls and progress of excavation & construction is much faster as compared to the case where large number of struts is provided which create hindrance to the movement of equipment's and material & thus affects the progress adversely.

The combination of all the type of retaining walls, struts/anchors may be necessary for the project to suit the particular site. Based on the above broad principle, the support walls system for cut and cover shall be chosen for particular locations.

5.2.7 Elevated Section - Choice of Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability and the maximum standardization of the formwork for a wide span ranges.

The segmental construction has been chosen mainly due to the 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.

- Segmental construction permits a reduction of construction time as segments may be manufactured while substructure work proceeds and assembled rapidly thereafter.

- Segmental construction protects the environment as only space required for foundation and sub-station is required at site. The superstructure is manufactured at a place away from busy areas and placement of superstructure is done with the system erected from piers at heights.

- Segments are easy to stack in the casting yard/stacking yard in more than one layer, thereby saving in requirement of space.

- It is easier to transport smaller segments by road trailers on city roads.

- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Interference to the traffic during construction is significantly reduced.
- Segmental construction contributes towards aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

5.2.8 Types of Superstructures for Elevated Section

(A) Pre-cast segmental box girder using external unbounded tendon

(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.

Comparative advantages/disadvantages of the above two types are given below:

A. Precast Segmental Box Girder using External Unbounded Tendon.

This essentially consists of precast segmental construction with external pre-stressing and dry joints and is by far most preferred technique in fast track projects. 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. However, epoxy is dispensed with because water tight seal at the segment joints is not required because tendons are laid externally & protected by special wax or cement.

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

- 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.
- The elimination of the epoxy from the match-cast joints reduces costs and increases speed of construction further.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facility for inspection and monitoring of tendons during the entire service life of the structure.

Precast Segmental Box Girder using internal tendon is also use.

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

The single U type of viaduct structure is also a precast segmental construction with internal pre-stressing and requires gluing and temporary pre-stressing of segments. The match cast joints at the interface of two segments are also provided with shear keys. The main advantages for this type of structural configuration of superstructure are:

1. Built in sound barrier .
2. Built in cable support and system function.
3. Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
4. Built in structural elements capable to maintain the trains on the bridge in case of derailment (a standard barrier design allow this)
5. Built in maintenance and evacuation path on either side of the track.

5.2.9 However, 'U' section has following disadvantages:

(i) Inefficient structure sections

(ii) Requires cross pre-stressing of pier segments

(iii) At X-over locations the girders are to be connected at slab level hence changing of bearing at later stage becomes very difficult.

(iv) Costly than Box girder.

5.3 CONSTRUCTION METHODOLOGY

For the elevated sections it is recommended to have pre-cast segmental construction for super structure for the viaduct. For stations also the superstructure is generally of pre-cast members. The pre-cast construction will have 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.

- Minimum inconvenience is caused to the public utilizing the road as the superstructure launching is carried out through launching girder requiring narrow width of the road.

- As the pre-cast elements are cast on production line in a construction depot, very good quality can be ensured.

- The method is environment friendly as no concreting work is carried at site for the superstructure.

5.4 PRE-CAST CONSTRUCTION

5.4.1 Casting of Segments

For viaducts segmental pre-cast construction requires a casting yard. The construction depot will have facilities for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.5 Ha.To 3.0 Ha.is required for each construction depot.

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 cast segment will be transported on trailers and launched in position through launching girders.

5.4.2 Launching Scheme

Launching girder is specially designed for launching of segments. The suggested launching scheme is designed in such a way that initially the launching girder is erected on pier head at one end of the work. The segments are lifted in sequence and when the lifting is over, they are dry matched while hanging from the launching girder. After dry matching, the Segments are glued with epoxy and pre-stressed from one end. The girder is lowered on the temporary / permanent bearings after pre-stressing. The launching girder then moves over the launched span to next span and the sequences continue.

5.5 STRUCTURAL SYSTEM OF VIADUCT

5.5.1 Superstructure

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

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

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

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

For major crossing having spans greater than 31.0m, special continuous units normally of 3 span construction or steel girders have been envisaged.

All these continuous units (in case provided at obligatory location) will be constructed by cast-in-situ balanced cantilever construction technique.

5.5.2 Substructure

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.At this preliminary design stage, the size of pier is found to be limited to 1.8m to 2.0 m diameter of circular shape for most of its height so that it occupies the minimum space at ground level where the alignment often follows the central verge of existing roads.

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

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

The transverse spacing between bearings would be 3.2 m (to be studied in more details).

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

5.5.3 Foundation Recommendation

Deep Foundations, in the form of Bored Cast In-situ piles are recommended wherever expected heavy load transfer from the super structures and availability of dense competent strata at deeper depths. Bored cast in-situ pile foundations have been recommended keeping in consideration of site constraints for deep excavations, city area and vicinity of built of existing built up structuresPile foundations have been recommended for the foundations as per the stratum encountered. Hence, pile foundations with varying pile depths depending on soil characteristic have to be provided on a case-by-case basis.

5.5.4 Deck – Simple Spans

Salient features of the precast segmental construction method technique as envisaged for the project under consideration are indicated below:

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

The number of "breaks" in the stretch can be identified by Nos. of continuous units & stations.

The suggested method of erection will be detailed in drawings to be prepared, at the time of detailed design. 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 50t (to be finalized). The launching girder envisaged will be slightly longer than two span lengths. It must be able to negotiate curves in conjunction with temporary brackets.

Transportation of segments from casting yard to the point 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.

Box girder segments shall be match cast at the casting yard before being transported to location and erected in position. Post-tensioned cables shall be threaded in-situ and tensioned from one end. It is emphasized that for precast segmental construction only one-end pre-stressing shall be used.

The pre-stressing steel and pre-stressing system steel accessories shall be subjected to an acceptance test prior to their actual use on the works. The tests for the system shall be as per FIP Recommendations as stipulated in the special specifications. Only multi-strand jacks shall be used for tensioning of cables. Direct and indirect force measurement device (e.g. Pressure Gauge) shall be attached in consultation with system manufacturer.

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all segments so that they may be placed in the structure without damage. Segments shall be maintained in an upright position at all times and shall be stored, lifted and/or moved in a manner to prevent torsion and other undue stress. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings.

5.5.5 Epoxy Bonded Joints and Shear Keys

A minimum compressive stress of 3 kg/sq cm shall be provided uniformly over the cross-section for the closure stress on the epoxied joint until the epoxy has set. The curing period for application of the compressive stress, method of mixing and application of epoxy and all related aspects including surface preparation shall be as per approved manufacturer's specifications.

The purpose of the epoxy joint, which is about 1mm on each mating surface, shall be to serve as lubricant during segment positioning, to provide

Waterproofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting of one cable into other ducts.

The epoxy shall be special purpose and meet requirements of relevant provision of FIP (International Federation of Pre-stressed Concrete)

The temporary compressive stress during the curing period shall be applied by approved external temporary bar pre-stressing (such as Macalloy or Diwidag bar systems or approved equivalent).

5.6 CONSTRUCTION OF STATIONS

It is proposed to construct the elevated stations with elevated concourse over the road at most of the locations to minimize land acquisition. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus a separate structural configuration is required (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. However, there will be single viaduct column in the station area, which will be located on the median and supporting the concourse girders by a cantilever arm so as to eliminate the columns on right of way.

5.6.1 Grade of Concrete

It is proposed to carry out construction work with design mix concrete through computerized automatic Batching Plants with following grade of concrete 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
iv)	All precast element for viaduct and station	-	M -45
v)	Cantilever piers and portals	-	M -45
		-	M -60
vi)	Other miscellaneous structure	-	M -30

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

5.6.2 Reinforcement and pre-stressed Steel

It is proposed to use HYSD 500 or TMT steel as reinforcement bars.

For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 K 15 and or 19 K 15 is recommended (confirming to IS:14268).

5.6.3 Road width required during construction

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

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

i) Preliminary action for diversion of utility and preparation of estimates thereof.

ii) Reservation of land along the corridor, identification and survey for acquisition.

The SPV for the implementation of MEGA rail project has to take action for appointment of consultant for Project Management and proof checking including preparation of tender documents. Simultaneously, action is also to be taken for detailed design for structures for elevated & underground corridor.

5.7 GEO-TECHNICAL INVESTIGATIONS

5.7.1 Physiography

Ahmedabad is the largest city in the state of Gujarat. It is located in Western India on the banks of the River Sabarmati, 32 km from the state capital Gandhinagar. It is the former capital of Gujarat and also the financial capital of Gujarat. Ahmedabad is located at 23.030 N and 72.580 E at an elevation of 53 m. The Sabarmati River frequently dries up in summer, leaving only small stream of water. Except for the small hills of Thaltej - Jodhpur Tekra, the city is almost flat. Gandhinagar is the capital of the state of the Gujarat. Gandhinagar has an average elevation of about 81 m. The city sits on the banks of the River Sabarmati in North - Central - East of Gujarat.

5.7.2 Geology

The well known agriculturally rich alluvial basin of Gujarat rises from the estuarine tacts between Narmada and Tapi rivers, and extends 402 Km Northwards merging into the deserts plains ofRajasthan and the Rann of Kutch.

The alluvial plains of Gujarat are belongs to Quaternary group. The project site area is covered with deep layers recently placed alluvial sands.

5.7.3 Seismicity

The site is located in Seismic Zone III as per Seismic Zoning map of India. The basic HorizontalSeismic Co-efficient (Io) is 0.04 and Seismic Zone Factor (Fo) is 0.20

The region of Kutch and Gujarat has been subject to many earthquake in the past.

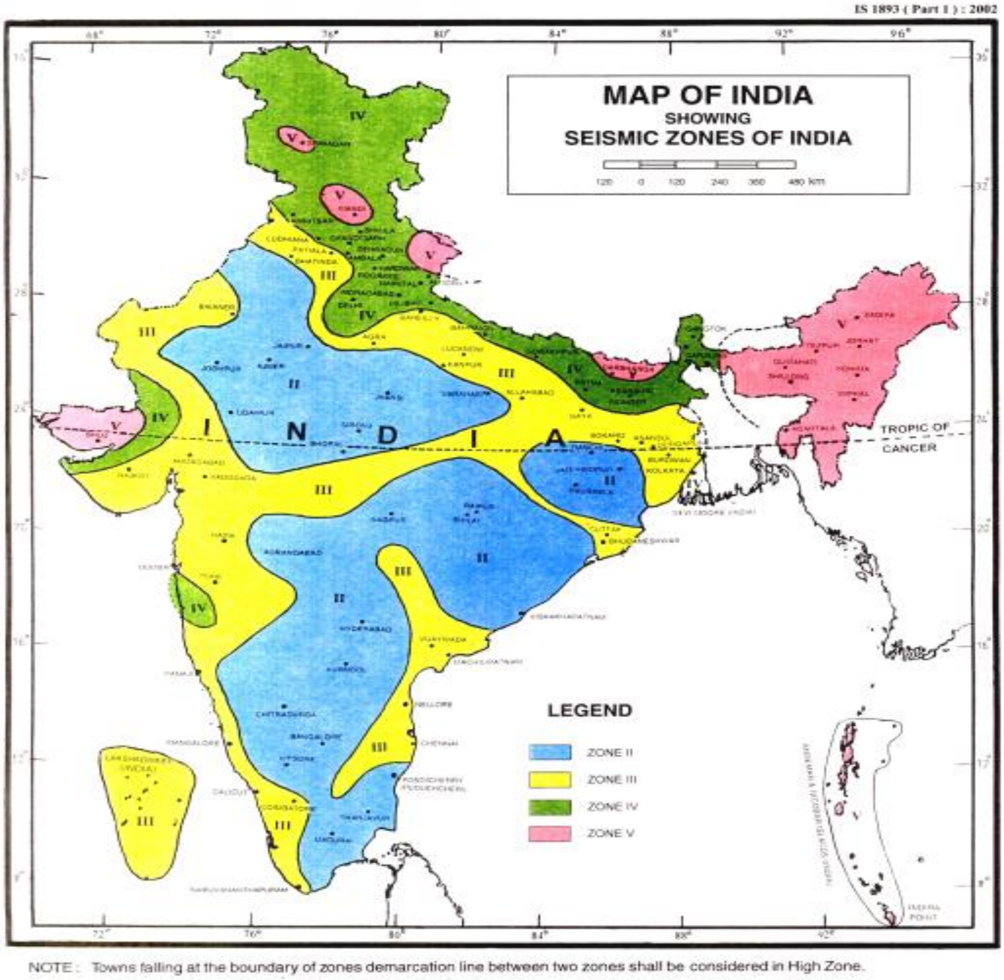


Figure 4.1: Seismic zones of India

5.8 OBJECTIVE OF GEOTECHNICAL INVESTIGATION

The main objectives of Geo-Technical Investigation Services are:

- To determine the required strength characteristics of the underlying soil/rock strata to design the foundation of the structure proposed to be constructed at various locations.
- To determine the subsurface profile of the underlying strata.

5.9 DETAILS OF BORE HOLES

5.9.1 Investigation Works

Geotechnical investigation work at site was carried out to determine the existing subsoil strata, proposed type & depth of foundations and safe bearing capacity of foundations required for the proposed two Metro Corridors . Borehole locations were identified at the ground along with the Client and drilling work is commenced.

5.9.2 Geology of the area

The soil formation in the site is observed to be homogenous in nature, and little variability is expected. Generally two layer homogeneous sub-soil profile has been noticed in the boreholes

5.9.3 Boring in Soil and Rock

In soils, boreholes of diameter 100mm to 150mm were drilled with the help of a posthole auger. Power winch was used to extend the boreholes with the help of Extension rods and auger, upto the required depth. Any loose soil was carefully removed from the bottom of the borehole so that the penetration test may be performed on an undisturbed surface of strata. Water table was recorded in each borehole, if met.

Rock coring was obtained by use of rotary drilling method, because of its ability in detaining higher quality of rock samples. Rock coring was carried out by using diamond bits and Tungsten carbide bits. For better core recovery in hard rock like basalt and granites, diamond bits were used. NX size of bit was used in coring. The drilling operation was conducted by attaching bits to core barrels through reamer shells. Methodology followed for boring confirmed IS: 1892-1979 and IS: 6926-1996.
Water was used as the drilling fluid, care was taken to see that water into the hole, be minimum, consistent with adequate removal of cutting from the hole and proper cooling of the bit. The rock core samples is preserved and stored as specified in IS: 4078-1980. The bore logs are as under:-

Table 5.1 - Borehole Details

S.No	BH No	Chainage	Reduced Level	Depth of BH	Water Table Depth
Motera Stadium to APMC					
1	BH 16	15092.35	58.566	30.00m	Not Met
2	BH 17	14223.382	56.6	30.00m	9.50m
3	BH 18	13469.70	56.9	30.00m	Not Met
4	BH 19	12706.095	57.037	30.00m	Not Met
5	BH 20	11938.171	53.316	30.00m	Not Met
6	BH 21	11077.50	51.605	30.00m	9.50m

S.No	BH No	Chainage	Reduced Level	Depth of BH	Water Table Depth
Motera Stadium to APMC					
7	BH 22	11224	50.01	30.00m	13.00m
8	BH 23	11080	54.00	30.00m	3.00m
9	BH 24	10232	52.32	30.00m	Not Met
10	BH 25	9632	51.05	30.00m	Not Met
11	BH 26	9160	47.23	30.00m	Not Met
12	BH 27	8005	52.052	30.00m	18.00m
13	BH 28	7034.60	51.231	30.00m	Not Met
14	BH 29	6145.728	49.938	30.00m	23.00m
15	BH 30	5434.424	48.920	30.00m	20.00m
16	BH 31	4711.35	47.100	30.00m	17.50m
17	BH 32	3915.257	47.223	30.00m	21.50m
18	BH 33	3302.281	46.80	30.00m	22.00m
19	BH 34	2523.76	49.897	30.00m	21.00m
20	BH 35	1739.38	47.711	30.00m	17.00m
21	BH 36	925.781	42.48	30.00m	7.00m
22	BH 37	180.0	42.661	30.00m	10.00m
Ashram Road to Thaltej					
23	BH 42	6588.54	50.547	37.00m	10.00m
24	BH 43	6105.38	50.670	36.50m	12.00m
25	BH 44	4711.16	49.75	30.00m	Not Met
26	BH 45	5252.44	49.84	30.00m	Not Met
27	BH 46	3937.13	48.55	30.00m	Not Met
28	BH 47	3055.66	48.40	30.00m	Not Met
29	BH 48	2961.75	49.5	30.00m	20.00m
30	BH 49	1572.38	50.2	30.00m	19.25m
31	BH 50	754	56.8	30.00m	Not Met
32	BH 51	0	51.875	30.00m	Not Met

Borehole Details from Sabarmati River to Vastral

BH No.	Location (Existing Km.)	Max. Depth of Drilling (m)	Water Table	Stratum at the termination depth
1	Sabarmati river	50.00	10.80m	Soft Disintegrated Rock
2	Kasturba gandhi road	50.00	6.30m	Soft Disintegrated Rock
3	Ghee Kanta	50.00	6.00m	Soft Disintegrated Rock
4	New Arvind mill	50.00	9.60m	Soft Disintegrated Rock
5	New Cotton Mill	50.00	8.40m	Soft Disintegrated Rock
6	Swastik Circle	50.00	7.00m	Soft Disintegrated Rock
7	Rabari Colony	50.00	3.30m	Soft Disintegrated Rock
8	Mahadev Nagar	50.00	28.30m	Soft Disintegrated Rock
9	Triveni Park	50.00	25.80m	Soft Disintegrated Rock
10	Vastral	50.00	Nill	Soft Disintegrated Rock

Note-Bore hole details from Motera Stadium to APMC and Ashram Road to Thaltej has been taken from the ahmedabad DPR 2005 submitted earlier by DMRC.

5.10 FIELD TESTS & LABORATORY TESTS

5.10.1 Standard Penetration Tests

This is a field test to determine “penetration resistance of stratum at the test depth”. This was conducted in the boreholes at 1.5 to 3.0 m intervals generally up to refusal or upto termination depth (at locations where refusal stratum was not encountered) using procedures described in IS: 2131. In this test, driving bit was replaced by split spoon sampler (50.8 mm OD and 35 mm ID). Sampler of length 60cm was then driven by dropping 63.5 kg hammer on top of driving collar with free fall of 75 cm. Sampler was first driven through 15 cm as”Seating drive”. It was further driven through 30 cm. Number of blows required to drive the sampler for 30 cm beyond seating drive was termed as “Penetration Resistance, “N”. Where full penetration of 30cm was not possible (refusal conditions), blows and corresponding penetration was recorded.

5.10.2 Grain Size Analysis

TheGrain Size Analysis of different samples collected from boreholes were done as per IS: 2720(part IV).

5.10.3 Atterberg’s Limits

The liquid limit and plastic limit were conducted as per IS: 2720(part V) on soil samples.

5.10.4 Field Content Density and Moisture

The Undisturbed Soil Samples were tested for field density and moisture content as per IS: 2720(part II).

5.10.5 Specific Gravity

The soil samples were tested for specific gravity as per IS: 2720(part III).

5.10.6 Direct Shear Test

The undisturbed soil samples were tested for direct shear tests.

5.10.7 Chemical Analysis of Soil

Chemical analysis of soil samples were conducted for PH, Sulphates (ppm) and for Chloride (ppm).

5.10.8 Chemical Analysis of Water

Chemical analysis of soil samples were conducted for PH, Sulphates (ppm) and for Chloride (ppm).

5.10.9 Rock Test Analysis

Rock samples were collected from the bore holes and tested for water absorption, porosity and dry density.

5.11 NET ALLOWABLE BEARING PRESSURE

Considering the proposed structure and taking into account the 'N' values, an allowable settlement of 25 mm has been adopted for evaluating the net allowable bearing capacity, based on the settlement criterion.

Average shear strength parameters have been used for calculating safe bearing capacity from shear failure criterion as per IS: 6403-1981 .Lower of the two values obtained from settlement and shear criteria is used in arriving at net allowable bearing capacity of the soil

5.12 SATTLEMENT CRITERIA: IS-8009 (PART-I) APPROACH

Net allowable bearing pressure is computed by adopting design 'N' value of 50 (conservative approach) at refusal strata as per IS-8009 (part-I) approach.

In IS: 8009, settlement for 10 t/m2 for various foundation widths varying from 1m to 6m is available depending on design SPT 'N' values. The net allowable bearing pressure is evaluated for 25mm allowable settlement.

5.13 CONCLUSION AND RECOMMENDATION

- 10 boreholes were drilled along metro alignment in order to obtain information about subsurface layers.

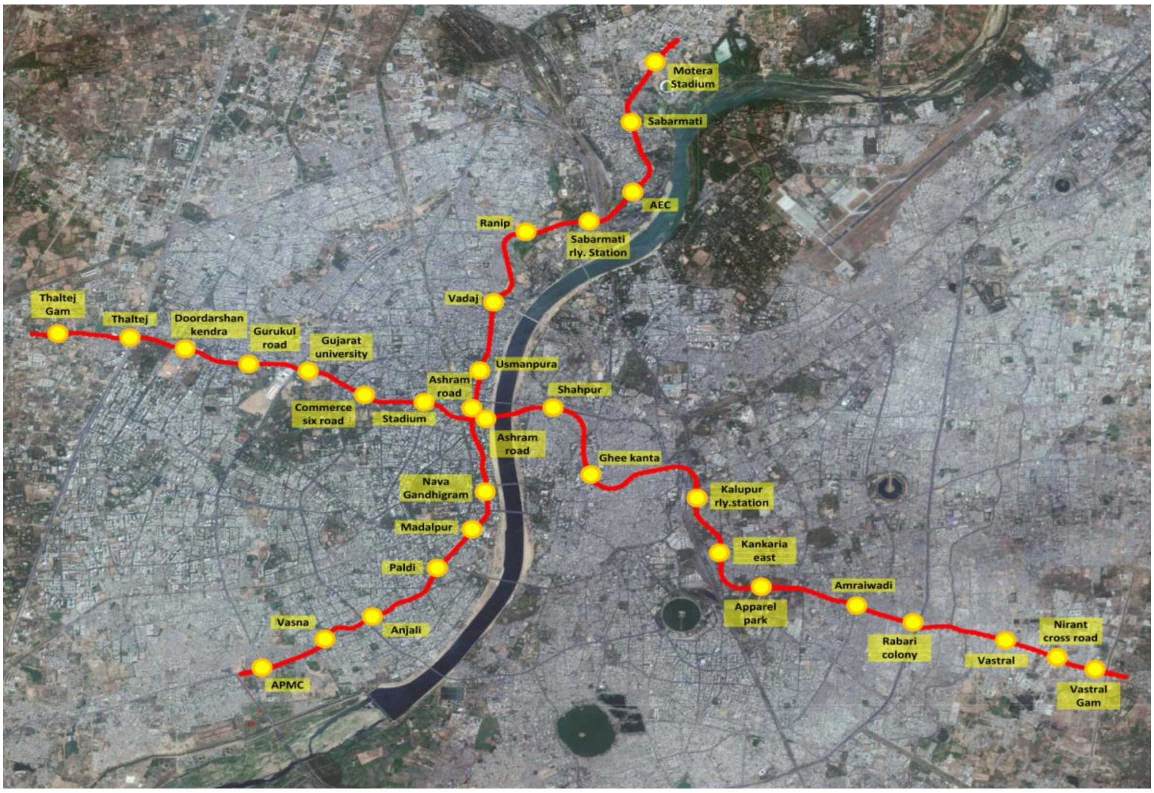
- The soil formation in the site is observed to be homogenous in nature, and little variability is expected. Generally two layer homogeneous sub-soil profile has been noticed in the boreholes as explained briefly in Section 5.0 above.

- Ground water table was met in all the boreholes except BH 10 at the time of investigation mentioned in table . Proper dewatering arrangements are necessary to excavate up to the footing level below the ground water table.

- If the in-situ material is to be used as a backfilling material, it should be compacted to not less than 97% of the MDD in 300 mm layers.

- Based on the sub-soil profile noticed and considering heavy load transfer expected from the structures, Deep Foundations, in the form of Bored Cast In-situ piles are recommended.

- For pile load capacity calculations, bored cast in-situ piles of 1200 mm, 1500 mm & 1800mm are considered. Recommended Termination depth of piles below EGL & safe loads on piles considering pile with M35 grade concrete is as follows.



5.14 LAND

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

5.14.1 Land Requirement for following Major Components

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

5.14.2 Land for Underground stretches

No land at surface is required permanently for underground section, except for small areas for entry/exit structures, traffic integration, chilling plant and ventilation shafts at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road.

5.14.3 Land required for elevated stretches

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

The normal viaduct structure of elevated Metro is about 10 m (edge to edge) wide. Ideally the required right of way is 10m. However, for reasons of safety a clean marginal distance / setback of about 5 m is necessary from either edge of the viaduct (or 10 m on both sides of the centre line) wherein no structures are to be located. it ensures road access and working space all along the viaduct for working of emergency equipments and fire brigade. In stretches, where the elevated alignment has to be located away from road, a strip of 20-m width is proposed for acquisition.

In view of the constraints on space on ground floor, it is proposed to provide the concourse area exactly below the Station Building at mezzanine level. All the stations in elevated stretch including terminal station are planned with side platforms. Normally, the ideal width required for station building in is 28.0m. The staircase giving access to concourse area from ground will be located at the edge of footpaths or in front marginal open setback of the buildings in the as far as possible in the open space. Nevertheless it is not possible to find open space at all the locations therefore acquisition of certain private structures is inevitable.

5.14.4 Land for Switch-over Ramps

Switch-over ramps are required for transition from the underground to elevated section or *vice versa*. The ramp covers a stretch at ground for the whole width of structure for two tracks (about 10.5m including the protection works). 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. Two such ramps are provided in East-West corridor.

5.14.5 Land for Traffic integration

As indicated in station planning para certain land is required for traffic integration at the each station. But no land for traffic integration has been ear marked at this stage however this should be identified and ear marked where ever possible closure to the proposed station locations.

5.14.6 Land for Traction and Receiving Substation and Radio Towers

Two RSS each is proposed to be located for Thaltej Gam to Vastral Gam and APMC to Motera Stadium Corridor. Hence, an area of 22400 m^2 has been earmarked exact location will be decided at the time of implementation of the project. No additional land proposed for locating radio towers. These will be accommodated in the land already acquired. Land required for RSS will be as tabulated below.

Table 5.2 - Details of Land Required for RSS

S. No.	Name of Corridor	Area (m^2)	Ownership
1.	Thaltej Gam to Vastral Gam	11200	Government
2.	APMC to Motera Stadium	11200	Government
	Total	**22400**	

5.14.7 Land Requirement for Stations & Running section

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

To the extent possible the Entry and Exit points of stations (underground and elevated) were planned on the in open spaces between foot paths and building offsets as far as possible. But, for locating other station facilities such as chiller plants, ventilation shafts, underground water tanks, generator set room etc., land acquisition is proposed

The details of land permanently required for depot, running sections and stations are indicated in the **Table 5.3, Table 5.4 and Table 5.5** and the areas identified for acquisition are shown in Figs. L - 4.1 to L - 4.29 and are placed at the end of this chapter.

Table 5.3 - Details of Land Required for Depot

S. No.	Location	Area(m^2)	Ownership	Purpose
1.	New Cotton Mill	190936	Government	Depot
2.	Vasana	250000	Government	Depot
	Total	**440936**		

Table 5.4 - Details of Land Required for Depot

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
EAST – WEST CORRIDOR			
1	RS-1	1740.2	Private
2	RS-2	1574	Private
3	RS-3	23.8	Government
4	RS-4	334.6	Private
5	RS-5	3828.8	Private
6	RS-6	431.1	Private
7	RS-7	998.3	Private
8	RS-8	5677.8	Government
9	RS-9	2068.6	Government
10	RS-10	4586.2	Government
11	RS-11	833.4	Private
12	RS-12	1061.6	Government
13	RS-13	5651.1	Government
		TOTAL =28509.5 Sqm.	
		GOVT. =197672.4Sqm.	
		PVT. =22073Sqm	

S.NO.	PLOT NO.	AREA (m²)	REMARKS
NORTH - SOUTH CORRIDOR			
1	RS-1	4830.9	Government
2	RS-2	353.4	Private
3	RS-3	9155.2	Private
4	RS-4	29377.2	Government
5	RS-5	10295.2	Government
6	RS-6	572	Private
7	RS-7	3797.3	Government
8	RS-8	5982.7	Government
9	RS-9	398	Private
10	RS-10	164	Private
		TOTAL = 64925.9Sqm.	
		GOVT. =54283.3Sqm.	
		PVT. =10642.6Sqm	

Table 5.5 - Details of Land Required for Stations

S.No	Station Name	Land Area(m²)	Ownership	Remarks
Thaltej to Vstral Gam Corridor				
1.0	THALTEJ GAM	700	Government	Exits, entries and ancillary buildings
2.0	THALTEJ	700	Private	Exits, entries and ancillary buildings
3.0	DOORDARSHAN KENDRA	700	Private	Exits, entries and ancillary buildings
4.0	GURUKUL ROAD	700	Private	Exits, entries and ancillary buildings
5.0	GUJARAT UNIVERSITY	700	Private	Exits, entries and ancillary buildings
6.0	COMMERCE SIX ROAD	700	Private	Exits, entries and ancillary buildings
7.0	STADIUM	700	Private	Exits, entries and ancillary buildings
8.0	ASHRAM ROAD	700	Private	Exits, entries and ancillary buildings
9.0	SHAHPUR	1440	Government	Exits, entries and ancillary buildings
10.0	GHEE KANTA	1440	Government	Exits, entries and ancillary buildings
11.0	KALUPUR RLY.STATION	1440	Government	Exits, entries and ancillary buildings
12.0	KANKARIA EAST	1440	Private	Exits, entries and ancillary

S.No	Station Name	Land Area(m^2)	Ownership	Remarks
				buildings
13.0	APPAREL PARK			Land included in Depot area
14.0	AMRAIWADI	700	Private	Exits, entries and ancillary buildings
15.0	RABARI COLONY	700	Private	Exits, entries and ancillary buildings
16.0	VASTRAL	700	Private	Exits, entries and ancillary buildings
17.0	NIRANT CROSS ROAD	700	Private	Exits, entries and ancillary buildings
18.0	VASTRAL GAM	700	Private	Exits, entries and ancillary buildings
APMC to Motera Stadium Corridor				
1	APMC	700	Private	Exits, entries and ancillary buildings
2	VASNA	700	Government	Exits, entries and ancillary buildings
3	ANJALI	700	Private	Exits, entries and ancillary buildings
4	PALDI	700	Private	Exits, entries and ancillary buildings
5	MADALPUR	700	Private	Exits, entries and ancillary buildings
6	NAVA GANDHIGRAM	700	Private	Exits, entries and ancillary buildings
7	ASHRAM ROAD	700	Private	Exits, entries and ancillary buildings
8	USMANPURA	700	Private	Exits, entries and ancillary buildings
9	VADAJ	700	Government	Exits, entries and ancillary buildings
10	RANIP	700	Government	Exits, entries and ancillary buildings
11	SABARMATI RLY. STATION	3920	Private	Exits, entries and ancillary buildings
12	AEC	700	Private	Exits, entries and ancillary buildings
13	SABARMATI	700	Private	Exits, entries and ancillary buildings
14	MOTERA STADIUM	700	Private	Exits, entries and ancillary buildings

5.14.8 Land for Staff quarters, office complex and operation control centre (OCC)

A large number of officers and staff will be required to be deployed permanently to take care of project implementation and post construction operational activities. Moreover metro office complex and metro operation control centre will also be required. It is proposed to keep the provision of **5.0 ha** of government land for this purpose. Exact location of land has not been identified at this stage. It may be decided at the time of project implementation.

5.14.9 Temporary office accommodation

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

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

Table 5.6 - Details of Temporary Land office accommodation

S. No.	Description	Thaltejgam to Vastral Gam(m^2)		APMC to Motera Stadium(m^2)		Total(m^2)
		Govt.	Pvt.	Govt.	Pvt.	
1	Temporary office accommodation	8213		6168		14381
2	Segment Casting Yard	80000		60000		140000
	Total	**88213**		**66168**		**154381**

5.14.10 Segment Casting Yard

Large numbers of pre-cast segments are required for construction of elevated/underground structures for which a large open area is required for setting up of casting yards. As far as possible, this area should be close to the site, easily accessible and away from habitation. Considering the various factors, it is proposed to setup four segment casting yards for East-West corridor and three Casting yards for North-South Corridor. Accordingly a provision of **14.0ha** land has been proposed on temporary basis considering 2.0 ha of land for each segment casting yard for a period of a period of four years.

5.14.11 Summary of Land Requirements

Abstract of land requirements for different components of this corridor is given in Tables below. However, the land requirement is summarized below:

a) Govt Land permanently required for stations, Depot, Ramp and running section **77.406ha.**

b) Private Residential and Commercial Required for stations, Ramp and Running section **5.348ha**

c) Total land required for the project is **82.754ha.**

Table 5.7 - Summary of Permanent Land Requirement (All figures in Sq. m)

S. No.	Description	Thaltej Gam to Vastral Gam		APMC to Motera Stadium		Total
		Govt.	Pvt.	Govt.	Pvt.	
1	Stations	5020	9840	2100	10920	27880
2	Running Section	197672	22073	54283	10643	284671
3	Depot	190936		250000		440936
4	Staff Quarter,Office Complex and OCC	50000				50000
5	Receiving Substation(RSS)	11200		11200		22400
6	Mid Shaft	1650				1650
	Total	**456478**	**31913**	**317583**	**21563**	**827537**

*** Total land required for the project is mentioned here above does not include land require for traffic integration/parking.**

Total	=	**82.754 Ha**
Government	=	**77.406 Ha**
Private	=	**5.348 Ha**

Table 5.8 - Summary of Temporary Land Requirement

S. No.	Description	Thaltejgam to Vastral Gam		APMC to Motera Stadium		Total
		Govt.	Pvt.	Govt.	Pvt.	
1	Temporary office accommodation	8213		6168		14381
2	Segment Casting Yard	80000		60000		140000
	Total	**88213**		**66168**		**154381**

Total	=	**15.438 Ha**
Government	=	**15.438 Ha**

Total land required for temporary acquisition is **15.4ha** which assumed that it will be government open land.

5.15 UTILITY DIVERSIONS

5.15.1 Introduction

Besides the details of various aspects e.g. transport demand analysis, route alignment, station locations, system design, viaduct structure, geo-technical investigations etc. as brought out in previous paras, there are a number of other engineering issues, which are required to be considered in sufficient details before really deciding on taking up any infrastructure project of such magnitude. Accordingly, following engineering items have been studied and described in this para.

Existing underground and at surface utilities and planning for their diversion during construction, if necessary.

5.15.2 Utility and Services

The DMRC has collected details of various utilities from concerned agencies/organisations directly for the entire alignment. Large number of sub-surface, surface and over head utility services viz. sewers, water mains, storm water drains, telephone cables, O.H electrical transmission lines, electric poles, traffic signals, etc. are existing along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Table 5.9 - Utility Detail

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
1	0+000	1+480	OFC	BSNL WTR LINE
2	0+000	1+480	OFC	BSNL WTR LINE
3	0+000	1+725	OFC	Reliance OFC
4	0+000	1+850	OFC	Vodafone OFC
5	0+180	0+690	OFC	Tata Communications
6	0+210	0+210	OFC	Vodafone OFC
7	0+210	0+650	OFC	Vodafone OFC
8	0+500	0+500	GasLine	Adani 04 Inch Steel Pipeline
9	0+500	0+670	GasLine	Adani 04 Inch Steel Pipeline
10	0+650	0+650	OFC	Vodafone OFC
11	0+670	0+670	GasLine	Adani 04 Inch Steel Pipeline
12	0+675	0+675	Copper Cable	BSNL COPPER LINE
13	0+675	1+650	Copper Cable	BSNL COPPER LINE
14	0+675	1+650	Copper Cable	BSNL COPPER LINE
15	0+680	0+680	GasLine	Adani 12 Inch Steel Pipeline

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
16	0+680	0+840	GasLine	Adani 12 Inch Steel Pipeline
17	0+680	0+680	OFC	Tata Tele Cable
18	0+680	1+870	OFC	Tata Tele Cable
19	0+690	0+690	OFC	Tata Communications
20	0+690	1+850	OFC	Tata Communications
21	0+700	0+700	Copper Cable	BSNL COPPER LINE
22	0+700	1+480	OFC	BSNL DUCT LINE
23	0+840	0+840	GasLine	Adani 12 Inch Steel Pipeline
24	0+840	0+150	GasLine	Adani 12 Inch Steel Pipeline
25	1+150	3+700	GasLine	Adani 12 Inch Steel Pipeline
26	1+480	1+575	GasLine	Adani gas 63 MM MDPE Line
27	1+480	1+480	Copper Cable	BSNL COPPER LINE
28	1+480	1+480	OFC	BSNL DUCT LINE
29	1+480	1+650	OFC	BSNL DUCT LINE
30	1+480	1+860	OFC	BSNL WTR LINE
31	1+500	1+500	GasLine	Adani gas 63 MM MDPE Line
32	1+500	1+850	GasLine	Adani gas 63 MM MDPE Line
33	1+575	1+575	GasLine	Adani gas 63 MM MDPE Line
34	1+620	1+850	GasLine	Adani gas 63 MM MDPE Line
35	1+650	1+825	Copper Cable	BSNL COPPER LINE
36	1+650	1+700	OFC	BSNL DUCT LINE
37	1+700	1+700	OFC	BSNL DUCT LINE
38	1+700	1+850	OFC	BSNL DUCT LINE
39	1+700	1+850	OFC	BSNL DUCT LINE
40	1+725	1+725	OFC	Reliance OFC
41	1+725	1+850	OFC	Reliance OFC
42	1+850	1+850	OFC	BSNL DUCT LINE
43	1+850	2+350	OFC	Reliance OFC
44	1+860	1+860	OFC	BSNL WTR LINE
45	1+860	2+360	OFC	BSNL WTR LINE
46	1+870	1+870	OFC	Tata Tele Cable
47	1+900	1+900	OFC	Airtel OFC
48	2+300	2+360	OFC	Tata Tele Cable
49	2+300	2+360	OFC	Tata Communications
50	2+300	4+325	OFC	Vodafone OFC
51	2+350	2+475	GasLine	Adani gas 63 MM MDPE Line
52	2+350	2+975	OFC	Reliance OFC
53	2+360	2+360	OFC	BSNL DUCT LINE
54	2+360	3+200	OFC	BSNL DUCT LINE
55	2+360	3+200	OFC	BSNL DUCT LINE

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
56	2+360	2+360	OFC	BSNL WTR LINE
57	2+360	3+650	OFC	BSNL WTR LINE
58	2+360	2+375	OFC	Tata Tele Cable
59	2+360	2+375	OFC	Tata Communications
60	2+375	2+375	OFC	Tata Tele Cable
61	2+375	4+300	OFC	Tata Tele Cable
62	2+375	3+700	OFC	Tata Communications
63	2+400	3+600	Copper Cable	BSNL COPPER LINE
64	2+425	2+425	GasLine	Adani gas 32 MM MDPE Line
65	2+575	2+575	OFC	Airtel OFC
66	2+575	4+175	OFC	Airtel OFC
67	2+600	2+925	GasLine	Adani gas 63 MM MDPE Line
68	2+775	2+775	Copper Cable	BSNL COPPER LINE
69	2+775	3+700	Copper Cable	BSNL COPPER LINE
70	2+800	2+850	GasLine	Adani gas 63 MM MDPE Line
71	2+975	2+975	OFC	Reliance OFC
72	3+200	3+630	OFC	BSNL DUCT LINE
73	3+325	3+650	GasLine	Adani gas 63 MM MDPE Line
74	3+325	3+325	OFC	Reliance OFC
75	3+325	3+380	OFC	Reliance OFC
76	3+380	3+380	OFC	Reliance OFC
77	3+380	3+700	OFC	Reliance OFC
78	3+480	3+480	OFC	Reliance OFC
79	3+480	3+650	OFC	Reliance OFC
80	3+480	3+650	OFC	Reliance OFC
81	3+525	3+600	GasLine	Adani gas 63 MM MDPE Line
82	3+625	4+300	GasLine	Adani gas 125 MM MDPE Line
83	3+630	3+630	OFC	BSNL DUCT LINE
84	3+630	4+220	OFC	BSNL DUCT LINE
85	3+640	3+640	OFC	Tata Communications
86	3+650	4+100	GasLine	Adani gas 125 MM MDPE Line
87	3+650	3+650	OFC	BSNL WTR LINE
88	3+840	3+840	OFC	Reliance OFC
89	3+860	3+860	Copper Cable	BSNL COPPER LINE
90	3+860	4+200	Copper Cable	BSNL COPPER LINE
91	3+860	3+860	OFC	Tata Tele Cable
92	3+860	4+300	OFC	Tata Tele Cable
93	4+080	4+080	GasLine	Adani 04 Inch Steel Pipeline
94	4+080	4+130	GasLine	Adani 04 Inch Steel Pipeline
95	4+100	4+100	GasLine	Adani gas 125 MM MDPE Line

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
96	4+130	4+130	GasLine	Adani 04 Inch Steel Pipeline
97	4+175	4+175	OFC	Airtel OFC
98	4+175	4+220	OFC	Airtel OFC
99	4+200	4+250	Drainage Line	Drainage 1350 mm dia pipeline
100	4+200	4+280	Water Line	Water pipeline 300 mm dia
101	4+210	4+210	OFC	BSNL DUCT LINE
102	4+220	4+220	OFC	Airtel OFC
103	4+220	4+260	OFC	Airtel OFC
104	4+220	4+220	Copper Cable	BSNL COPPER LINE
105	4+220	4+220	OFC	BSNL DUCT LINE
106	4+225	4+225	OFC	BSNL UG LINE
107	4+225	4+225	Water Line	Water pipeline 200 mm dia
108	4+225	4+225	Water Line	Water pipeline 300 mm dia
109	4+230	4+230	Water Line	Water pipeline 450 mm dia
110	4+240	4+265	Drainage Line	Drainage 150 mm dia pipeline
111	4+250	4+250	GasLine	Adani gas 90 MM Line
112	4+250	4+250	OFC	BSNL UG LINE
113	4+250	4+250	OFC	BSNL UG LINE
114	4+250	4+250	Drainage Line	Drainage 450 mm dia pipeline
115	4+250	4+275	Drainage Line	Drainage 600 mm dia pipeline
116	4+250	4+275	Drainage Line	Drainage 300 mm dia pipeline
117	4+250	4+250	Storm Water Drain	Storm water drainage 600 MM Dia
118	4+250	4+250	Storm Water Drain	Storm water nala 2M x 2 M
119	4+250	4+250	Water Line	Water pipeline 150 mm dia
120	4+250	4+250	Water Line	Water pipeline 200 mm dia
121	4+260	4+260	OFC	Airtel OFC
122	4+260	4+525	OFC	Airtel OFC
123	5+850	5+850	OFC	BSNL WTR LINE
124	5+850	8+030	OFC	BSNL WTR LINE
125	7+880	7+925	Electric Line	HT CABLE 0.1
126	7+880	7+910	Electric Line	HT CABLE 70
127	7+900	7+950	Electric Line	LT cable 70 4C
128	7+900	8+100	Electric Line	LT cable 240 4C
129	7+900	8+100	Electric Line	LT cable 240 4C
130	7+900	8+000	Electric Line	LT cable 120 4C
131	7+910	7+910	Electric Line	HT CABLE 70
132	7+910	7+950	Electric Line	HT CABLE 70
133	7+925	7+925	Electric Line	HT CABLE 0.1
134	7+925	7+925	Electric Line	HT CABLE 185
135	7+930	9+980	OFC	Vodafone OFC

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
136	7+930	7+930	Electric Line	HT CABLE 70
137	7+930	8+040	Electric Line	HT CABLE 70
138	7+930	8+125	Electric Line	HT CABLE 70
139	7+950	8+000	Electric Line	LT cable 240 4C
140	7+950	8+000	Electric Line	LT cable 240 4C
141	7+950	8+000	Electric Line	LT cable 240 4C
142	7+950	8+000	Electric Line	LT cable 120 4C
143	7+950	8+700	Electric Line	HT CABLE 300
144	7+950	7+950	Electric Line	HT CABLE 70
145	7+950	8+125	Electric Line	HT CABLE 70
146	8+000	8+050	Electric Line	LT cable 25 4C
147	8+000	8+050	Electric Line	LT cable 10 4C
148	8+030	9+150	OFC	BSNL WTR LINE
149	8+030	9+150	OFC	BSNL WTR LINE
150	8+040	8+040	Electric Line	HT CABLE 0.1
151	8+040	9+150	Electric Line	HT CABLE 0.1
152	8+040	8+040	Electric Line	HT CABLE 70
153	8+050	8+100	Electric Line	LT cable 10 4C
154	8+070	9+140	OFC	BSNL DUCT LINE
155	8+070	9+140	OFC	Tata Tele Cable
156	8+100	8+180	OFC	Reliance OFC
157	8+100	8+150	Water Line	Water pipeline 300 mm dia
158	8+100	8+150	Water Line	Water pipeline 300 mm dia
159	8+125	8+125	OFC	Airtel OFC
160	8+125	8+125	Electric Line	HT CABLE 70
161	8+125	8+570	Electric Line	HT CABLE 70
162	8+130	8+130	Water Line	Water pipeline 100 mm dia
163	8+140	8+140	Drainage Line	Drainage 300 mm dia pipeline
164	8+150	8+200	Electric Line	LT cable 25 4C
165	8+150	8+500	Copper Cable	BSNL COPPER LINE
166	8+150	8+350	Drainage Line	Drainage 450 mm dia pipeline
167	8+150	8+150	OFC	Incable OFC
168	8+150	8+530	OFC	Incable OFC
169	8+150	8+150	Storm Water Drain	Storm Water Nala 2.5 M x 2.5 M
170	8+150	9+980	OFC	Vodafone OFC
171	8+150	8+150	Water Line	Water pipeline 200 mm dia
172	8+150	8+150	Water Line	Water pipeline 300 mm dia
173	8+150	8+210	Water Line	Water pipeline 300 mm dia
174	8+150	8+250	Electric Line	HT CABLE 70
175	8+170	8+930	Water Line	Water pipeline 150 mm dia

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
176	8+180	8+180	OFC	Reliance OFC
177	8+180	9+150	OFC	Reliance OFC
178	8+200	8+500	Electric Line	LT cable 240 4C
179	8+210	9+000	Water Line	Water pipeline 300 mm dia
180	8+220	8+220	Drainage Line	Drainage 300 mm dia pipeline
181	8+250	8+250	Electric Line	HT CABLE 185
182	8+250	8+520	Electric Line	HT CABLE 185
183	8+250	8+250	Electric Line	HT CABLE 70
184	8+250	8+340	Electric Line	HT CABLE 70
185	8+250	8+350	Electric Line	LT cable 25 4C
186	8+250	8+350	Electric Line	LT cable 240 4C
187	8+260	8+260	GasLine	Adani 04 Inch Steel Pipeline
188	8+260	8+360	GasLine	Adani 04 Inch Steel Pipeline
189	8+340	8+340	Electric Line	HT CABLE 70
190	8+340	8+500	Electric Line	HT CABLE 70
191	8+350	9+150	Drainage Line	Drainage 600 mm dia pipeline
192	8+350	8+500	Electric Line	LT cable 240 4C
193	8+355	8+355	OFC	Airtel OFC
194	8+360	8+360	GasLine	Adani 04 Inch Steel Pipeline
195	8+430	8+430	Drainage Line	Drainage 150 mm dia pipeline
196	8+480	8+480	Drainage Line	Drainage 150 mm dia pipeline
197	8+500	8+550	Electric Line	LT cable 70 4C
198	8+500	8+600	Electric Line	LT cable 10 4C
199	8+500	8+750	Electric Line	LT cable 240 4C
200	8+500	8+900	Electric Line	LT cable 240 4C
201	8+500	8+500	Copper Cable	BSNL COPPER LINE
202	8+500	8+840	Copper Cable	BSNL COPPER LINE
203	8+500	8+840	Copper Cable	BSNL COPPER LINE
204	8+500	8+500	OFC	Incable OFC
205	8+500	8+500	Electric Line	HT CABLE 70
206	8+500	8+580	Electric Line	HT CABLE 70
207	8+520	8+520	Drainage Line	Drainage 150 mm dia pipeline
208	8+520	8+520	Electric Line	HT CABLE 185
209	8+520	8+630	Electric Line	HT CABLE 185
210	8+520	8+520	Electric Line	HT CABLE 70
211	8+550	8+600	Electric Line	LT cable 10 4C
212	8+550	8+600	Electric Line	LT cable 70 4C
213	8+555	8+555	OFC	Airtel OFC
214	8+570	8+700	Electric Line	HT CABLE 70
215	8+590	8+590	Electric Line	HT CABLE 70

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
216	8+590	8+700	Electric Line	HT CABLE 70
217	8+600	8+600	Drainage Line	Drainage 150 mm dia pipeline
218	8+630	8+630	Electric Line	HT CABLE 185
219	8+630	8+700	Electric Line	HT CABLE 185
220	8+640	8+640	Drainage Line	Drainage 150 mm dia pipeline
221	8+700	9+150	OFC	GTPL OFC
222	8+700	8+700	Electric Line	HT CABLE 185
223	8+700	9+150	Electric Line	HT CABLE 185
224	8+700	8+780	Electric Line	HT CABLE 300
225	8+700	8+700	Electric Line	HT CABLE 300
226	8+700	8+750	Electric Line	HT CABLE 300
227	8+700	8+700	Electric Line	HT CABLE 70
228	8+700	8+900	Electric Line	HT CABLE 70
229	8+700	8+920	Electric Line	HT CABLE 70
230	8+700	8+750	Electric Line	LT cable 240 4C
231	8+750	8+800	Electric Line	LT cable 10 4C
232	8+750	8+900	Electric Line	LT cable 240 4C
233	8+750	8+750	Electric Line	HT CABLE 70
234	8+760	8+760	Drainage Line	Drainage 300 mm dia pipeline
235	8+760	8+760	OFC	Vodafone OFC
236	8+760	8+760	Electric Line	HT CABLE 300
237	8+775	8+775	OFC	Incable OFC
238	8+775	9+100	OFC	Incable OFC
239	8+775	8+775	OFC	Reliance OFC
240	8+830	8+830	Electric Line	HT CABLE 70
241	8+840	9+125	Copper Cable	BSNL COPPER LINE
242	8+840	9+075	Copper Cable	BSNL COPPER LINE
243	8+840	8+840	Storm Water Drain	Storm water nala 2M x 2 M
244	8+840	8+925	Storm Water Drain	Storm water nala 2M x 2 M
245	8+850	8+900	Electric Line	LT cable 10 4C
246	8+900	8+950	Electric Line	LT cable 10 2C
247	8+900	8+950	Electric Line	LT cable 10 2C
248	8+900	9+100	Electric Line	HT CABLE 70
249	8+925	8+925	Storm Water Drain	Storm water nala 2M x 2 M
250	8+925	8+925	Water Line	Water pipeline 200 mm dia
251	8+925	9+130	Water Line	Water pipeline 300 mm dia
252	8+930	8+930	OFC	Vodafone OFC
253	8+930	8+930	Water Line	Water pipeline 150 mm dia
254	8+940	8+930	OFC	Vodafone OFC
255	8+940	9+180	OFC	Vodafone OFC

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
256	8+950	9+000	Electric Line	LT cable 70 4C
257	8+950	9+050	Electric Line	LT cable 120 4C
258	8+980	9+180	OFC	BSNL OFC LINE
259	9+000	9+000	OFC	Airtel OFC
260	9+000	9+160	OFC	Airtel OFC
261	9+000	9+150	Water Line	Water pipeline 300 mm dia
262	9+000	9+050	Electric Line	LT cable 25 4C
263	9+010	9+010	Water Line	Water pipeline 150 mm dia
264	9+020	9+020	Water Line	Water pipeline 200 mm dia
265	9+100	9+150	Electric Line	LT cable 70 4C
266	9+100	9+250	OFC	Incable OFC
267	9+100	9+170	Electric Line	HT CABLE 70
268	9+100	9+100	Electric Line	HT CABLE 70
269	9+100	9+170	Electric Line	HT CABLE 70
270	9+125	9+125	Copper Cable	BSNL COPPER LINE
271	9+140	9+140	OFC	BSNL DUCT LINE
272	9+140	9+140	Drainage Line	Drainage 450 mm dia pipeline
273	9+140	9+140	OFC	Tata Tele Cable
274	9+150	9+200	Electric Line	LT cable 10 4C
275	9+150	9+200	Electric Line	LT cable 10 2C
276	9+150	9+200	Electric Line	LT cable 10 2C
277	9+150	9+180	OFC	BSNL DUCT LINE
278	9+150	9+150	OFC	BSNL WTR LINE
279	9+150	9+150	Water Line	Water pipeline 300 mm dia
280	9+150	9+150	Electric Line	HT CABLE 0.1
281	9+160	9+160	OFC	Airtel OFC
282	9+170	9+170	OFC	Reliance OFC
283	9+170	9+170	Electric Line	HT CABLE 70
284	9+175	9+175	GasLine	Adani gas 125 MM MDPE Line
285	9+175	9+175	Electric Line	HT CABLE 185
286	9+200	9+200	Water Line	Water pipeline 200 mm dia
287	9+200	9+250	Electric Line	LT cable 25 4C
288	9+200	9+250	Electric Line	LT cable 10 2C
289	9+200	9+250	Electric Line	LT cable 10 2C
290	9+200	9+250	Electric Line	LT cable 10 2C
291	9+250	9+300	Electric Line	LT cable 10 2C
292	9+250	9+300	Electric Line	LT cable 25 4C
293	9+250	9+300	Electric Line	LT cable 10 4C
294	9+250	9+300	Electric Line	LT cable 10 4C
295	9+250	9+300	Electric Line	LT cable 10 4C

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
296	9+300	9+350	Electric Line	LT cable 10 4C
297	9+350	9+400	Electric Line	LT cable 10 2C
298	9+400	9+450	Electric Line	LT cable 10 4C
299	9+400	9+450	Electric Line	LT cable 10 2C
300	10+480	10+480	Water Line	Water Pipeline
301	10+600	10+840	OFC	BSNL OFC LINE
302	10+600	10+840	OFC	Reliance OFC
303	10+600	10+600	Electric Line	HT LINES
304	10+620	10+725	Water Line	Water Pipeline
305	10+700	10+700	GasLine	Adani 12 Inch Steel Pipeline
306	10+700	10+700	GasLine	Gas Pipeline
307	10+700	10+900	GasLine	Gas Pipeline
308	10+725	10+900	Water Line	Water Pipeline
309	10+800	10+850	Drainage Line	Drain
310	10+840	10+840	OFC	BSNL OFC LINE
311	10+840	11+025	OFC	BSNL OFC LINE
312	10+840	11+000	OFC	Reliance OFC
313	10+850	10+850	OFC	Airtel OFC
314	10+850	10+950	OFC	Airtel OFC
315	10+850	10+850	OFC	BSNL WTR LINE
316	10+850	11+000	OFC	BSNL WTR LINE
317	11+000	11+000	OFC	BSNL WTR LINE
318	11+000	11+080	OFC	BSNL WTR LINE
319	11+025	11+025	OFC	Airtel OFC
320	11+025	11+110	OFC	Airtel OFC
321	11+025	11+025	OFC	BSNL OFC LINE
322	11+025	11+075	OFC	BSNL OFC LINE
323	11+075	11+075	OFC	BSNL OFC LINE
324	11+075	11+100	OFC	BSNL OFC LINE
325	11+080	11+080	OFC	BSNL WTR LINE
326	11+100	11+100	OFC	BSNL OFC LINE
327	11+100	12+350	OFC	BSNL OFC LINE
328	11+100	12+200	GasLine	Gas Pipeline
329	11+750	11+825	GasLine	Adani 08 Inch Steel Pipeline
330	11+760	12+900	OFC	Airtel OFC
331	11+800	12+275	OFC	BSNL WTR LINE
332	11+825	11+825	GasLine	Adani 08 Inch Steel Pipeline
333	11+825	12+200	GasLine	Adani 08 Inch Steel Pipeline
334	12+050	12+310	Water Line	Western trunk Main Line
335	12+110	12+480	Water Line	Water Pipeline

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
336	12+150	12+370	OFC	Reliance OFC
337	12+200	12+200	GasLine	Adani 08 Inch Steel Pipeline
338	12+200	14+150	GasLine	Adani 08 Inch Steel Pipeline
339	12+200	12+200	GasLine	Gas Pipeline
340	12+200	12+825	GasLine	Gas Pipeline
341	12+225	12+340	OFC	Incable OFC
342	12+240	13+200	Water Line	Rasika Water pipe
343	12+250	12+250	OFC	BSNL WTR LINE
344	12+250	13+000	OFC	Vodafone OFC
345	12+275	12+830	OFC	BSNL WTR LINE
346	12+275	12+830	OFC	BSNL WTR LINE
347	12+280	12+330	OFC	GTPL OFC
348	12+280	12+280	OFC	Tata Tele Cable
349	12+300	12+900	Water Line	Package IV EX Waterline 300 mm dia
350	12+300	12+350	Electric Line	LT cable 120 4C
351	12+300	12+900	Electric Line	LT cable 240 4C
352	12+300	12+300	Storm Water Drain	Package IV Storm water line
353	12+300	12+820	Storm Water Drain	Package IV Storm water line
354	12+310	12+310	Water Line	Western trunk Main Line
355	12+320	12+320	GasLine	Adani gas 90 MM MDPE Line
356	12+320	12+850	GasLine	Adani gas 90 MM MDPE Line
357	12+340	12+760	OFC	Incable OFC
358	12+350	12+350	OFC	BSNL OFC LINE
359	12+360	12+500	OFC	BSNL OFC LINE
360	12+370	12+650	OFC	Reliance OFC
361	12+375	13+160	Water Line	Package IV EX Waterline 300 mm dia
362	12+450	12+450	Drainage Line	Package IV Drainage 300 mm dia
363	12+450	12+500	Electric Line	LT cable 240 4C
364	12+500	12+825	Copper Cable	BSNL COPPER LINE
365	12+500	12+825	Copper Cable	BSNL COPPER LINE
366	12+500	12+625	OFC	BSNL OFC LINE
367	12+550	12+600	Electric Line	LT cable 10 4C
368	12+600	12+650	Electric Line	LT cable 10 2C
369	12+625	12+900	OFC	BSNL OFC LINE
370	12+650	12+710	OFC	Reliance OFC
371	12+650	12+700	Electric Line	LT cable 25 4C
372	12+700	12+700	Drainage Line	Package IV Drainage 300 mm dia
373	12+710	12+800	OFC	Reliance OFC
374	12+720	12+720	Storm Water Drain	Package IV Storm water line
375	12+730	14+070	Storm Water Drain	Package IV Storm water line

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
376	12+750	12+800	Electric Line	LT cable 10 2C
377	12+760	12+760	OFC	Incable OFC
378	12+800	12+900	OFC	Reliance OFC
379	12+800	12+850	Electric Line	LT cable 10 2C
380	12+825	12+825	Copper Cable	BSNL COPPER LINE
381	12+825	12+900	Copper Cable	BSNL COPPER LINE
382	12+830	12+830	OFC	BSNL WTR LINE
383	12+830	12+900	OFC	BSNL WTR LINE
384	12+860	14+100	Drainage Line	Drain 150 mm
385	12+860	14+100	Storm Water Drain	Package IV Storm water line
386	12+900	12+900	OFC	Airtel OFC
387	12+900	14+050	OFC	Airtel OFC
388	12+900	12+900	Copper Cable	BSNL COPPER LINE
389	12+900	12+975	Copper Cable	BSNL COPPER LINE
390	12+900	12+975	Copper Cable	BSNL COPPER LINE
391	12+900	12+900	OFC	BSNL OFC LINE
392	12+900	12+980	OFC	BSNL OFC LINE
393	12+900	12+900	OFC	BSNL WTR LINE
394	12+900	13+025	OFC	BSNL WTR LINE
395	12+900	13+025	OFC	BSNL WTR LINE
396	12+900	12+975	Water Line	Package IV EX Waterline 450 mm dia
397	12+900	14+100	OFC	Reliance OFC
398	12+900	13+150		VISAT-KOBA Powerline
399	12+900	12+900	Water Line	Western trunk Main Line
400	12+950	13+350	Electric Line	LT cable 240 4C
401	12+950	12+980	OFC	BSNL OFC LINE
402	12+975	12+975	Copper Cable	BSNL COPPER LINE
403	12+975	13+200	Copper Cable	BSNL COPPER LINE
404	12+975	13+730	Water Line	Package IV EX Waterline 450 mm dia
405	12+975	12+975	Storm Water Drain	Package IV Storm water line
406	12+980	13+170	OFC	BSNL OFC LINE
407	13+000	13+275	OFC	Vodafone OFC
408	13+025	13+250	OFC	BSNL WTR LINE
409	13+160	13+160	Water Line	Package IV EX Waterline 200 mm dia
410	13+170	13+170	OFC	BSNL OFC LINE
411	13+170	13+190	OFC	BSNL OFC LINE
412	13+175	13+175	OFC	Incable OFC
413	13+175	14+050	OFC	Incable OFC
414	13+190	13+190	OFC	BSNL OFC LINE
415	13+200	13+200	Copper Cable	BSNL COPPER LINE

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
416	13+200	14+100	Copper Cable	BSNL COPPER LINE
417	13+200	13+200	OFC	BSNL OFC LINE
418	13+200	14+125	OFC	BSNL OFC LINE
419	13+200	13+200	Drainage Line	Package IV Drainage 450 mm dia
420	13+200	13+580	Water Line	Rasika Water pipe
421	13+225	13+225	GasLine	Adani gas 90 MM MDPE Line
422	13+250	13+300	Electric Line	LT cable 10 4C
423	13+250	13+300	Electric Line	LT cable 240 4C
424	13+250	13+300	Electric Line	LT cable 240 4C
425	13+250	13+400	OFC	BSNL WTR LINE
426	13+250	13+400	OFC	BSNL WTR LINE
427	13+250	14+200	Water Line	Package IV EX Waterline 300 mm dia
428	13+275	13+480	OFC	Vodafone OFC
429	13+300	13+350	Electric Line	LT cable 10 4C
430	13+300	13+350	Electric Line	LT cable 10 2C
431	13+350	13+400	Electric Line	LT cable 10 4C
432	13+350	13+400	Electric Line	LT cable 70 4C
433	13+400	13+850	OFC	BSNL WTR LINE
434	13+480	13+550	OFC	Vodafone OFC
435	13+500	13+550	Electric Line	LT cable 240 4C
436	13+500	13+550	Electric Line	LT cable 240 4C
437	13+500	14+000	Electric Line	LT cable 240 4C
438	13+500	13+550	Electric Line	LT cable 10 4C
439	13+540	13+540	GasLine	Adani gas 63 MM MDPE Line
440	13+540	13+540	GasLine	Adani gas 90 MM MDPE Line
441	13+540	13+540	Water Line	Package IV EX Waterline 600 mm dia
442	13+550	13+730	Water Line	Package IV EX Waterline 300 mm dia
443	13+550	14+050	OFC	Vodafone OFC
444	13+580	13+580	Water Line	Rasika Water pipe
445	13+580	14+180	Water Line	Rasika Water pipe
446	13+700	13+700	Drainage Line	Package IV Drainage 450 mm dia
447	13+700	13+750	Electric Line	LT cable 10 2C
448	13+800	13+800	Storm Water Drain	Package IV Storm water line
449	13+800	13+850	Electric Line	LT cable 10 4C
450	13+850	14+100	OFC	BSNL WTR LINE
451	13+850	13+900	Electric Line	LT cable 10 2C
452	13+850	14+100	OFC	BSNL WTR LINE
453	13+920	13+920	Water Line	Package IV EX Waterline 400 mm dia
454	13+950	14+150	Electric Line	LT cable 120 4C
455	14+000	14+050	Electric Line	LT cable 10 4C

N-S Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
456	14+000	14+050	Electric Line	LT cable 10 2C
457	14+050	14+150	OFC	Incable OFC
458	14+050	14+150	OFC	Vodafone OFC
459	14+050	14+100	Electric Line	LT cable 10 2C
460	14+050	14+100	Electric Line	LT cable 10 2C
461	14+050	14+100	Electric Line	LT cable 10 2C
462	14+050	14+100	Electric Line	LT cable 10 2C
463	14+050	14+100	Electric Line	LT cable 10 4C
464	14+070	14+100	Storm Water Drain	Package IV Storm water line
465	14+075	14+075	Drainage Line	Package IV Drainage 450 mm dia
466	14+100	14+140	OFC	BSNL WTR LINE
467	14+100	14+150	Electric Line	LT cable 10 4C
468	14+100	14+150	Electric Line	LT cable 10 4C
469	14+100	14+150	Electric Line	LT cable 10 4C
470	14+100	14+150	Electric Line	LT cable 70 4C
471	14+100	14+150	Electric Line	LT cable 70 4C
472	14+125	14+225	OFC	BSNL OFC LINE
473	14+140	14+220	OFC	BSNL WTR LINE
474	14+150	14+160	OFC	Incable OFC
475	14+150	14+150	Storm Water Drain	Package IV Storm water 1800 mm dia

E-W Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
1	3+110	3+110	Electric Line	HT CABLE 185
2	3+110	3+180	Electric Line	HT CABLE 185
3	3+110	3+180	Electric Line	HT CABLE 185
4	3+140	3+140	Electric Line	HT CABLE 185
5	3+150	3+150	Electric Line	HT CABLE 185
6	3+150	3+200	Electric Line	LT cable 120 4C
7	3+150	3+250	Electric Line	LT cable 25 4C
8	3+150	3+250	Electric Line	LT cable 120 4C
9	3+150	3+250	Electric Line	LT cable 10 4C
10	3+150	3+300	Electric Line	LT cable 240 4C
11	3+150	3+300	Electric Line	LT cable 240 4C
12	3+150	3+350	Electric Line	LT cable 120 4C
13	3+160	3+160	Electric Line	HT CABLE 185
14	3+180	3+180	Electric Line	HT CABLE 185
15	3+180	3+240	Electric Line	HT CABLE 185

E-W Corridor in Ahmedabad				
Sr. No	Chainage		Utility	Utility Name
	From	To		
16	3+240	3+240	Electric Line	HT CABLE 185
17	3+240	3+350	Electric Line	HT CABLE 185
18	3+250	3+300	Electric Line	LT cable 10 2C
19	3+250	3+350	Electric Line	LT cable 120 4C
20	3+250	3+500	ofc cable	airtelofc cable
21	3+250	3+500	ofc cable	tatatele cable
22	3+250	3+500	ofc cable	BSNL duct line
23	3+250	3+350	ofc cable	BSNL UG line
24	3+300	3+350	ofc cable	BSNL ofc cable
25	3+300	3+350	water line	water 150mm dia pipe line
26	3+350	3+350	Electric Line	HT CABLE 185
27	3+350	3+380	Electric Line	HT CABLE 185
28	3+350	3+350	Electric Line	HT CABLE NO CABLE SIZE
29	3+350	3+400	storm water line	storm water 900mm dia
30	3+350	3+400	ofc line	Reliance ofc cable
31	3+350	3+400	ofc line	airtelofc cable
32	3+350	3+400	water line	water 300mm dia
33	3+350	3+400	water line	water 1200mm dia
34	3+350	3+400	drainage	drainage 1350mm dia
35	3+350	3+400	storm water line	storm water 1200mm dia
36	3+350	3+400	drainage	drainage 450mm dia
37	3+350	3+400	Electric Line	LT cable 240 4C
38	3+350	3+400	Electric Line	LT cable 240 4C
39	3+375	3+375	Electric Line	HT CABLE 70
40	3+380	3+380	Electric Line	HT CABLE 185
41	3+380	3+620	Electric Line	HT CABLE 185
42	3+400	3+450	Electric Line	LT cable 240 4C
43	3+400	3+600	Electric Line	LT cable 240 4C
44	3+400	3+500	Electric Line	LT cable 25 4C
45	3+400	3+450	Electric Line	HT CABLE 06
46	3+400	3+430	Electric Line	HT CABLE 70
47	3+450	3+600	Electric Line	LT cable 240 4C
48	3+470	3+500	Electric Line	HT CABLE 70
49	3+470	3+500	Electric Line	HT CABLE 70
50	3+500	3+550	Electric Line	LT cable 240 4C
51	3+500	3+600	Electric Line	LT cable 10 4C
52	3+550	3+600	Electric Line	LT cable 10 4C
53	3+550	3+600	Electric Line	LT cable 10 4C
54	3+550	3+600	Electric Line	LT cable 10 4C
55	3+600	3+600	Electric Line	HT CABLE 120

E-W Corridor in Ahmedabad				
Sr. No	**Chainage**		**Utility**	**Utility Name**
	From	**To**		
56	3+600	3+620	Electric Line	HT CABLE 120
57	3+600	3+650	Electric Line	LT cable 240 4C
58	3+620	3+620	Electric Line	HT CABLE 70
59	14+000	14+050	ofc line	BSNL Copper line
60	14+000	14+050	ofc line	BSNL Copper line

Assessment of the type and location of underground utilities running along and across the proposed route alignment has been undertaken with the help of data available with concerned authorities, who generally maintain plans and data of such utility services. Particulars of main utilities i.e. trunk and main sewers/drainage conduits, water mains, OH & UG Electric cable, Telecom cable etc. have been marked on alignment plans.

5.15.3 Diversion of Underground Utilities

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

- Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.
- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout of piles in the foundation may be suitably adjusted to ensure that no foundation needs be constructed at the location, where utility is crossing the proposed alignment. The utility service can also be encased within the foundation piles.

5.15.4 Underground Stretch and Switch Over Ramp

The underground section in both the corridor is for a length of 6.257 km. As indicated in the previous paras due to various reasons, the entire length of underground section is proposed to be constructed with tunneling keeping a minimum cover of about 6m above the tunnel, except at stations which will be constructed by cut and cover method. Hence, the utility services existing in above ground or below ground position are not likely to be affected in underground stretch of the alignment except at station locations.

5.15.5 Elevated Stretch

The stretch from Thaltej to Ashram Road and Apparel park to Vastral in E-W corridor and APMC to Moterastatdiumin N-S corridor is elevated and is almost in the center of the road except at few locations as detailed in the Alignment description.

5.15.6 Sewer Lines, Storm Water Drains and Water Lines

The sewer/drainage lines generally exist in the service lanes i.e. away from main carriageway. However, in certain stretches, these have come near the central verge or under main carriageway, as a result of subsequent road widening.

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

5.15.7 Aboveground Utilities

Above ground utilities namely street light poles, traffic signal posts, telecommunication posts, junction boxes, etc. are also required to be shifted and relocated suitably during construction of elevated viaduct. Since these will be interfering with the proposed alignment. Approximate numbers of affected lamp/ telecom/elect posts & boxes are indicated in the Table 5.10 below

.

Table 5.10 - Affected Aboveground Services

S.No.	Description	East-West Corridor	North-South Corridor
1.	MH	158	144
2.	EP	125	----
3.	LP	118	277
4.	TSP	----	1

LP: Light Poles
EP: Electric Post
MH: Man Hole
TSP: Traffic Signal Post

5.15.8 Affected HT-Electric cables & PVC Cu Cable

At several places, 11kV/66kv power cables are running along & across the proposed alignment and few of them are likely to be affected. These lines need to be modified/shifted or cabled well in advance of construction along this route.

5.15.9 Telephone Poles

At several places, telephone poles pertaining to BSNL are also running along the proposed alignment in elevated position and few of them are likely to be affected. Detailed proposals for tackling these lines need to be prepared in consultation with the concerned agencies. However tentative provision has been made in cost estimates.

5.16 ISSUES RELATED TO INTERFACE WITH EXTERNAL AGENCIES.

In order to complete the work timely and successfully, for all the corridors under Chandigarh Metro Rail Projectnetwork, interface with external agencies on different issues shall have to be conducted as per details given in **Table 5.11.**

Table 5.11 - Interface with External Agencies

S.No.	Name of Agency	Issue
1	APMC	Removal of trees under the area of proposed corridors.
3	AUDA /GUDA/ RNB	Clearance of ROW & Bridges for Metro wherever encroached/occupied.
4	Indian Railways	Crossing of Railway lines at some places such as Sabarmati &Kalupur Railway Station ,
5	Ahmedabad /Gandhi Nagar Traffic Police	Alignment of various corridors under Phase-I network shall pass on/along the roads.
6	Torrent Power ,UGVCL	Shifting of HT Line

In addition to above, some more external agencies may have to be coordinated during the course of actual construction.

5.17 TRAFFIC DIVERSION

5.17.1 Need

Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction of various corridors under Metro Rail Project network. Any reduction of road space during Metro construction results in constrained traffic flow. In order to retain satisfactory levels of traffic flow up to the construction time; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

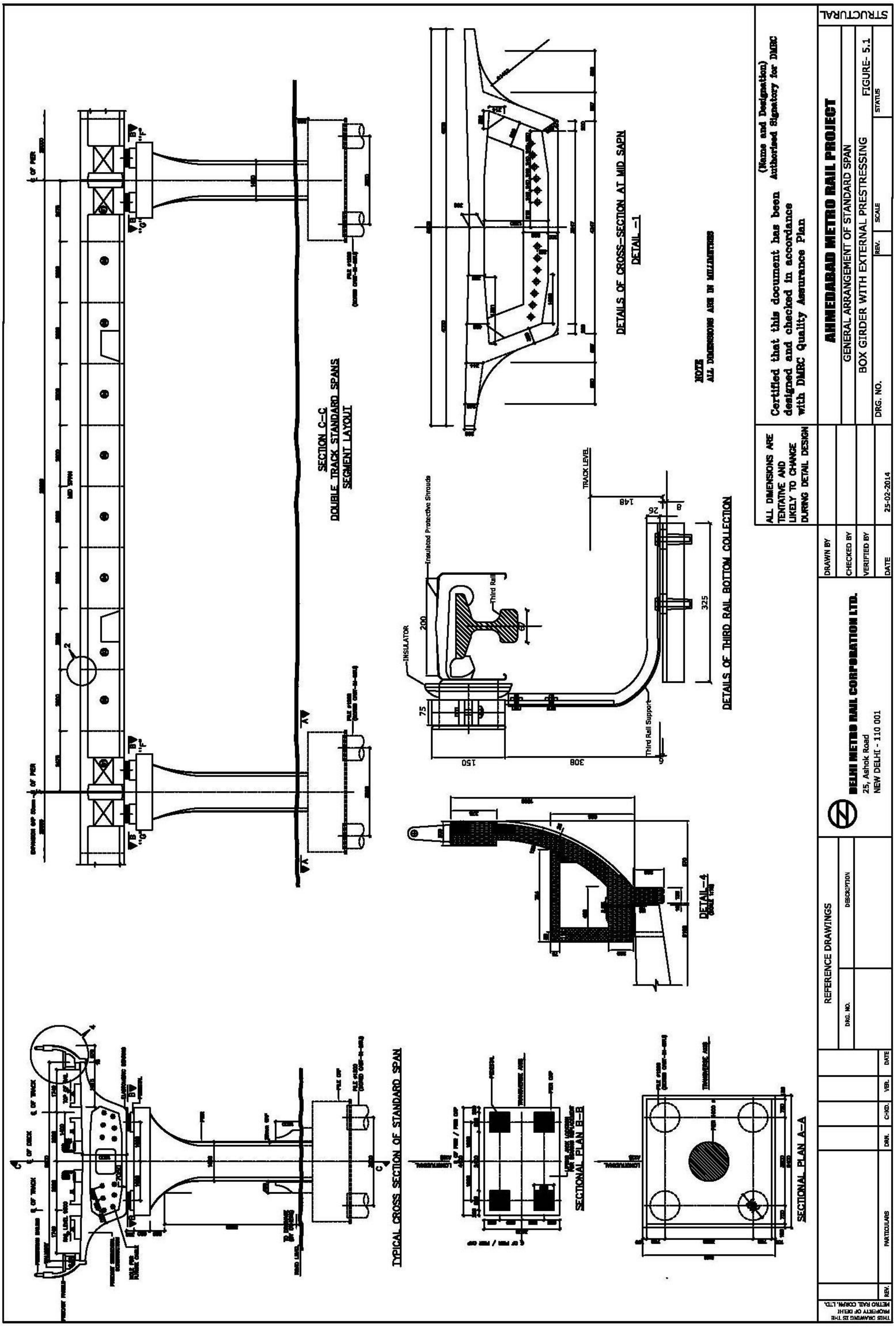
Various construction technologies are in place to ensure that traffic impedance is done at the minimum. They are:

- Some of the corridor length and stations have been proposed by Cut-and-Cover' method for construction of the underground segment. This means that the stretch between two points will have to be blocked during construction. However, temporary decking may be provided by blocking the road carriageway partially to permit traffic movement along the same stretch. Construction of switch-over-ramp also requires some road space.
- For elevated section wherever it is passing along the road, the requirement would be mainly along the central verge, as has already been done in case of elevated construction of metro corridors in Phase-I & II.
- As regards to the alignment cutting across a major traffic corridor, 'Continuous Cantilevered Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind.
- Wherever the stations are isolated, areas available around it should be utilized for road diversion purposes such as lay-byes and service roads.

5.17.2 Traffic Diversion Plans

Only temporary diversion plans will be required during construction of the Metro corridors under MEGA Metro Rail Project network. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from 'on-street' parking to informal activities. During the construction of works on underground sections by cut and cover, it is proposed that temporary decking may be provided by blocking the road carriageway partially to permit 'through' as well as right-turning traffic movements. Total blockage of traffic along the section will be done wherever reasonably good alternate road is available.

Keeping in view of future traffic growth and reduction of carriageway due to Metro construction, implementation of traffic management/diversion plans shall become inevitable for ensuring smooth traffic movement.


SECTION C-C
DOUBLE TRACK STANDARD SPANS
SEGMENT LAYOUT
DETAILS OF CROSS-SECTION AT MID SAPN
DETAIL -1
NOTE
ALL DIMENSIONS ARE IN MILLIMETRES
DETAILS OF THIRD RAIL BOTTOM COLLECTION
Insulated Protective Shroude
Third Rail
INSULATOR
Third Rail Support
TRACK LEVEL
DETAIL-4
TYPICAL CROSS SECTION OF STANDARD SPAN
SECTIONAL PLAN B-B
SECTIONAL PLAN A-A
Certified that this document has been designed and checked in accordance with DMRC Quality Assurance Plan
(Name and Designation)
Authorised Signatory for DMRC
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
STRUCTURAL
AHMEDABAD METRO RAIL PROJECT
GENERAL ARRANGEMENT OF STANDARD SPAN
BOX GIRDER WITH EXTERNAL PRESTRESSING
FIGURE- 5.1
DRG. NO.
REV.
SCALE
STATUS
DRAWN BY
CHECKED BY
VERIFIED BY
DATE
25-02-2014
DELHI METRO RAIL CORPORATION LTD.
25, Ashok Road
NEW DELHI - 110 001
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DRG. NO.
DESCRIPTION
REV.
PARTICULARS
DRN.
CHKD.
VER.
DATE
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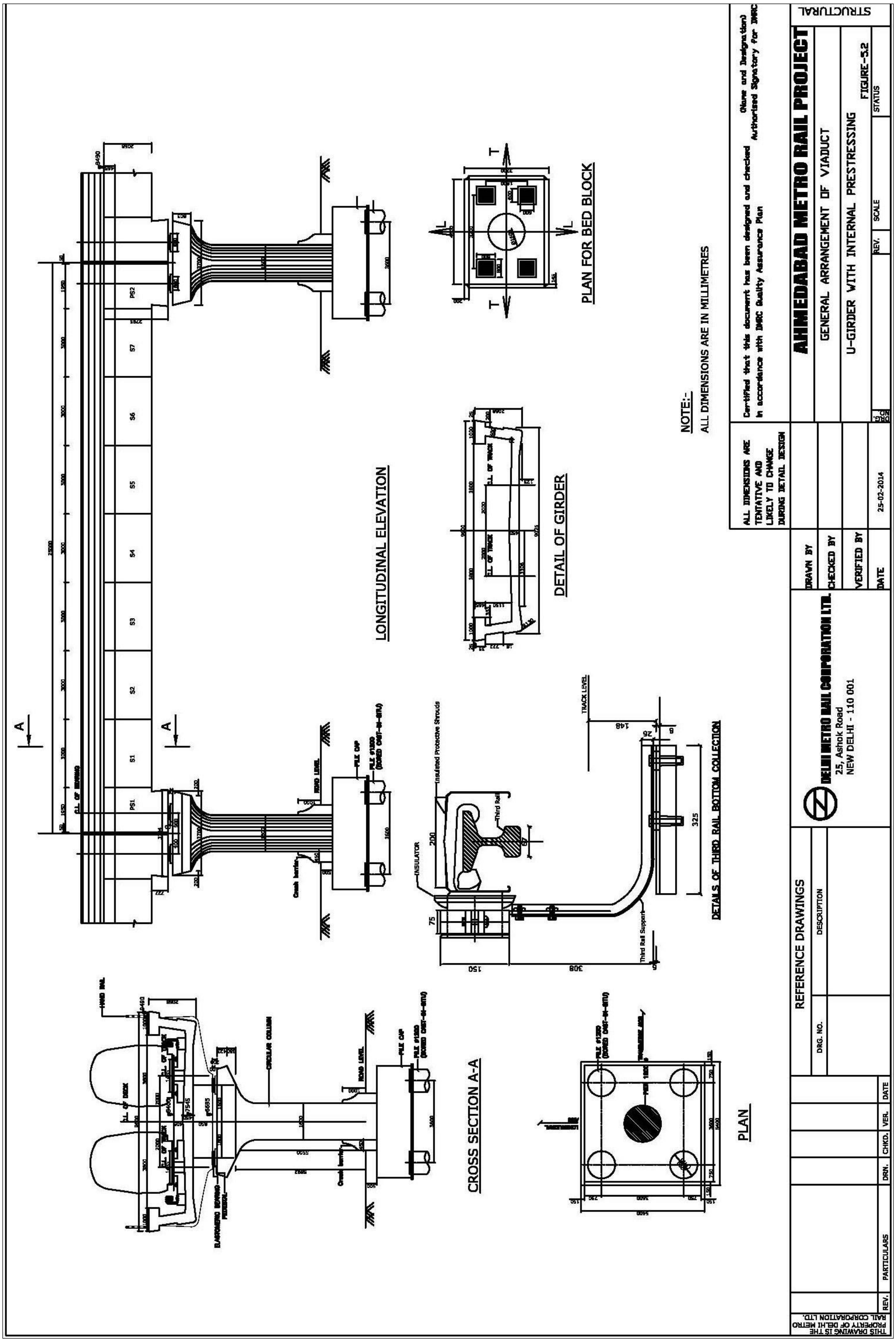
LONGITUDINAL ELEVATION
DETAIL OF GIRDER
PLAN FOR BED BLOCK
CROSS SECTION A-A
PLAN
DETAILS OF THIRD RAIL BOTTOM COLLECTION
NOTE:-
ALL DIMENSIONS ARE IN MILLIMETRES
REFERENCE DRAWINGS
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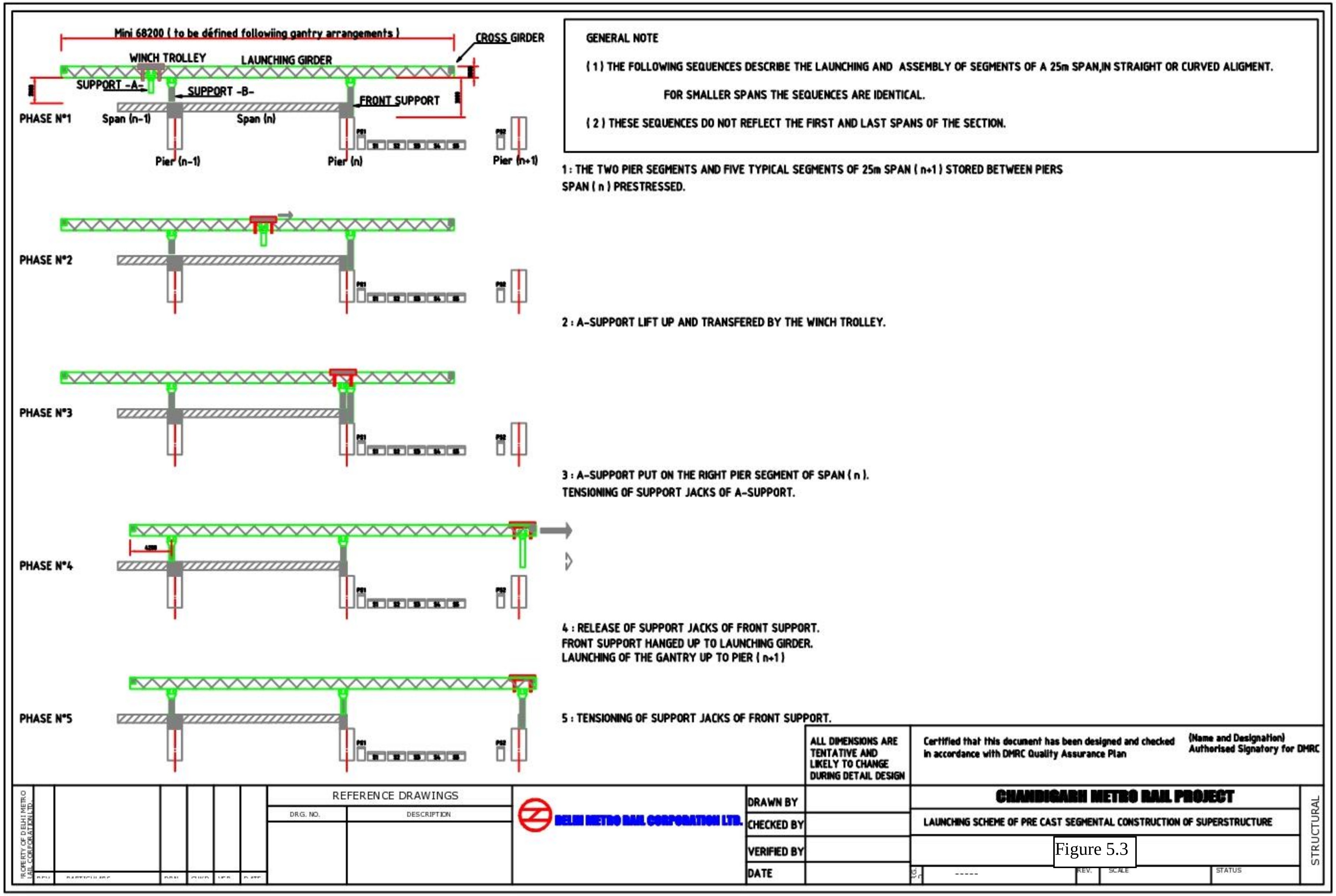
25, Ashok Road
NEW DELHI - 110 001
AHMEDABAD METRO RAIL PROJECT
GENERAL ARRANGEMENT OF VIADUCT
U-GIRDER WITH INTERNAL PRESTRESSING
FIGURE-5.2
STRUCTURAL
25-02-2014


Mini 68200 (to be défined followiing gantry arrangements)
CROSS GIRDER
WINCH TROLLEY
LAUNCHING GIRDER
SUPPORT -A-
SUPPORT -B-
FRONT SUPPORT
PHASE N°1
Span (n-1)
Span (n)
Pier (n-1)
Pier (n)
Pier (n+1)
PHASE N°2
PHASE N°3
PHASE N°4
PHASE N°5
GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
1 : THE TWO PIER SEGMENTS AND FIVE TYPICAL SEGMENTS OF 25m SPAN (n+1) STORED BETWEEN PIERS SPAN (n) PRESTRESSED.
2 : A-SUPPORT LIFT UP AND TRANSFERED BY THE WINCH TROLLEY.
3 : A-SUPPORT PUT ON THE RIGHT PIER SEGMENT OF SPAN (n).
TENSIONING OF SUPPORT JACKS OF A-SUPPORT.
4 : RELEASE OF SUPPORT JACKS OF FRONT SUPPORT.
FRONT SUPPORT HANGED UP TO LAUNCHING GIRDER.
LAUNCHING OF THE GANTRY UP TO PIER (n+1)
5 : TENSIONING OF SUPPORT JACKS OF FRONT SUPPORT.
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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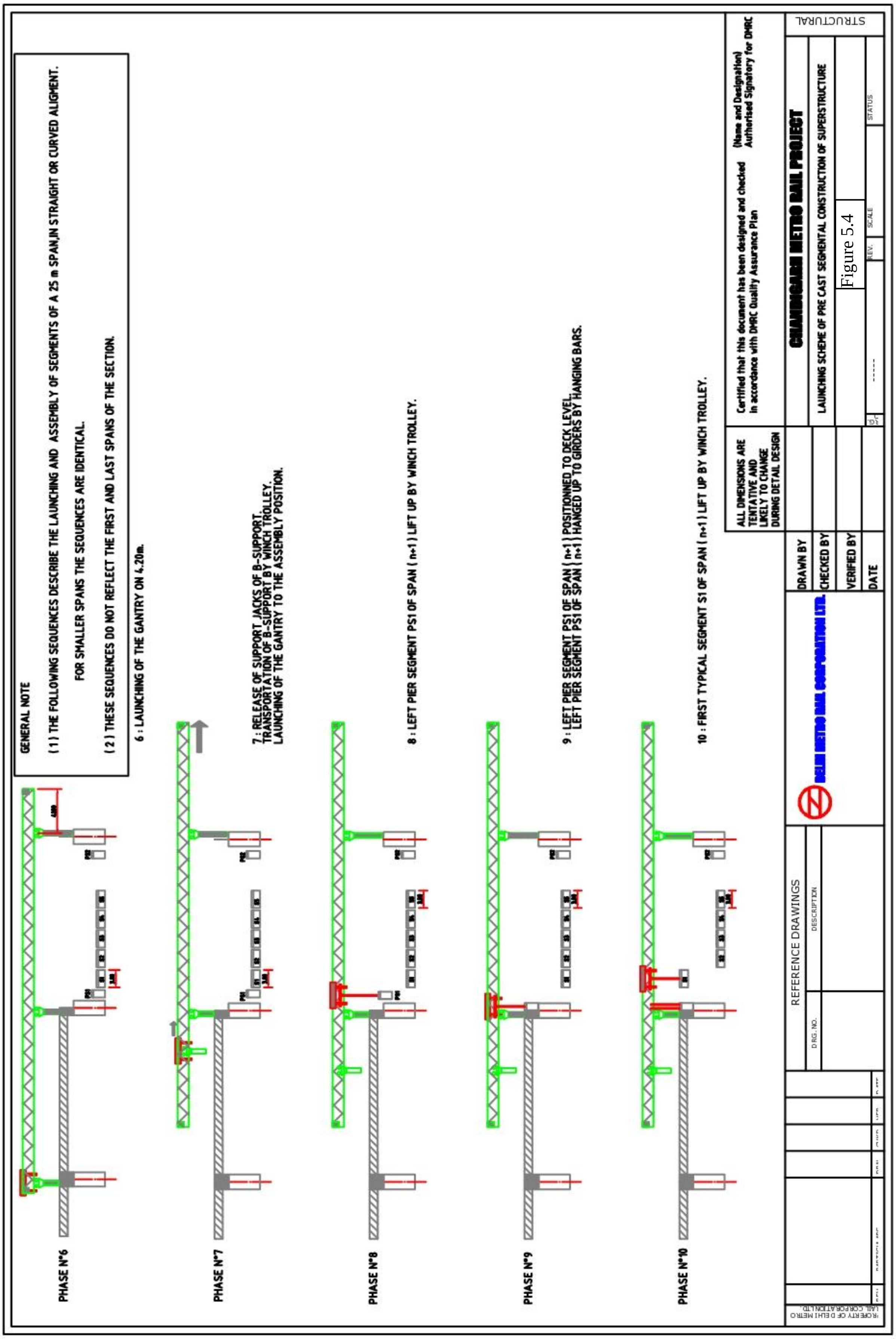
CHANDIGARH METRO RAIL PROJECT
LAUNCHING SCHEME OF PRE CAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE
REV.
SCALE
STATUS
STRUCTURAL

Figure 5.3


GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25 m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
PHASE N°6
6 : LAUNCHING OF THE GANTRY ON 4.20m.
PHASE N°7
7 : RELEASE OF SUPPORT JACKS OF B-SUPPORT.
TRANSPORTATION OF B-SUPPORT BY WINCH TROLLEY.
LAUNCHING OF THE GANTRY TO THE ASSEMBLY POSITION.
PHASE N°8
8 : LEFT PIER SEGMENT PS1 OF SPAN (n+1) LIFT UP BY WINCH TROLLEY.
PHASE N°9
9 : LEFT PIER SEGMENT PS1 OF SPAN (n+1) POSITIONNED TO DECK LEVEL.
LEFT PIER SEGMENT PS1 OF SPAN (n+1) HANGED UP TO GIRDERS BY HANGING BARS.
PHASE N°10
10 : FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) LIFT UP BY WINCH TROLLEY.
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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LAUNCHING SCHEME OF PRE CAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE
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Figure 5.4

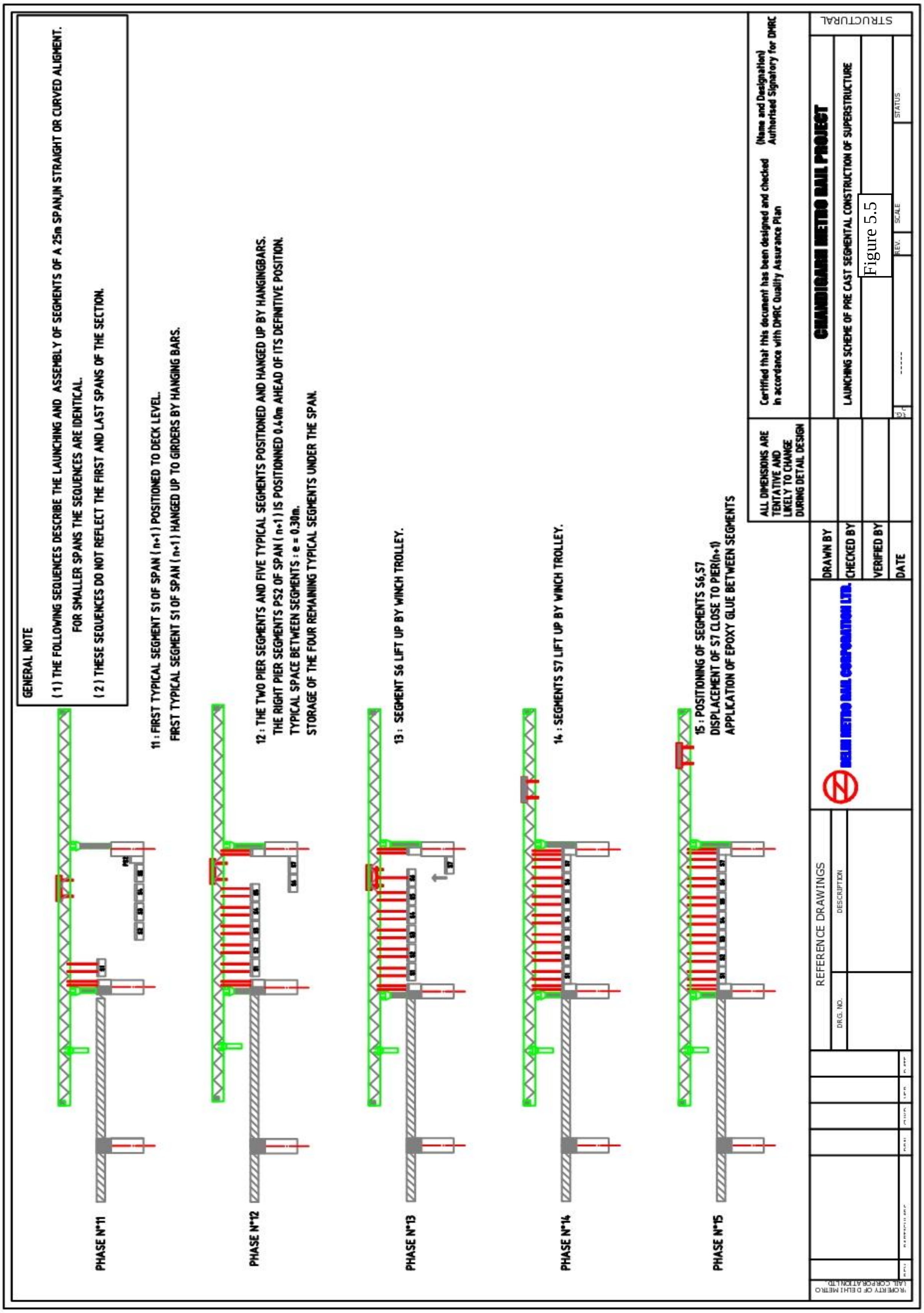
GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
PHASE N°11
11 : FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) POSITIONED TO DECK LEVEL.
FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) HANGED UP TO GIRDERS BY HANGING BARS.
PHASE N°12
12 : THE TWO PIER SEGMENTS AND FIVE TYPICAL SEGMENTS POSITIONED AND HANGED UP BY HANGINGBARS.
THE RIGHT PIER SEGMENTS PS2 OF SPAN (n+1) IS POSITIONNED 0.40m AHEAD OF ITS DEFINITIVE POSITION.
TYPICAL SPACE BETWEEN SEGMENTS : e = 0.30m.
STORAGE OF THE FOUR REMAINING TYPICAL SEGMENTS UNDER THE SPAN.
PHASE N°13
13 : SEGMENT S6 LIFT UP BY WINCH TROLLEY.
PHASE N°14
14 : SEGMENTS S7 LIFT UP BY WINCH TROLLEY.
PHASE N°15
15 : POSITIONING OF SEGMENTS S6,S7
DISPLACEMENT OF S7 CLOSE TO PIER(n+1)
APPLICATION OF EPOXY GLUE BETWEEN SEGMENTS
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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Figure 5.5
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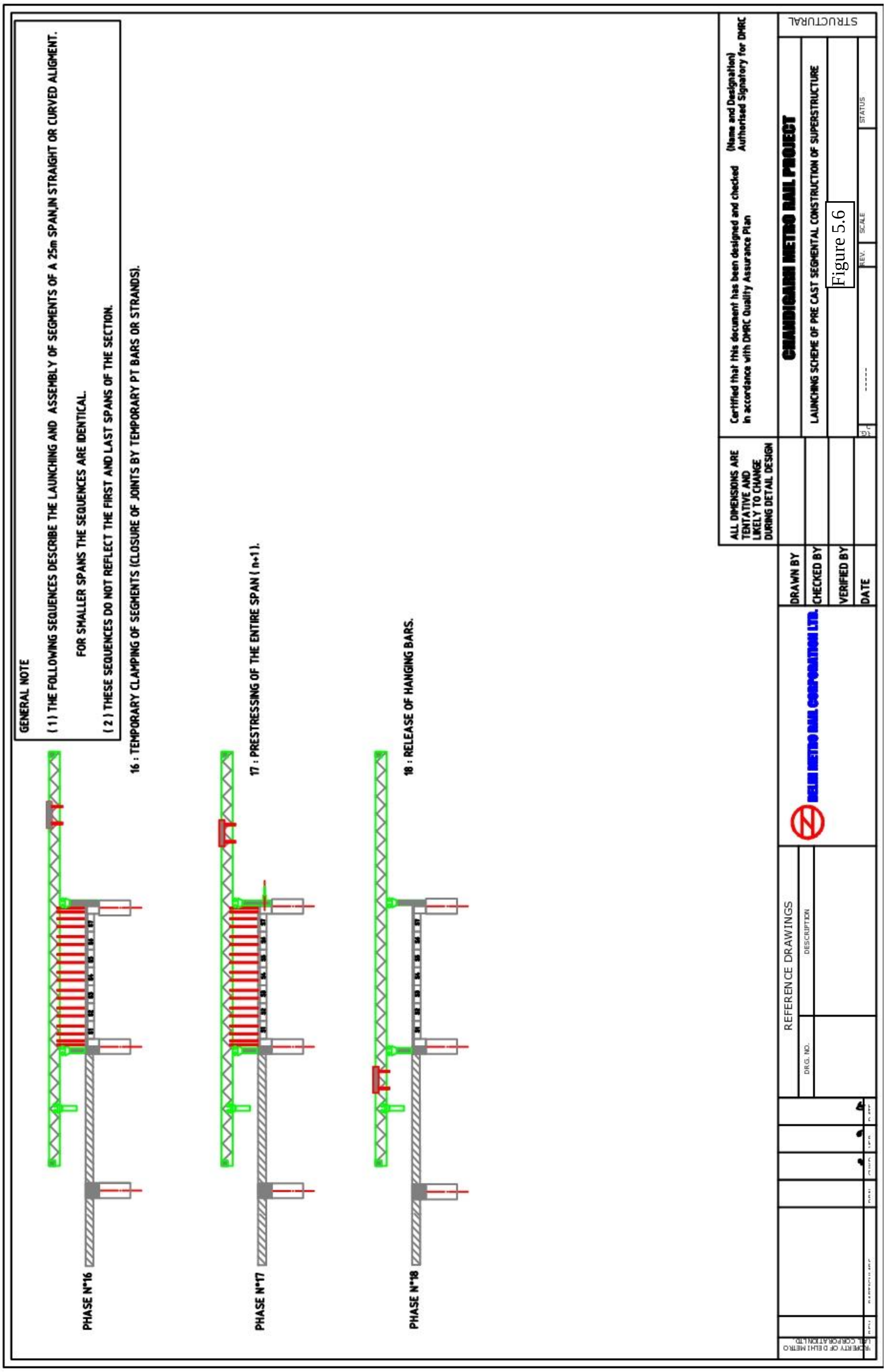
GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
16 : TEMPORARY CLAMPING OF SEGMENTS (CLOSURE OF JOINTS BY TEMPORARY PT BARS OR STRANDS).
17 : PRESTRESSING OF THE ENTIRE SPAN (n+1).
18 : RELEASE OF HANGING BARS.
PHASE N°16
PHASE N°17
PHASE N°18
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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Figure 5.6

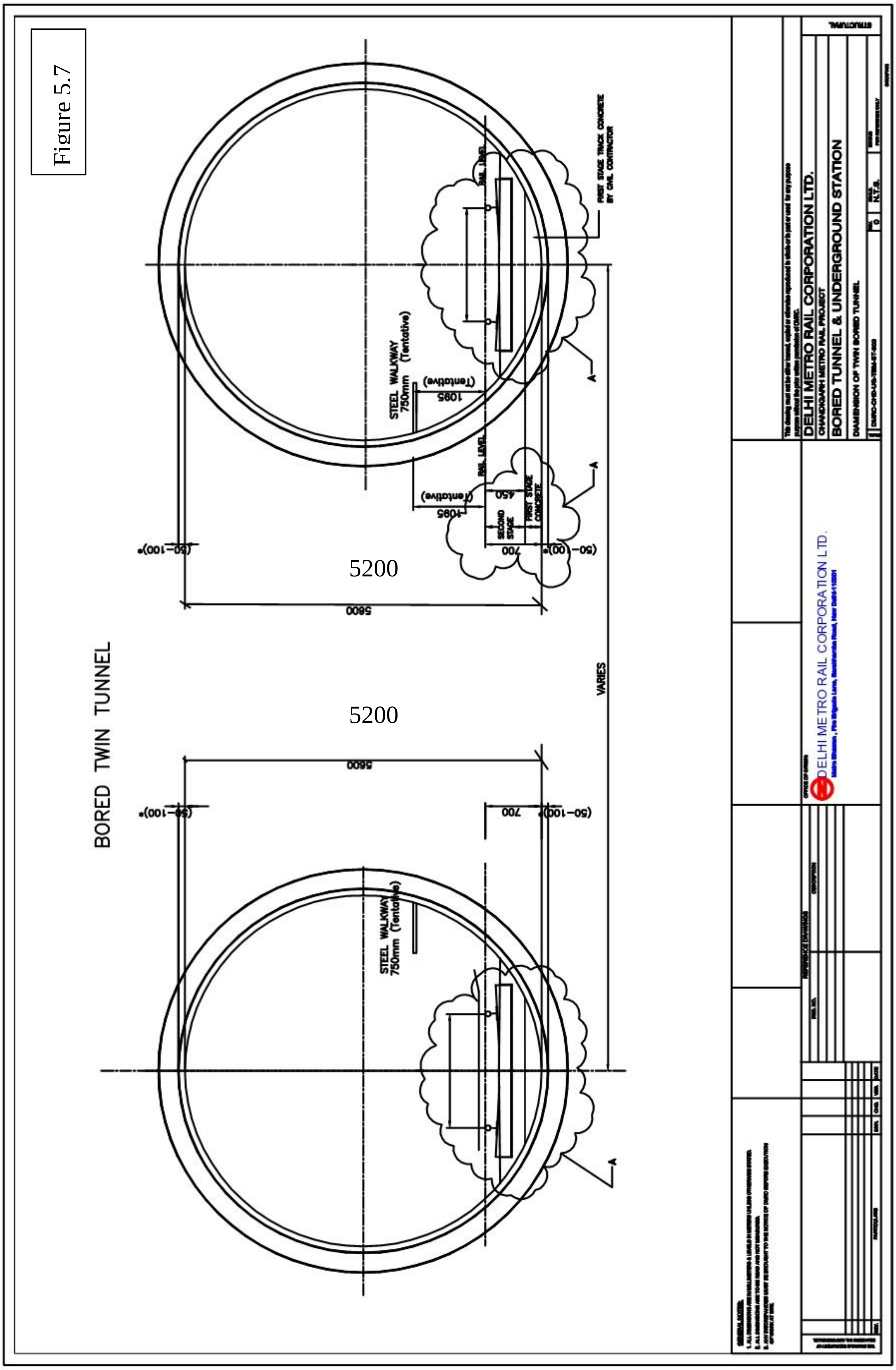

BORED TWIN TUNNEL
5200
5600
5200
5600
STEEL WALKWAY 750mm (Tentative)
1085 (Tentative)
700
(50-100)*
VARIES
RAIL LEVEL
FIRST STAGE TRACK CONCRETE BY CIVIL CONTRACTOR
DELHI METRO RAIL CORPORATION LTD.
CHANDIGARH METRO RAIL PROJECT
BORED TUNNEL & UNDERGROUND STATION
DIMENSION OF TWIN BORED TUNNEL

Figure 5.7

Figure 5.8

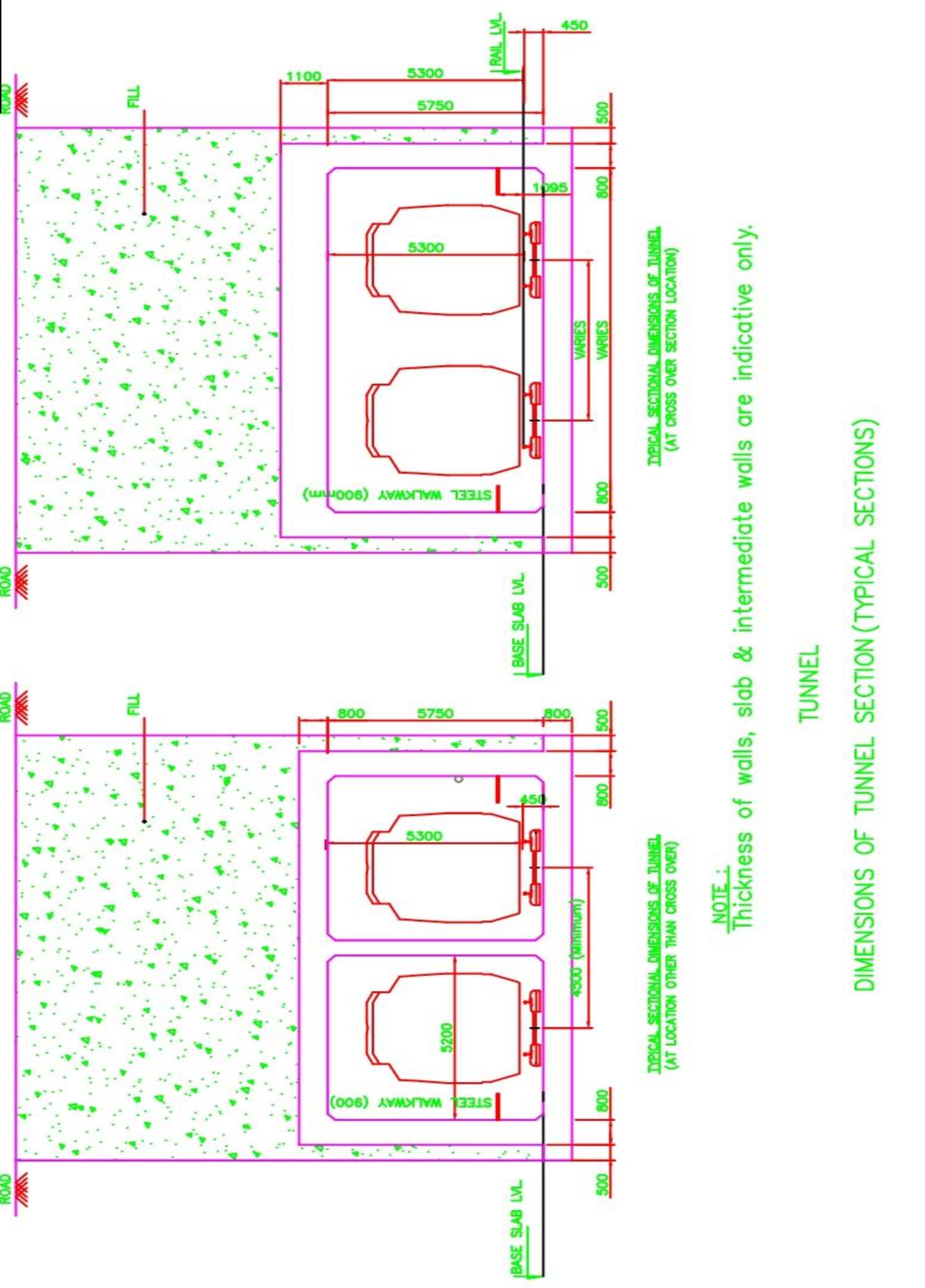

DIMENSIONS OF TUNNEL SECTION (TYPICAL SECTIONS)
TUNNEL
NOTE :
Thickness of walls, slab & intermediate walls are indicative only.
TYPICAL SECTIONAL DIMENSIONS OF TUNNEL
(AT CROSS OVER SECTION LOCATION)
TYPICAL SECTIONAL DIMENSIONS OF TUNNEL
(AT LOCATION OTHER THAN CROSS OVER)
ROAD
FILL
RAIL LVL
BASE SLAB LVL
STEEL WALKWAY (900mm)
STEEL WALKWAY (900)
VARIES
4500 (Minimum)
1100
5300
5750
450
1095
800
500
5200

Figure 5.9

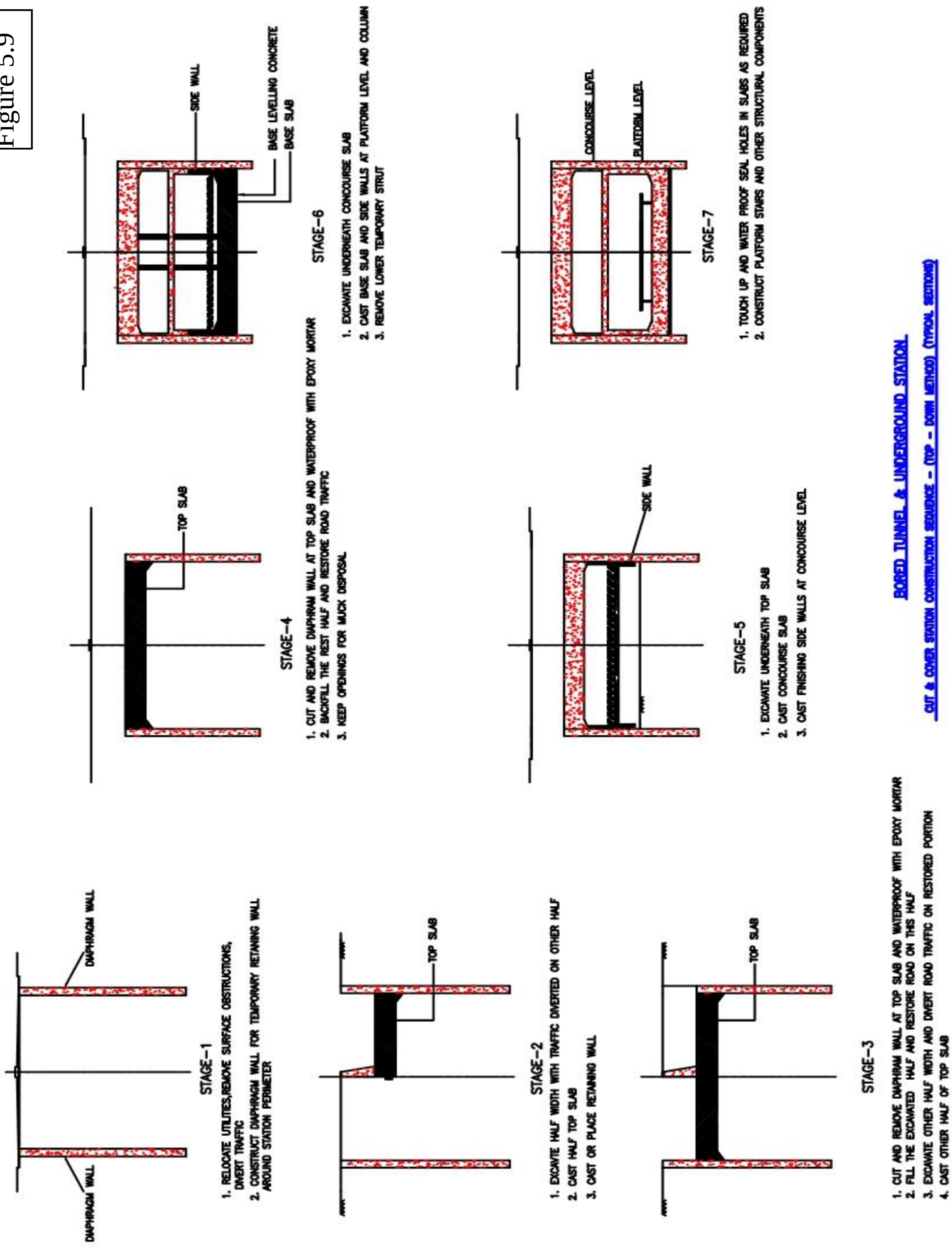

DIAPHRAGM WALL
DIAPHRAGM WALL
STAGE-1
1. RELOCATE UTILITIES,REMOVE SURFACE OBSTRUCTIONS, DIVERT TRAFFIC
2. CONSTRUCT DIAPHRAGM WALL FOR TEMPORARY RETANING WALL AROUND STATION PERIMETER
TOP SLAB
STAGE-2
1. EXCAVTE HALF WIDTH WITH TRAFFIC DIVERTED ON OTHER HALF
2. CAST HALF TOP SLAB
3. CAST OR PLACE RETAINING WALL
TOP SLAB
STAGE-3
1. CUT AND REMOVE DIAPHRAM WALL AT TOP SLAB AND WATERPROOF WITH EPOXY MORTAR
2. FILL THE EXCAVATED HALF AND RESTORE ROAD ON THIS HALF
3. EXCAVATE OTHER HALF WIDTH AND DIVERT ROAD TRAFFIC ON RESTORED PORTION
4. CAST OTHER HALF OF TOP SLAB
TOP SLAB
STAGE-4
1. CUT AND REMOVE DIAPHRAM WALL AT TOP SLAB AND WATERPROOF WITH EPOXY MORTAR
2. BACKFILL THE REST HALF AND RESTORE ROAD TRAFFIC
3. KEEP OPENINGS FOR MUCK DISPOSAL
SIDE WALL
STAGE-5
1. EXCAVATE UNDERNEATH TOP SLAB
2. CAST CONCOURSE SLAB
3. CAST FINISHING SIDE WALLS AT CONCOURSE LEVEL
SIDE WALL
BASE LEVELLING CONCRETE
BASE SLAB
STAGE-6
1. EXCAVATE UNDERNEATH CONCOURSE SLAB
2. CAST BASE SLAB AND SIDE WALLS AT PLATFORM LEVEL AND COLUMN
3. REMOVE LOWER TEMPORARY STRUT
CONCOURSE LEVEL
PLATFORM LEVEL
STAGE-7
1. TOUCH UP AND WATER PROOF SEAL HOLES IN SLABS AS REQUIRED
2. CONSTRUCT PLATFORM STAIRS AND OTHER STRUCTURAL COMPONENTS
BORED TUNNEL & UNDERGROUND STATION
CUT & COVER STATION CONSTRUCTION SEQUENCE - (TOP - DOWN METHOD) (TYPICAL SECTIONS)

Figure 5.10

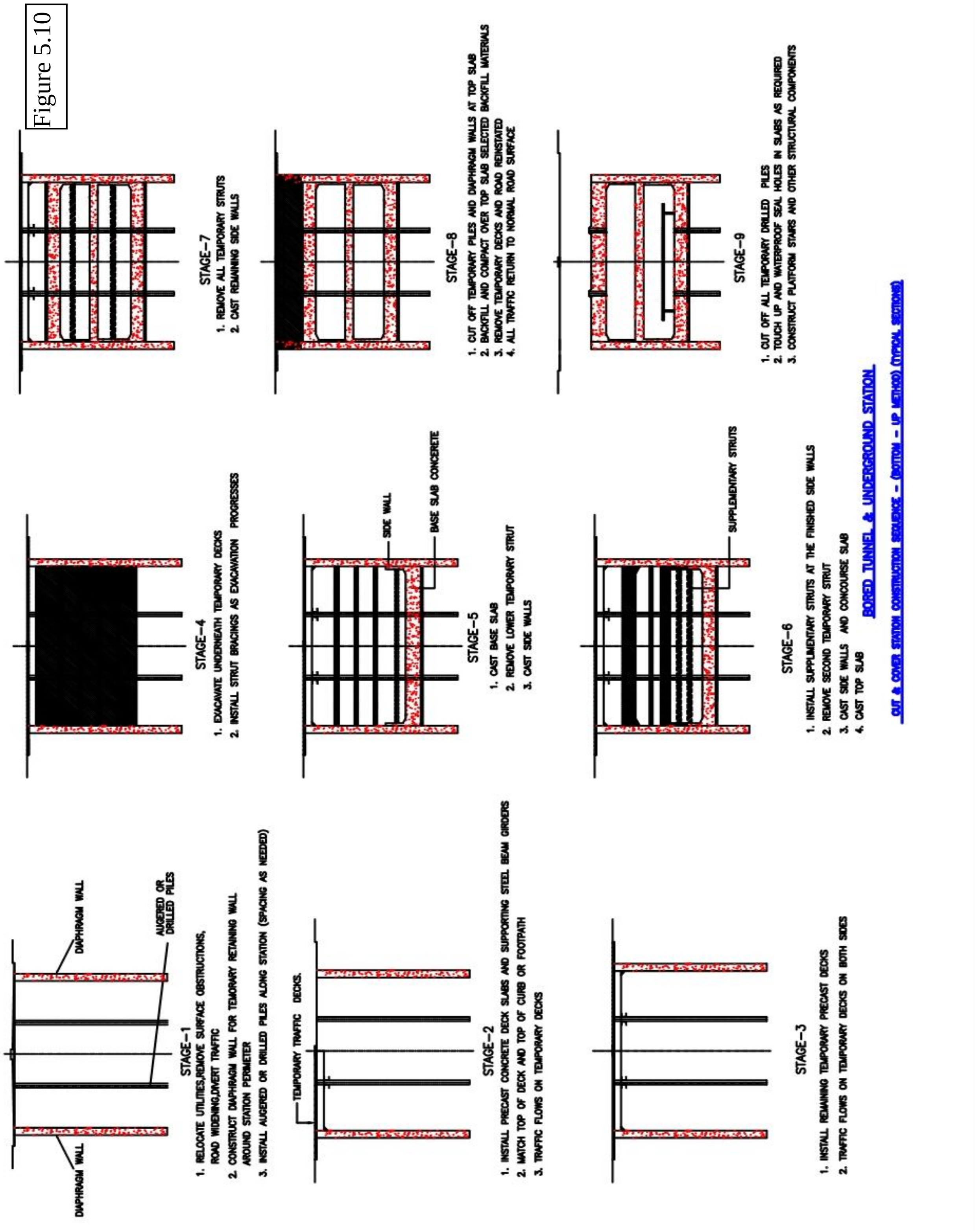
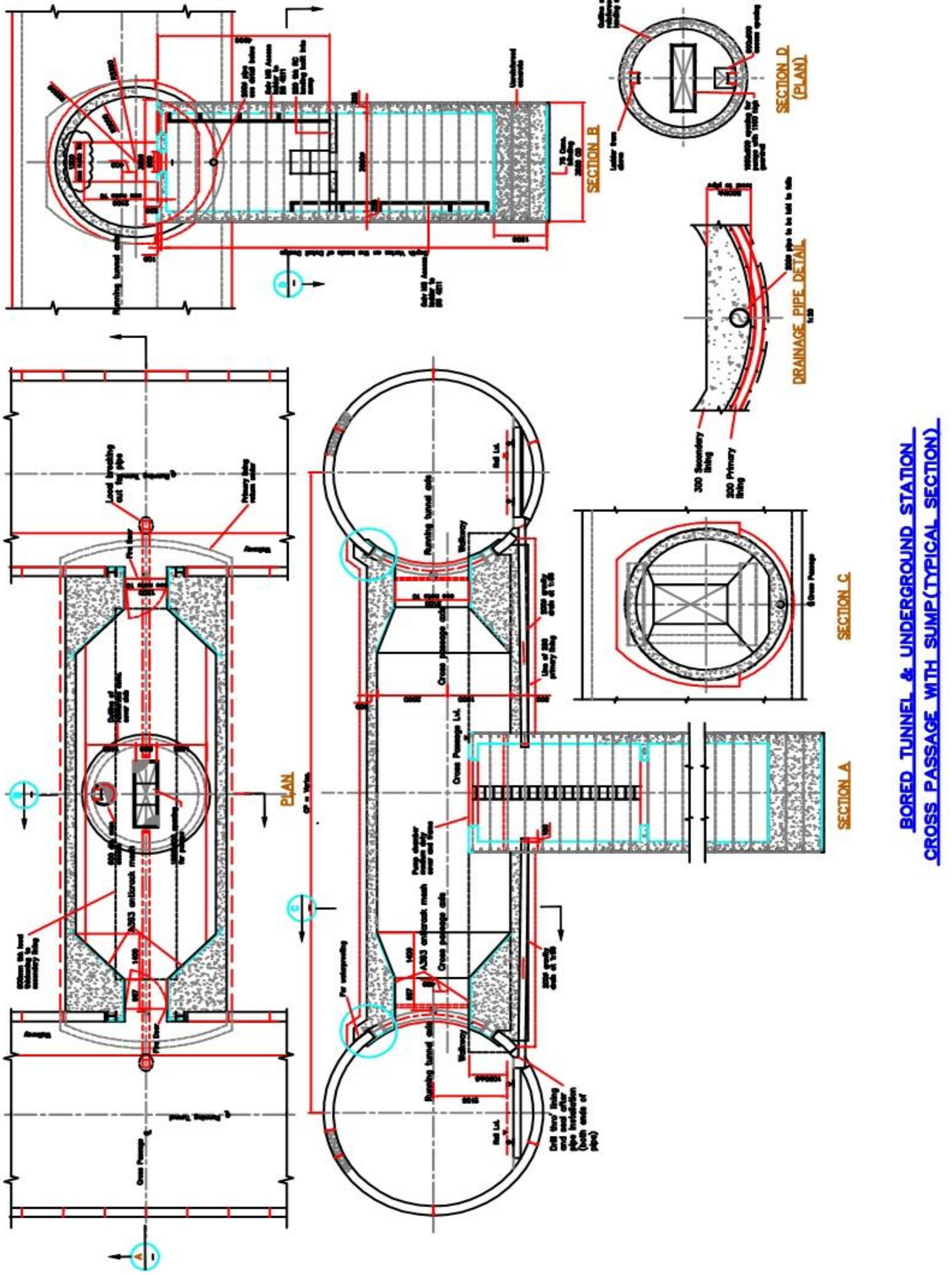
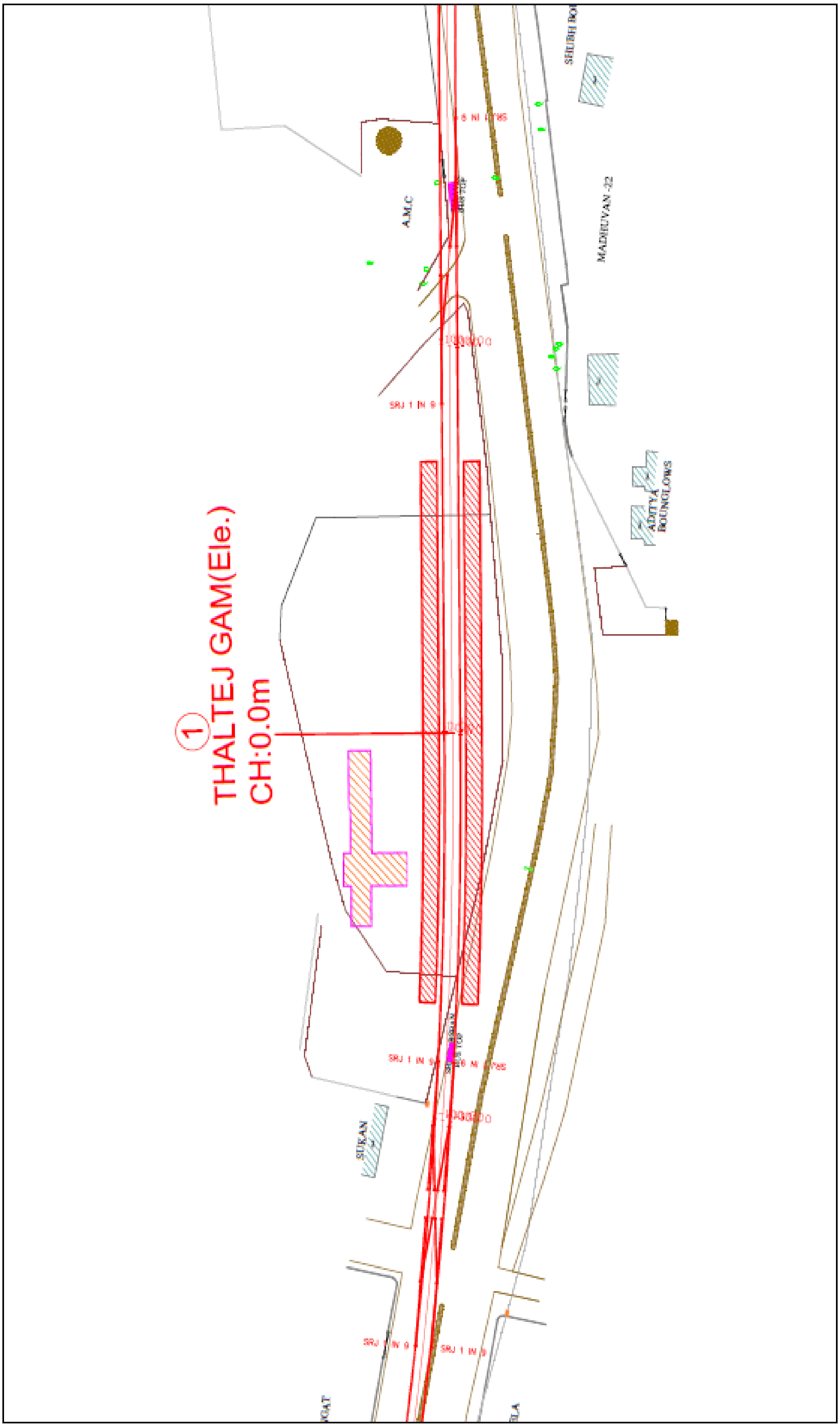
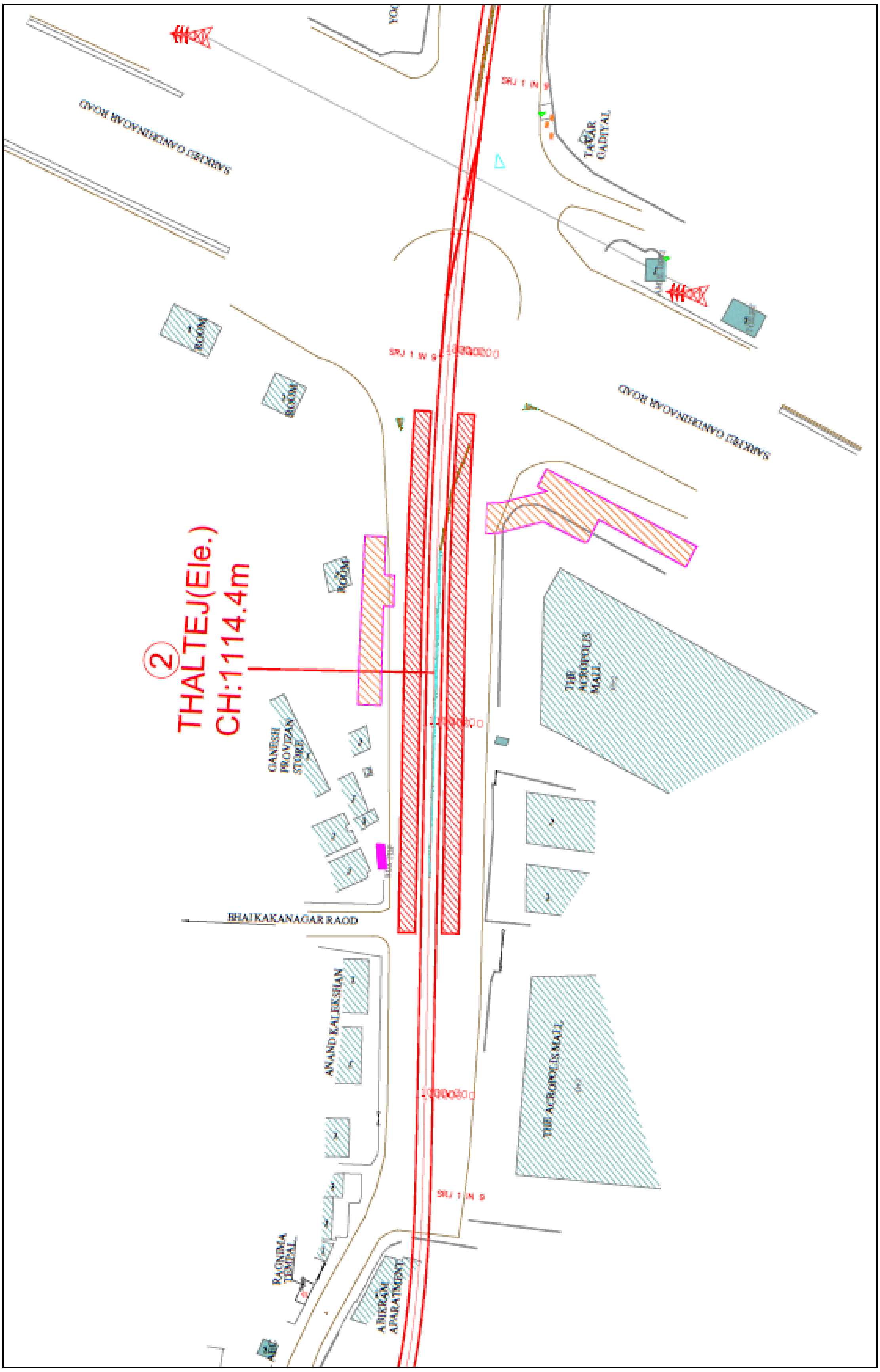
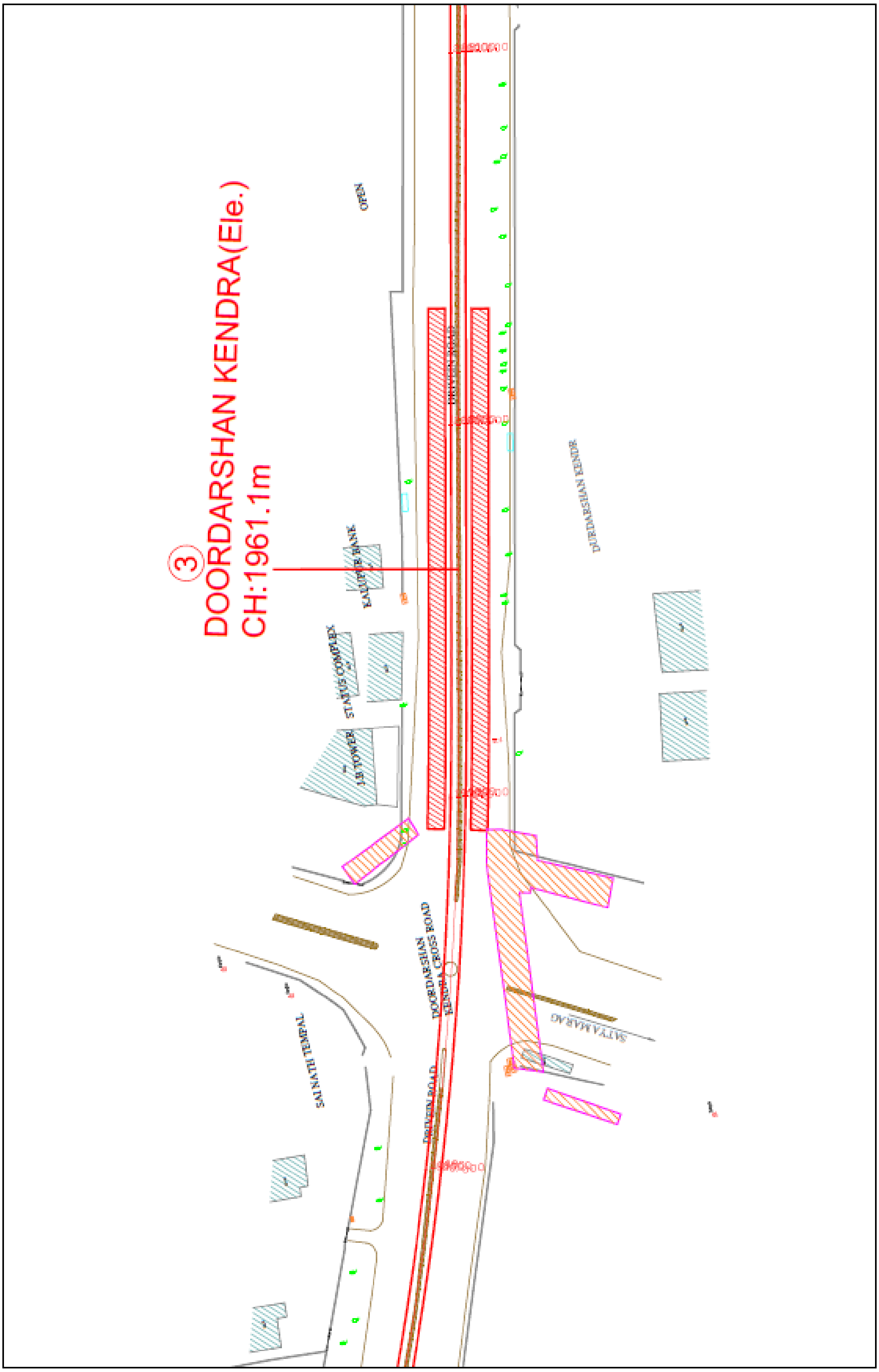

DIAPHRAGM WALL
AUGERED OR DRILLED PILES
DIAPHRAGM WALL
STAGE-1
1. RELOCATE UTILITIES,REMOVE SURFACE OBSTRUCTIONS, ROAD WIDENING,DIVERT TRAFFIC
2. CONSTRUCT DIAPHRAGM WALL FOR TEMPORARY RETAINING WALL AROUND STATION PERIMETER
3. INSTALL AUGERED OR DRILLED PILES ALONG STATION (SPACING AS NEEDED)
TEMPORARY TRAFFIC DECKS.
STAGE-2
1. INSTALL PRECAST CONCRETE DECK SLABS AND SUPPORTING STEEL BEAM GIRDERS
2. MATCH TOP OF DECK AND TOP OF CURB OR FOOTPATH
3. TRAFFIC FLOWS ON TEMPORARY DECKS
STAGE-3
1. INSTALL REMAINING TEMPORARY PRECAST DECKS
2. TRAFFIC FLOWS ON TEMPORARY DECKS ON BOTH SIDES
STAGE-4
1. EXACAVATE UNDERNEATH TEMPORARY DECKS
2. INSTALL STRUT BRACINGS AS EXCAVATION PROGRESSES
SIDE WALL
BASE SLAB CONCRETE
STAGE-5
1. CAST BASE SLAB
2. REMOVE LOWER TEMPORARY STRUT
3. CAST SIDE WALLS
SUPPLEMENTARY STRUTS
STAGE-6
1. INSTALL SUPPLIMENTARY STRUTS AT THE FINISHED SIDE WALLS
2. REMOVE SECOND TEMPORARY STRUT
3. CAST SIDE WALLS AND CONCOURSE SLAB
4. CAST TOP SLAB
STAGE-7
1. REMOVE ALL TEMPORARY STRUTS
2. CAST REMAINING SIDE WALLS
STAGE-8
1. CUT OFF TEMPORARY PILES AND DIAPHRAGM WALLS AT TOP SLAB
2. BACKFILL AND COMPACT OVER TOP SLAB SELECTED BACKFILL MATERIALS
3. REMOVE TEMPORARY DECKS AND ROAD REINSTATED
4. ALL TRAFFIC RETURN TO NORMAL ROAD SURFACE
STAGE-9
1. CUT OFF ALL TEMPORARY DRILLED PILES
2. TOUCH UP AND WATERPROOF SEAL HOLES IN SLABS AS REQUIRED
3. CONSTRUCT PLATFORM STAIRS AND OTHER STRUCTURAL COMPONENTS
BORED TUNNEL & UNDERGROUND STATION
CUT & COVER STATION CONSTRUCTION SEQUENCE - (BOTTOM - UP METHOD) (TYPICAL SECTIONS)

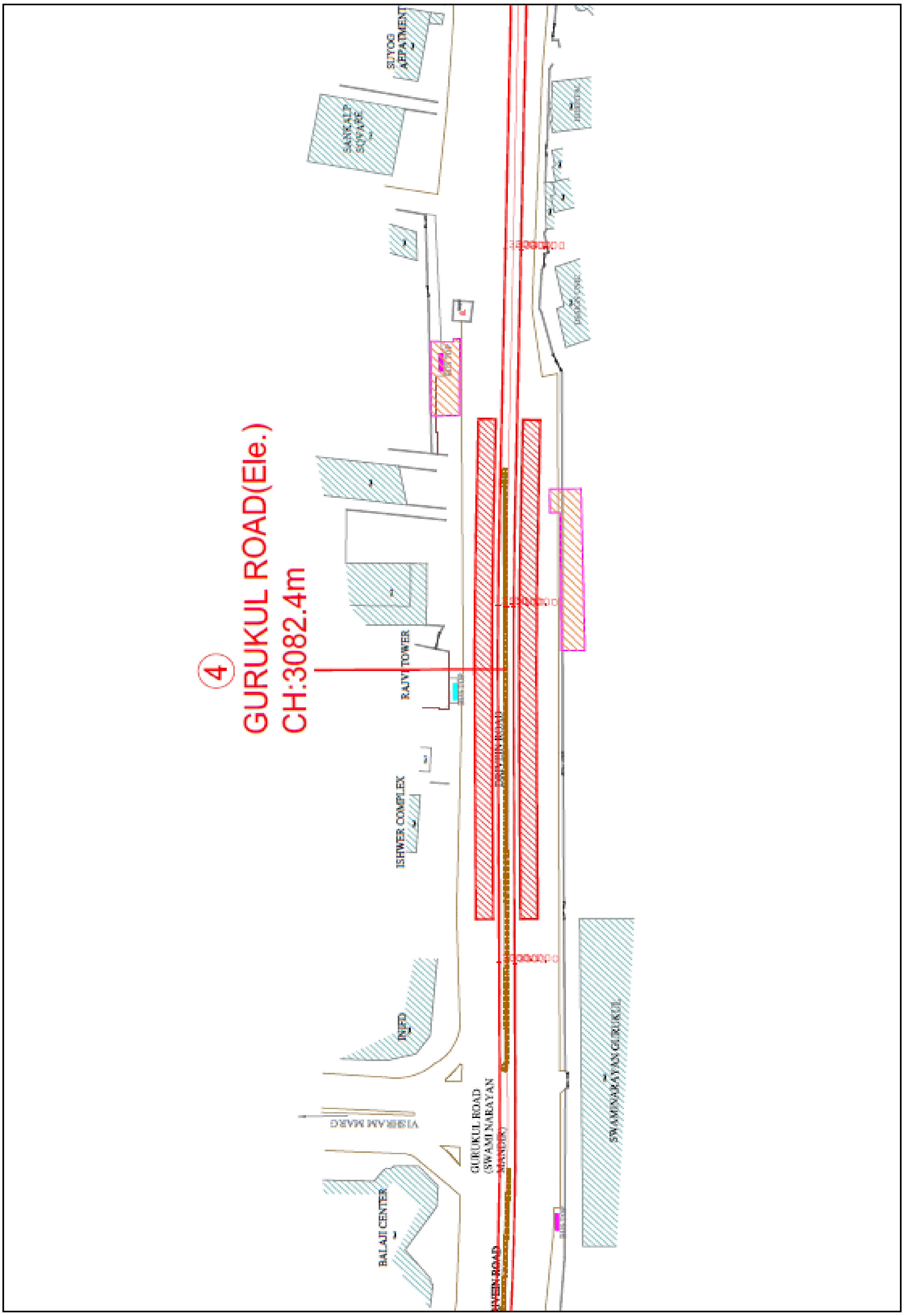
Figure 5.11

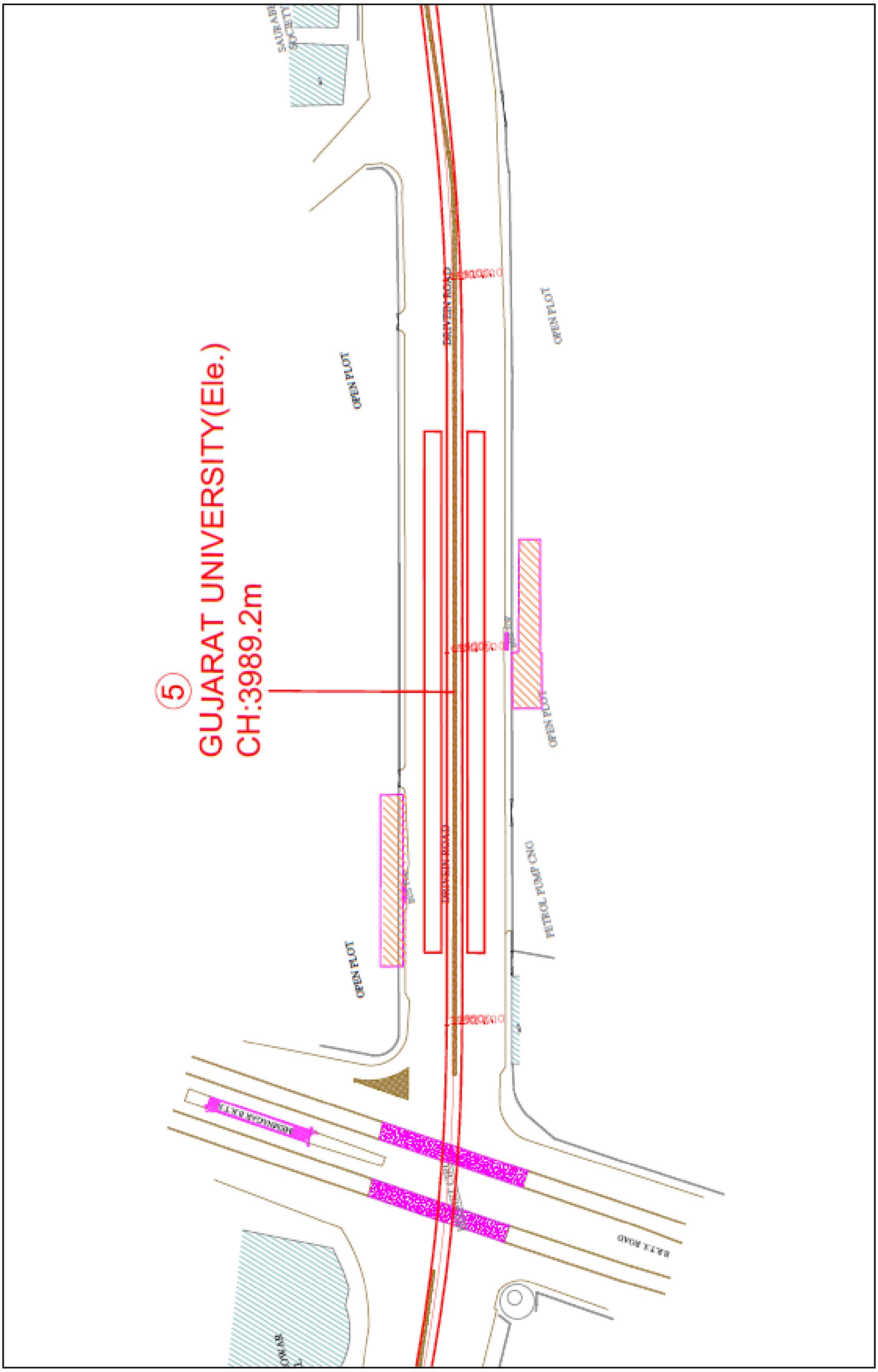

SECTION B
SECTION D (PLAN)
DRAINAGE PIPE DETAIL
PLAN
SECTION C
SECTION A
BORED TUNNEL & UNDERGROUND STATION
CROSS PASSAGE WITH SUMP (TYPICAL SECTION)

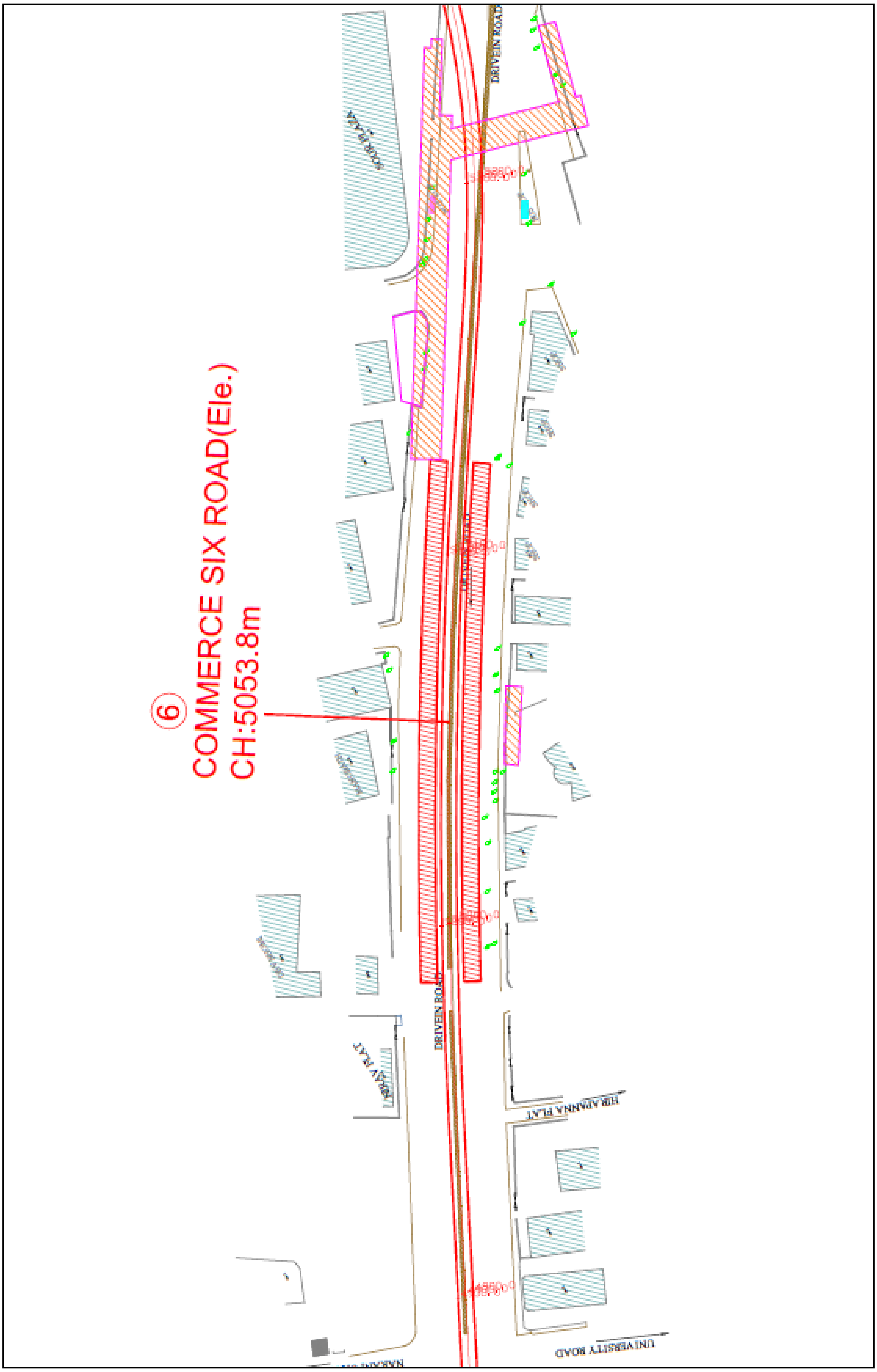

1
THALTEJ GAM(Ele.)
CH:0.0m
A.M.C
MADHUVAN -22
ADITYA BOUNGLOWS
SUKAN


2
THALTEJ(Ele.)
CH:1114.4m
SARKHEJ GANDHINAGAR ROAD
SARKHEJ GANDHINAGAR ROAD
BHAIKAKANAGAR RAOD
THE ACROPOLIS MALL
THE ACROPOLIS MALL
GANESH PROVIZAN STORE
ANAND KALEKSHAN
RAGNIMA TEMPAL
ABIRAM APARATMENT
ROOM
ROOM
ROOM

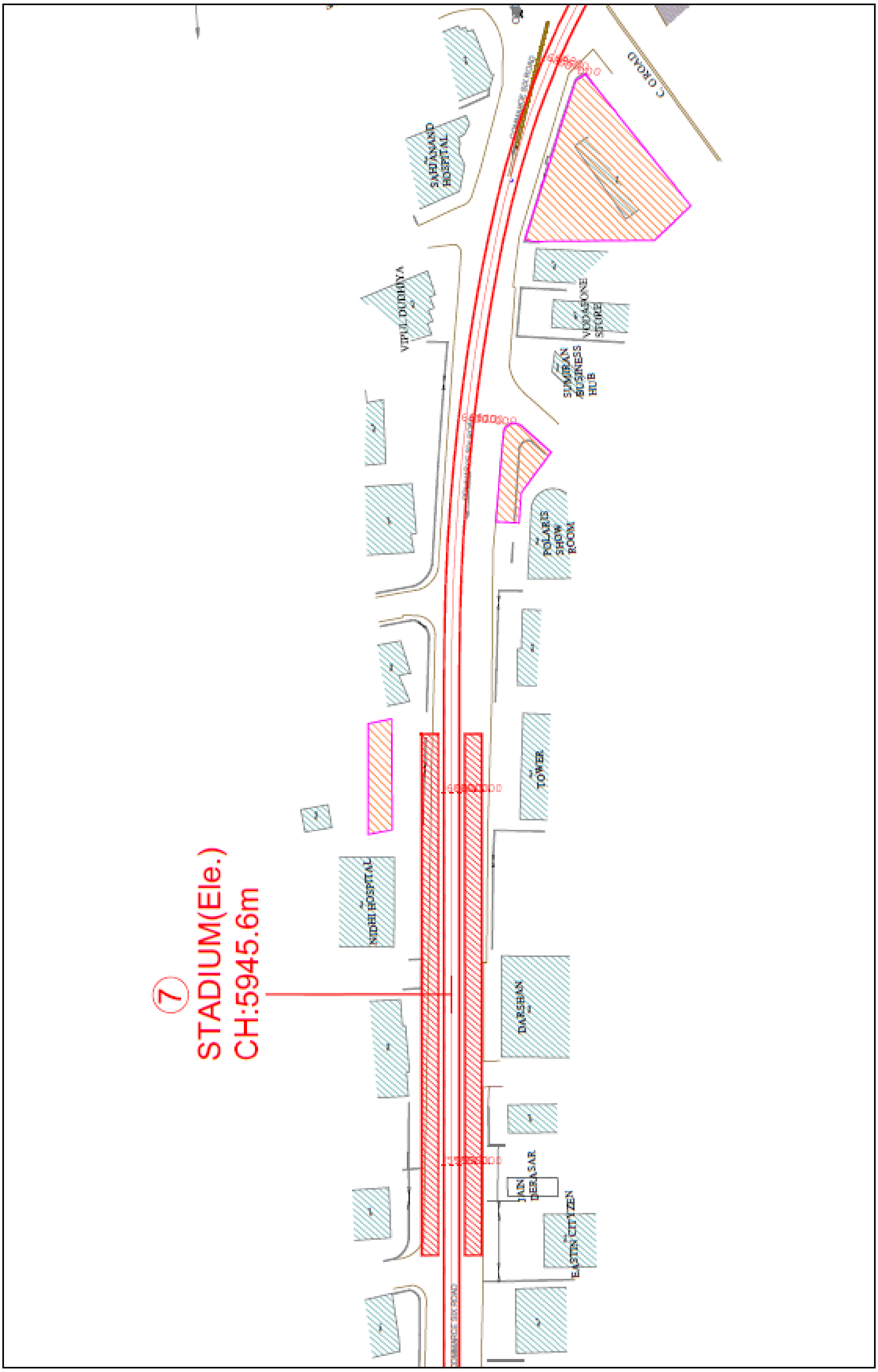

3
DOORDARSHAN KENDRA(Ele.)
CH:1961.1m
OPEN
DURDARSHAN KENDR
KALUPUR BANK
STATUS COMPLEX
J.B TOWER
DOORDARSHAN KENDRA CROSS ROAD
SAI NATH TEMPAL
SATYAMARAG
DRIVEIN ROAD

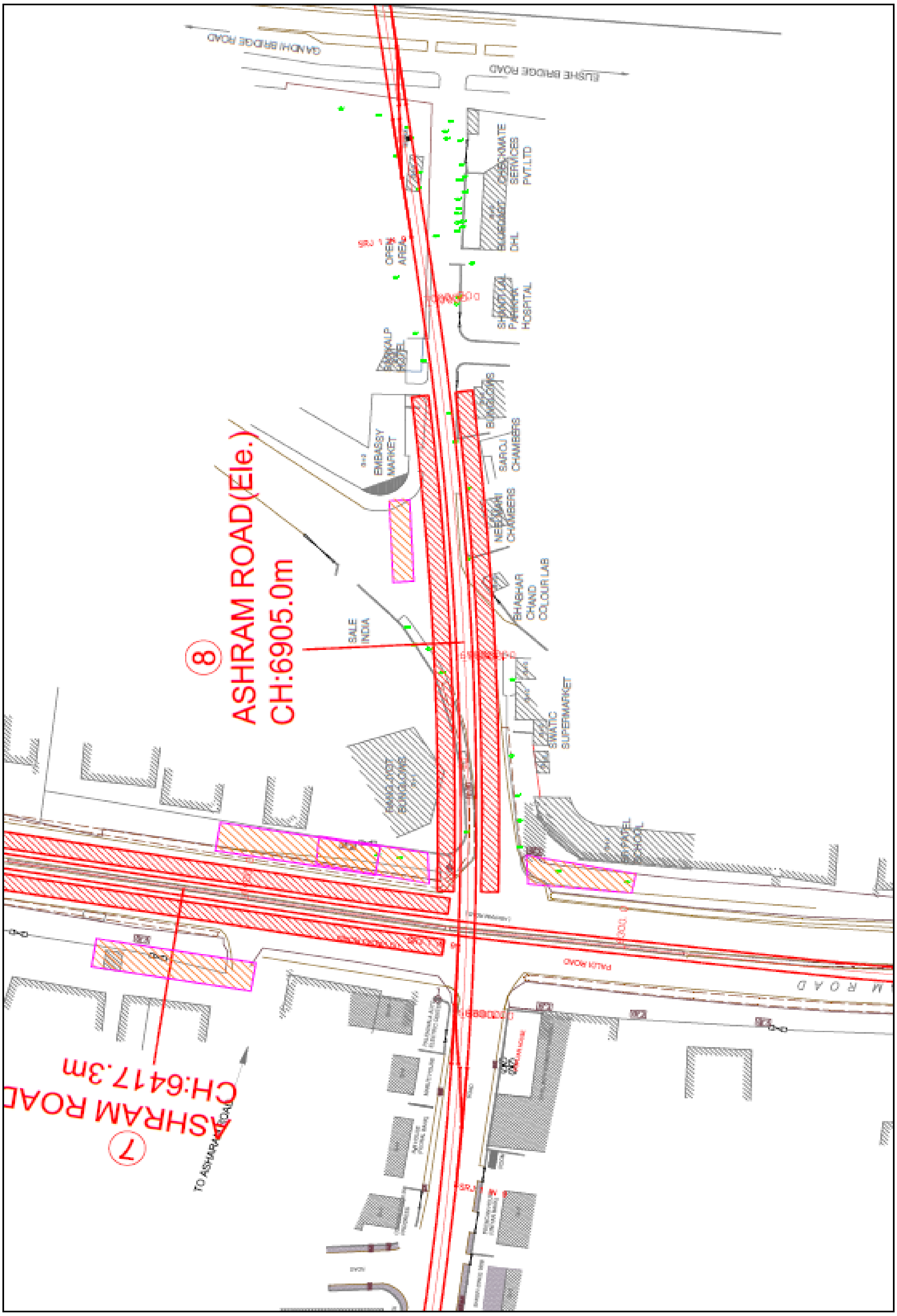

4
GURUKUL ROAD(Ele.)
CH:3082.4m
SUYOG APPARTMENT
SANKALP SQUARE
RAJIV TOWER
ISHWER COMPLEX
VISHRAM MARG
GURUKUL ROAD
(SWAMI NARAYAN
MANDIR)
BALAJI CENTER
SWAMINARAYAN GURUKUL

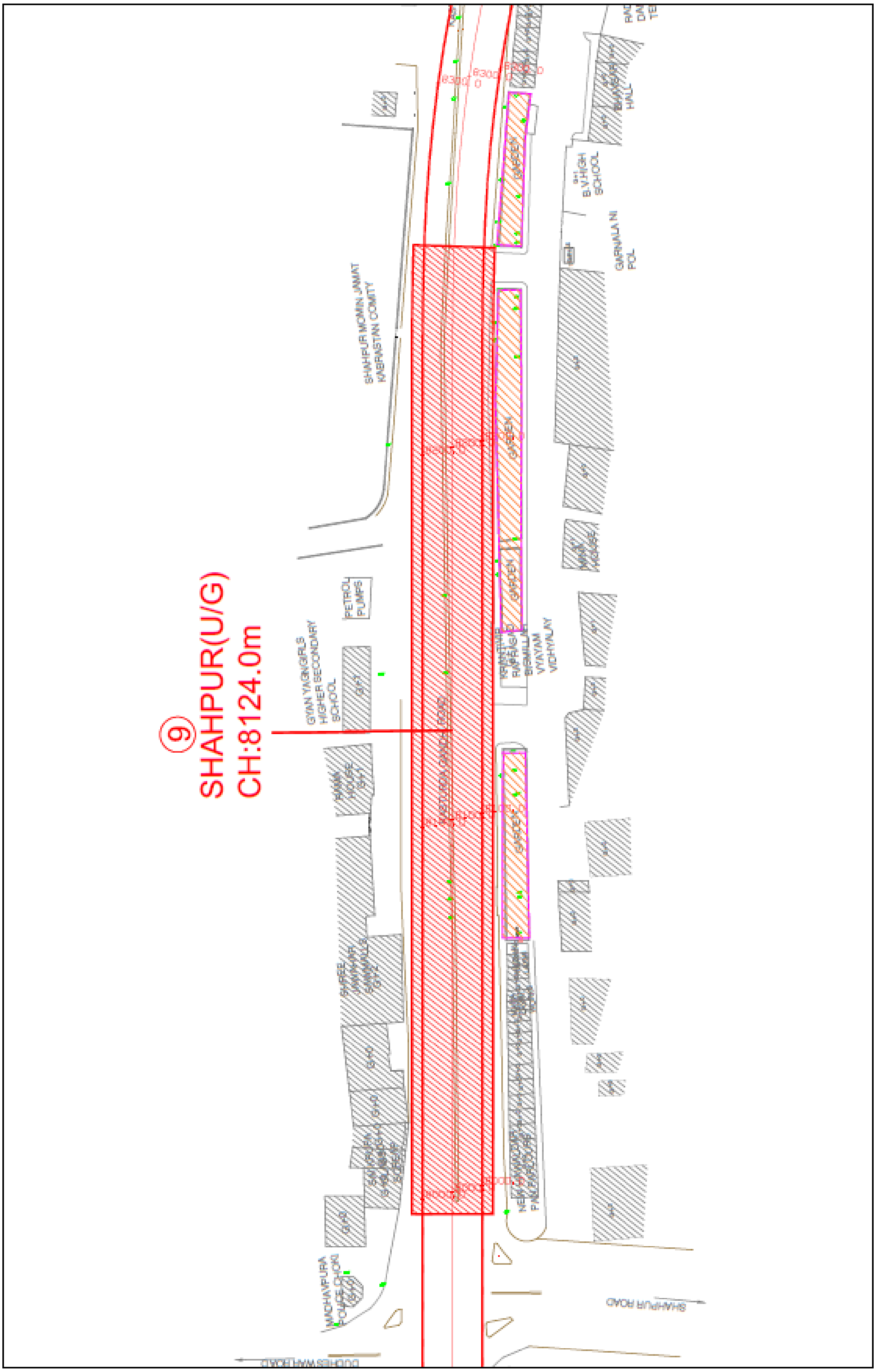

5
GUJARAT UNIVERSITY(Ele.)
CH:3989.2m
OPEN PLOT
OPEN PLOT
OPEN PLOT
OPEN PLOT
PETROL PUMP CNG

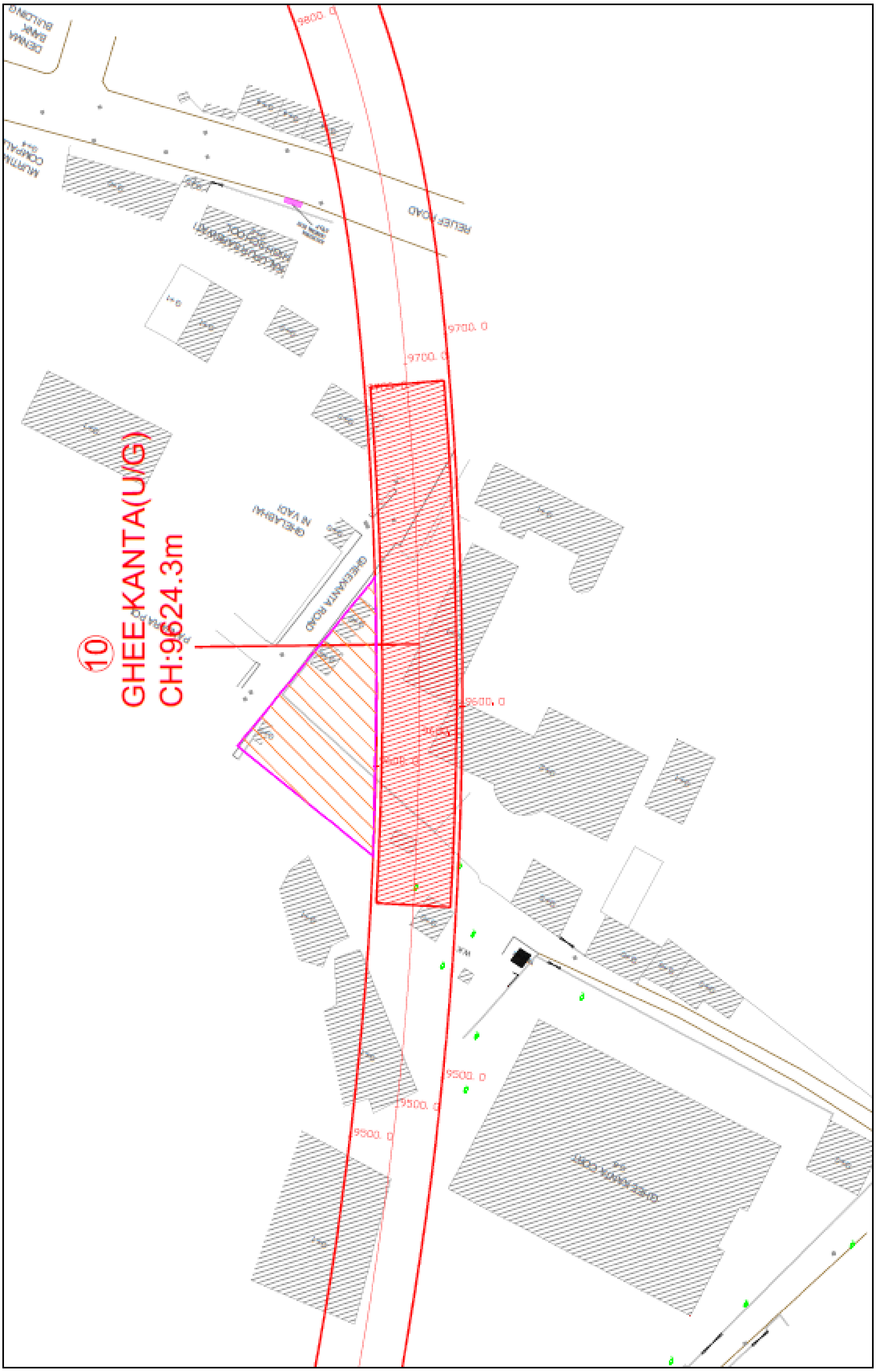


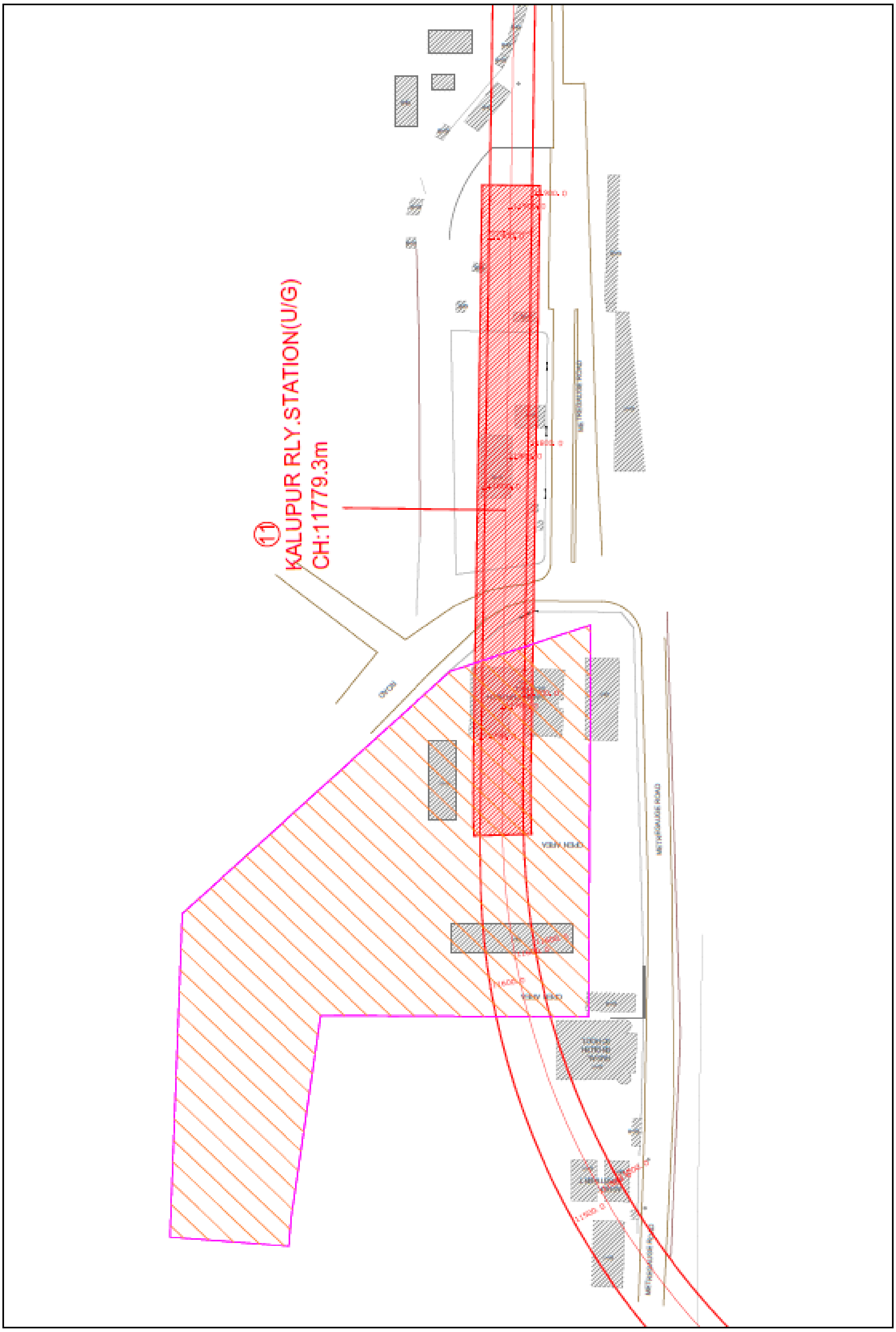
6
COMMERCE SIX ROAD(Ele.)
CH:5053.8m
DRIVEIN ROAD
DRIVEIN ROAD
UNIVERSITY ROAD

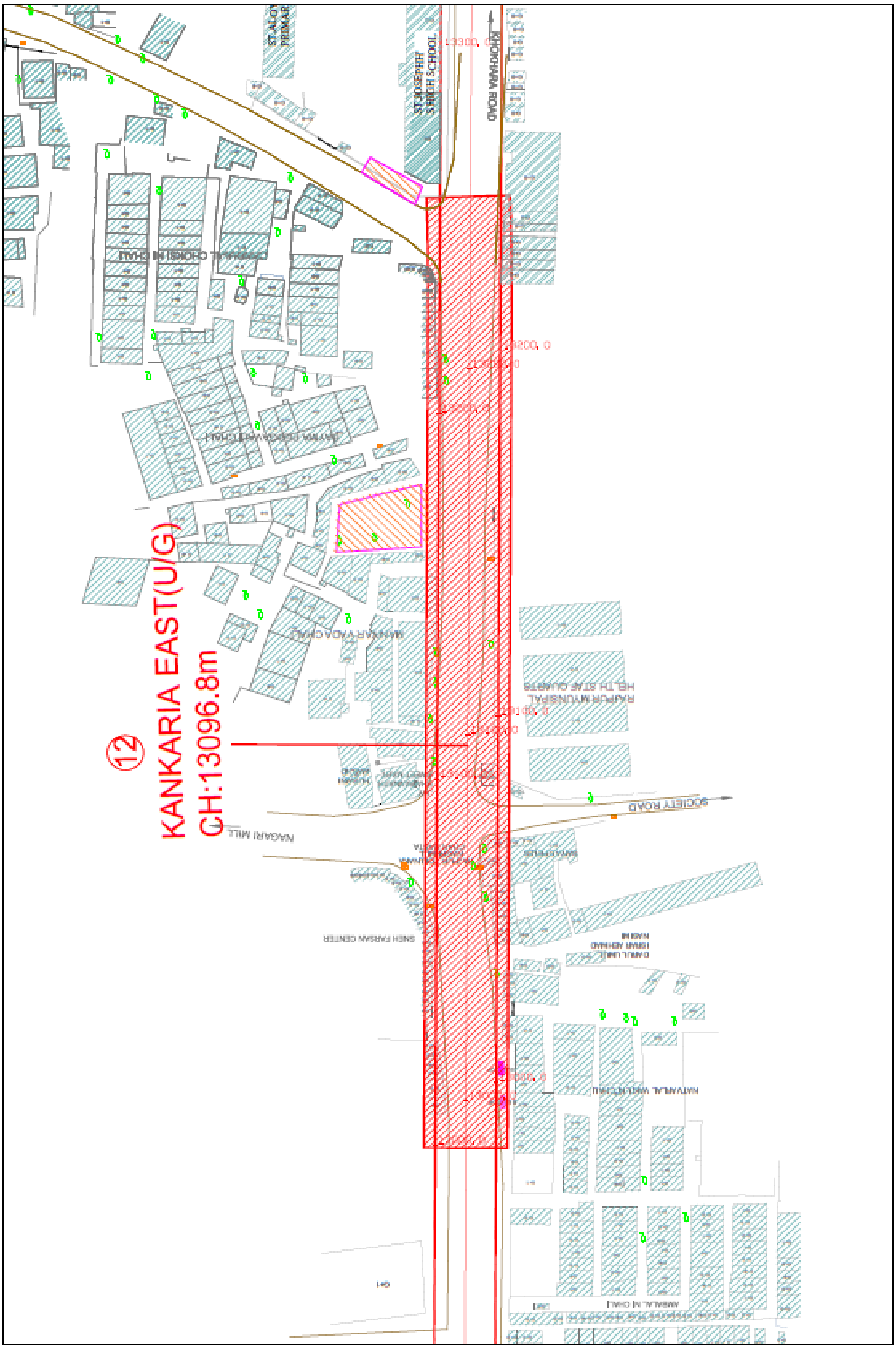

7
STADIUM(Ele.)
CH:5945.6m
SAHJANAND HOSPITAL
VIPUL DUDHIYA
C G ROAD
VODAFONE STORE
SUMIRAN BUSINESS HUB
POLARIS SHOW ROOM
TOWER
NIDHI HOSPITAL
DARSHAN
JAIN DERASAR
EASTIN CITYZEN


8
ASHRAM ROAD(Ele.)
CH:6905.0m
7
ASHRAM ROAD
CH:6417.3m

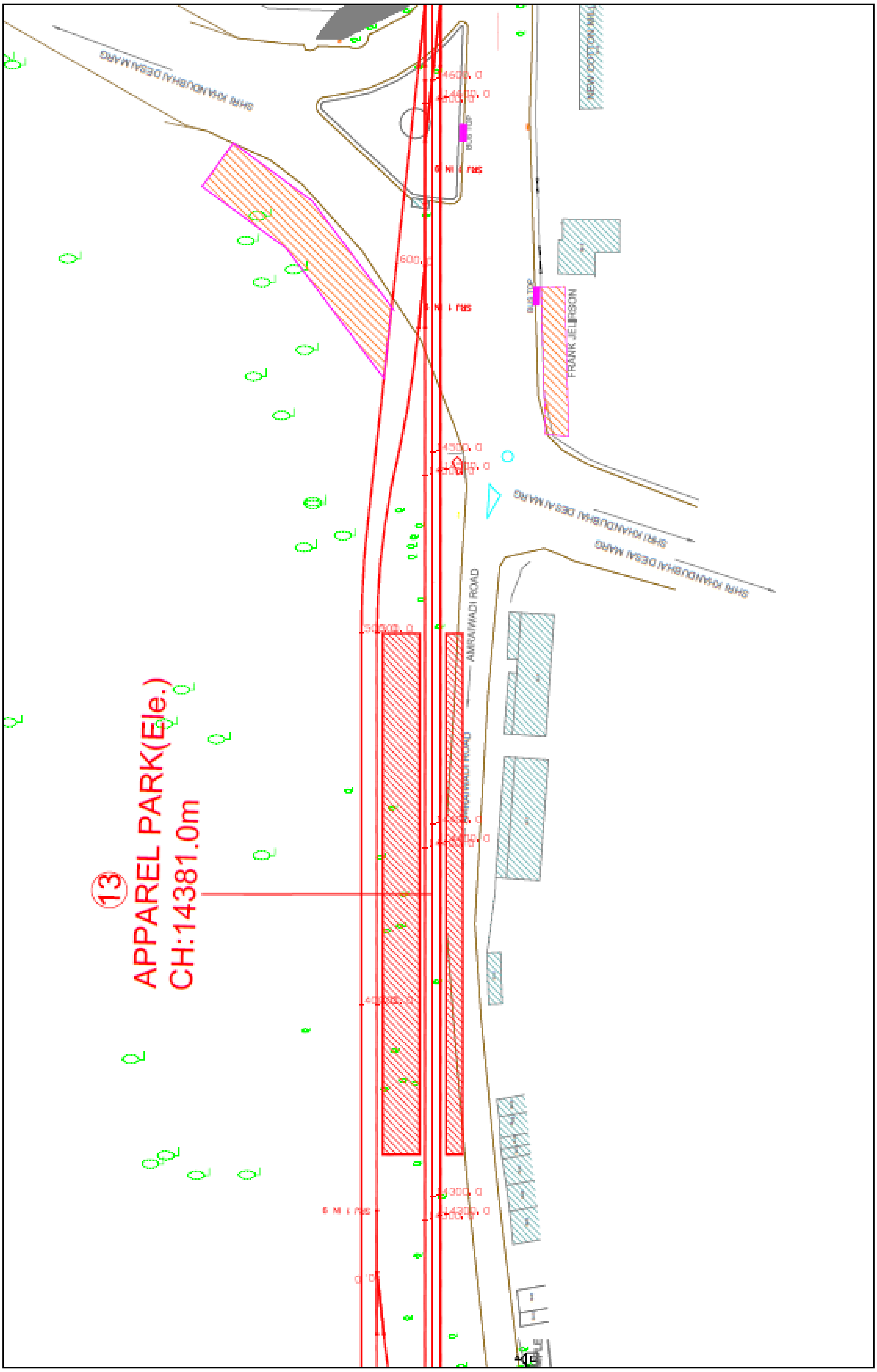

9
SHAHPUR(U/G)
CH:8124.0m
PETROL PUMPS
GARDEN
SHAHPUR MOMIN JAMAT KABRASTAN COMITY
GYAN YAGNGIRLS HIGHER SECONDARY SCHOOL
B.V.HIGH SCHOOL
GARNALA NI POL
SHAHPUR ROAD

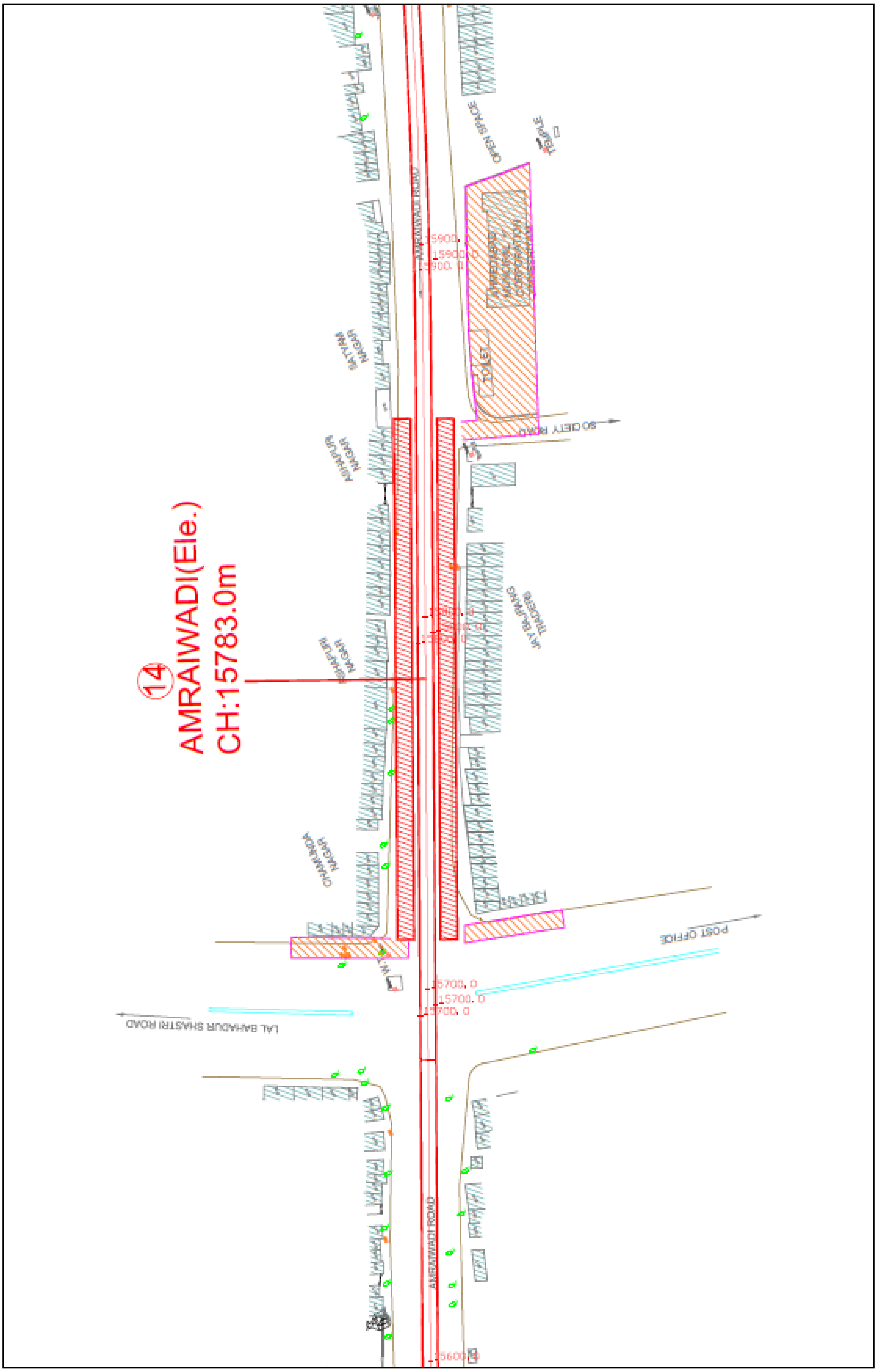

10
GHEE KANTA(U/G)
CH:9624.3m
RELIEF ROAD
GHEEKANTA ROAD

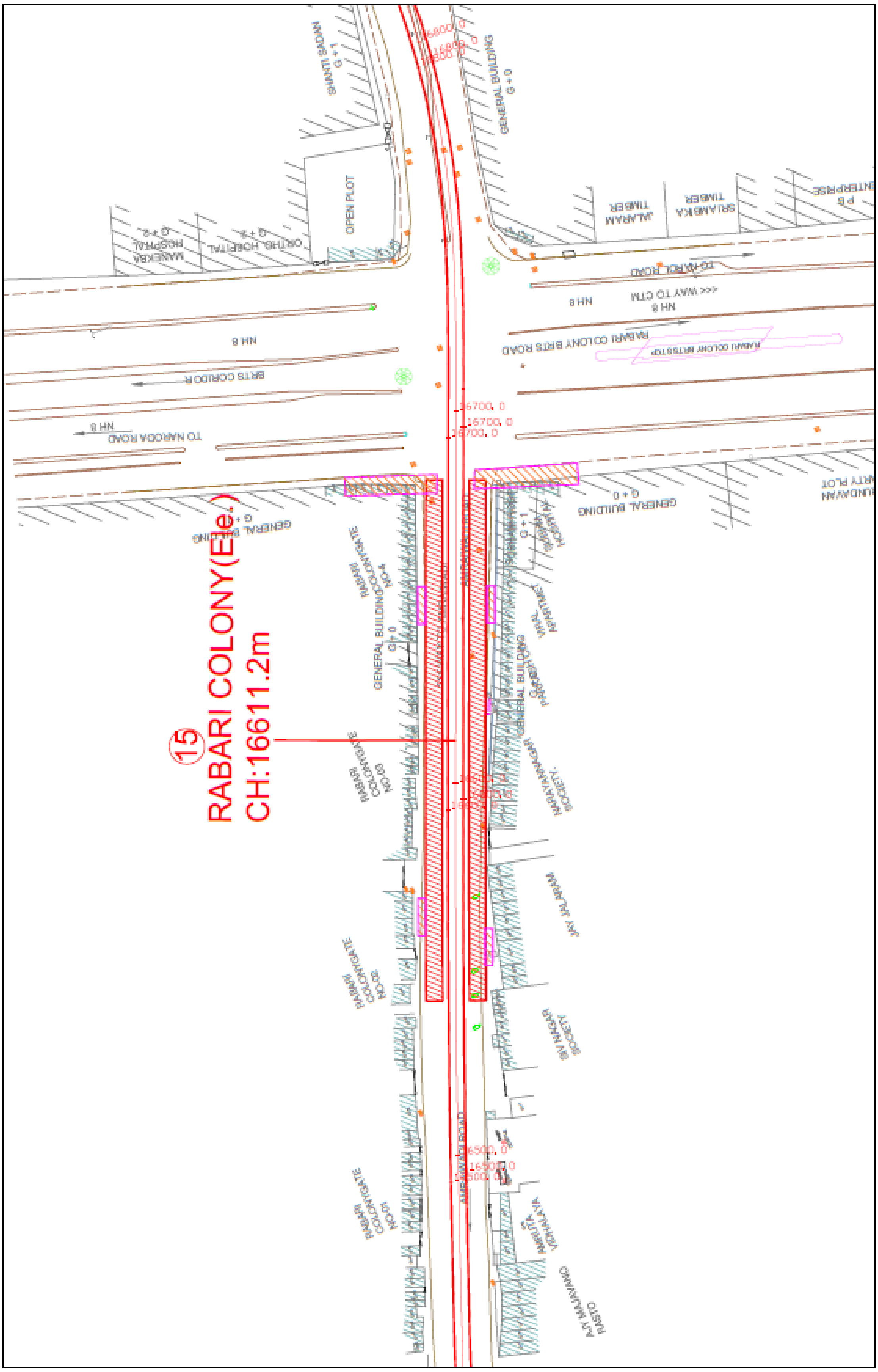

11
KALUPUR RLY.STATION(U/G)
CH:11779.3m

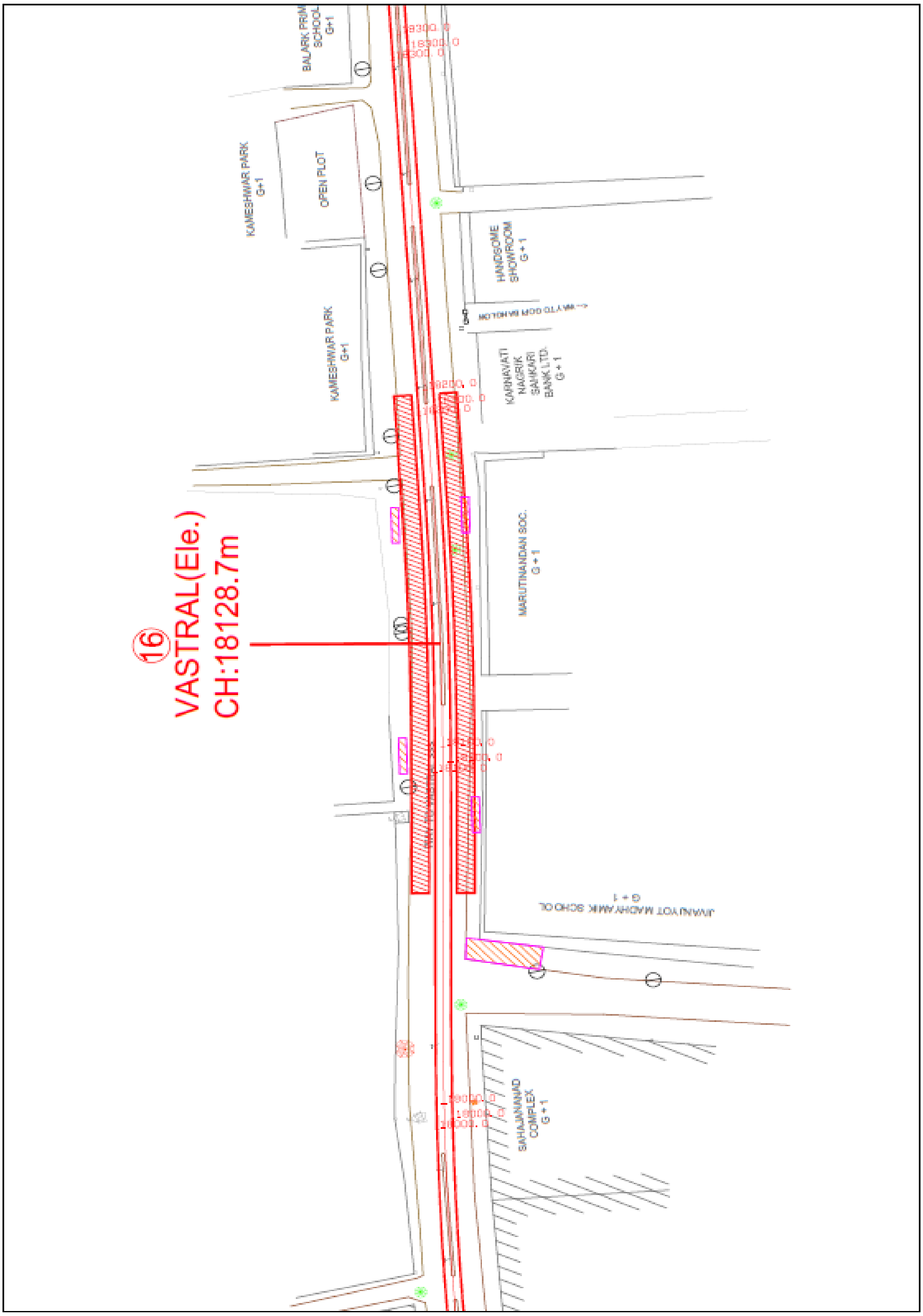


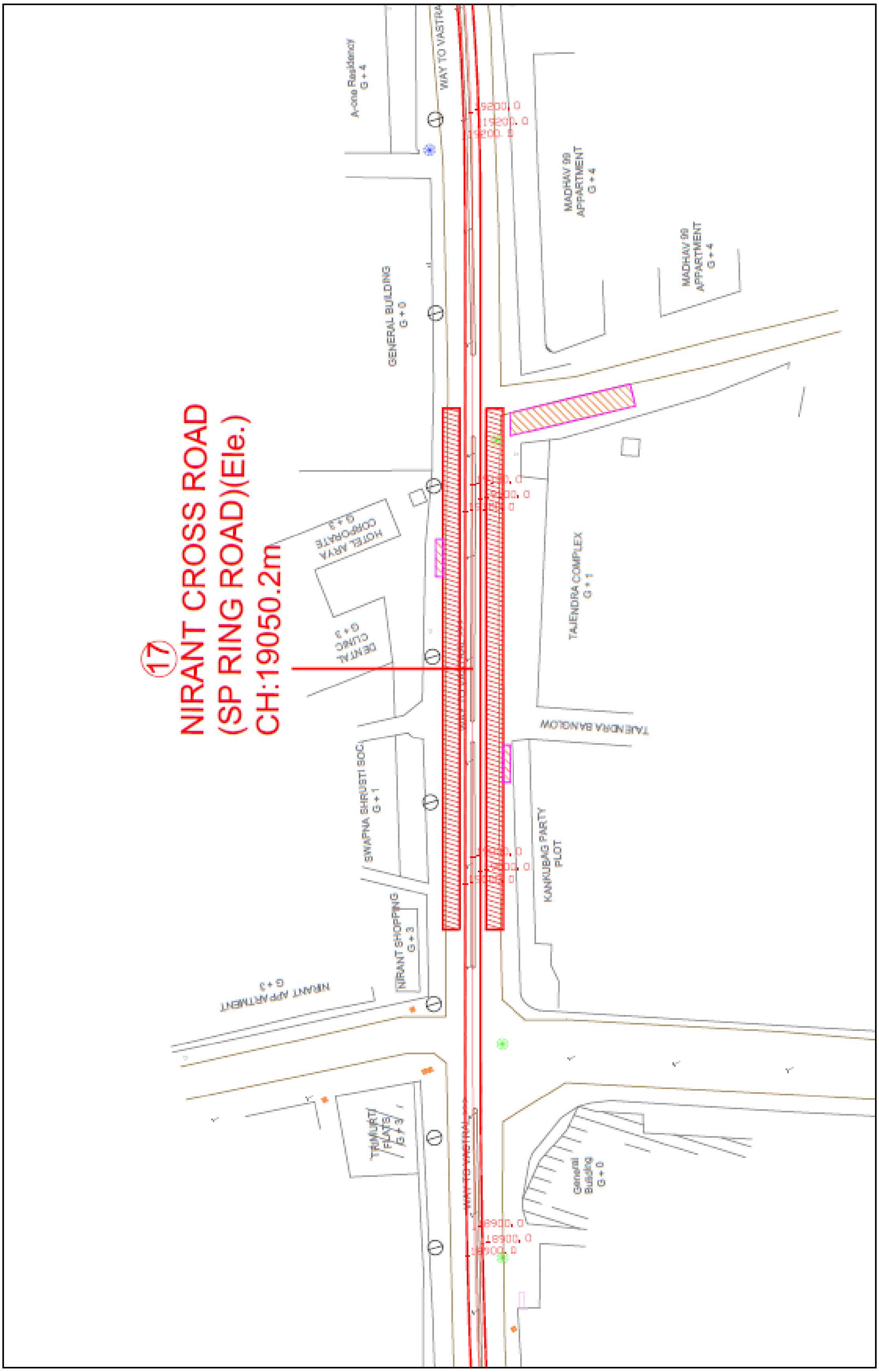
12
KANKARIA EAST(U/G)
CH:13096.8m
KHOKHARA ROAD
ST.JOSEPH'S HIGH SCHOOL
SOCIETY ROAD
NAGARI MILL
SNEH FARSAN CENTER

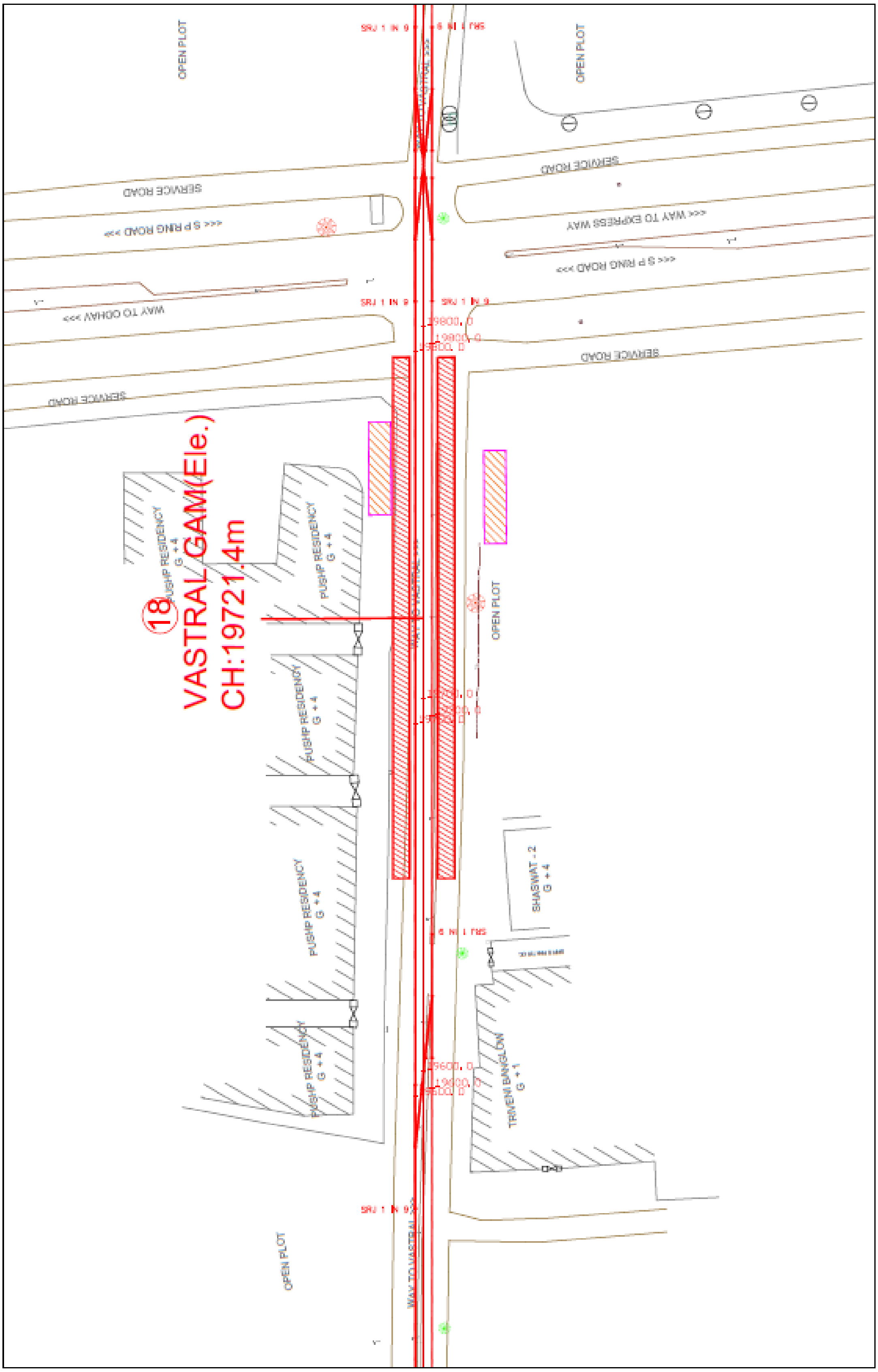

13
APPAREL PARK(Ele.)
CH:14381.0m
AMRAIWADI ROAD
SHRI KHANDUBHAI DESAI MARG

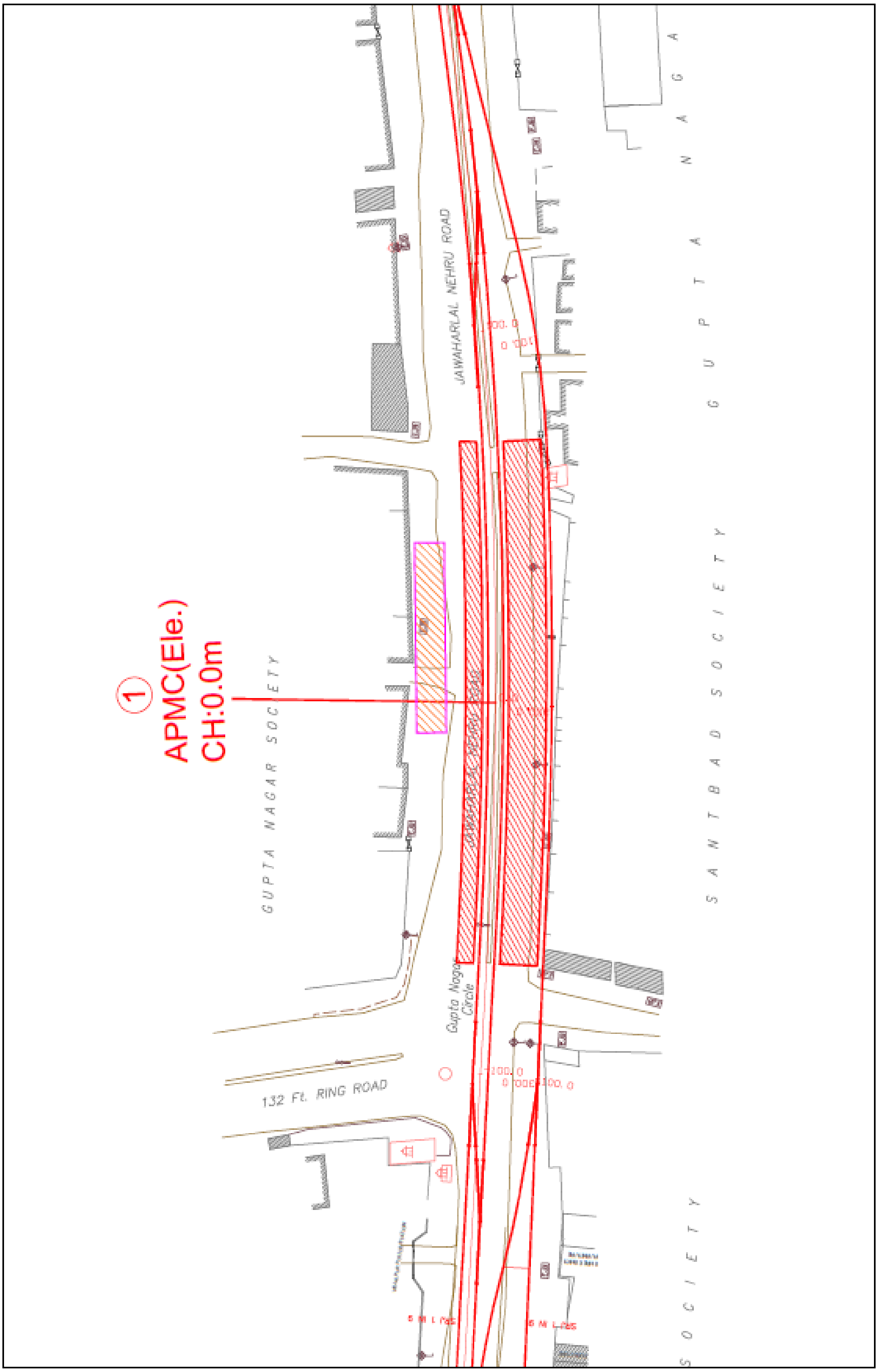

14
AMRAIWADI(Ele.)
CH:15783.0m
AMRAIWADI ROAD
LAL BAHADUR SHASTRI ROAD
SOCIETY ROAD
POST OFFICE
OPEN SPACE
TEMPLE
TOILET

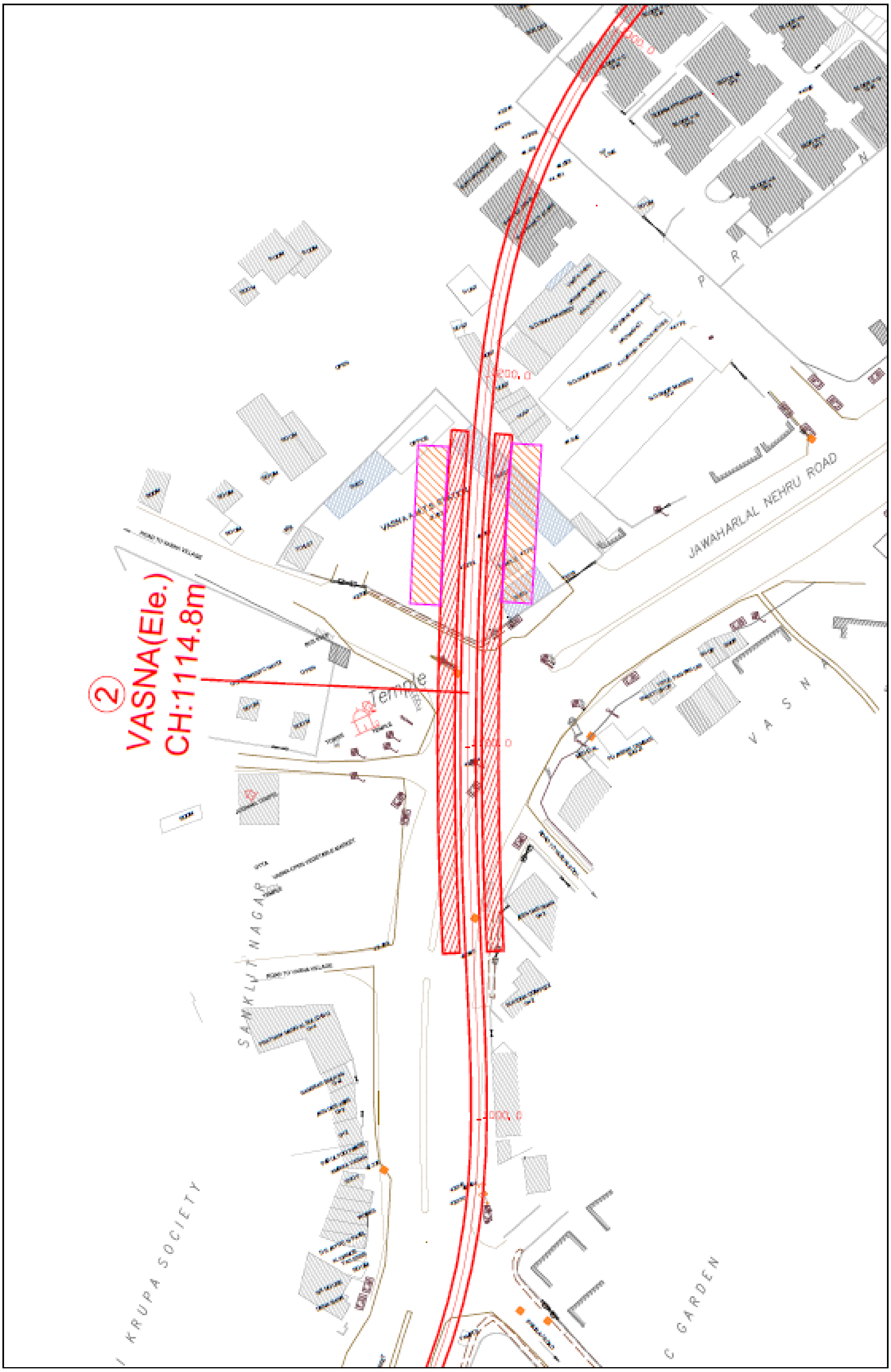

15
RABARI COLONY(Ele.)
CH:16611.2m

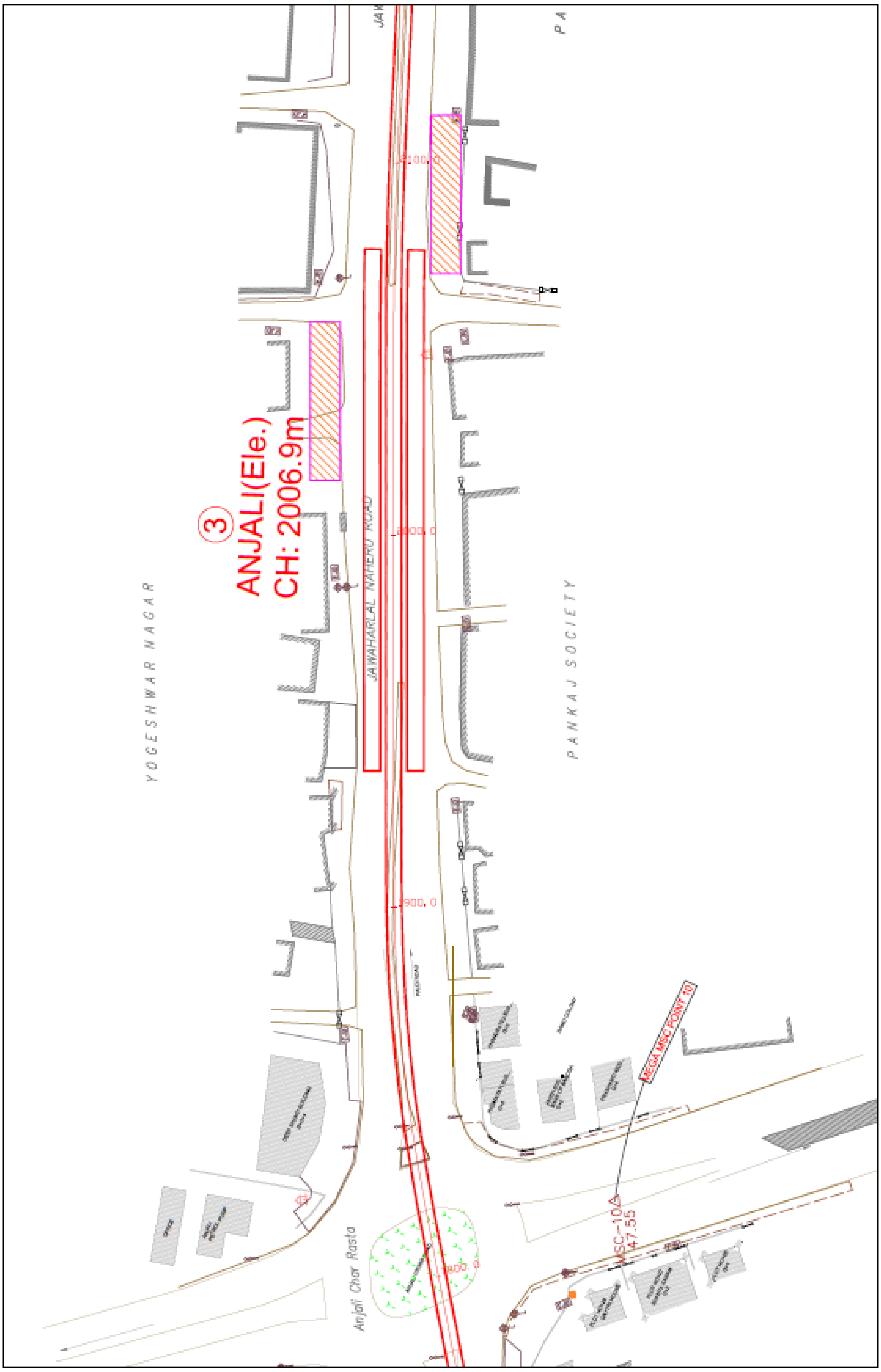

16
VASTRAL(Ele.)
CH:18128.7m
BALARK PRIM SCHOOL G+1
KAMESHWAR PARK G+1
OPEN PLOT
HANDSOME SHOWROOM G+1
KAMESHWAR PARK G+1
KARNAVATI NAGRIK SAHKARI BANK LTD. G+1
MARUTINANDAN SOC. G+1
JIVANJYOT MADHYAMIK SCHOOL G+1
SAHAJANAND COMPLEX G+1


17
NIRANT CROSS ROAD
(SP RING ROAD)(Ele.)
CH:19050.2m
A-one Residency
G + 4
WAY TO VASTRAL
MADHAV 99
APPARTMENT
G + 4
GENERAL BUILDING
G + 0
HOTEL ARYA
CORPORATE
G + 3
DENTAL
CLINIC
G + 3
TAJENDRA COMPLEX
G + 1
TAJENDRA BANGLOW
SWAPNA SHRUSTI SOC
G + 1
KANKUBAG PARTY
PLOT
NIRANT SHOPPING
G + 3
NIRANT APPARTMENT
G + 3
TRIMURTI
FLATS
G + 3
General
Building
G + 0
19200.0
18900.0

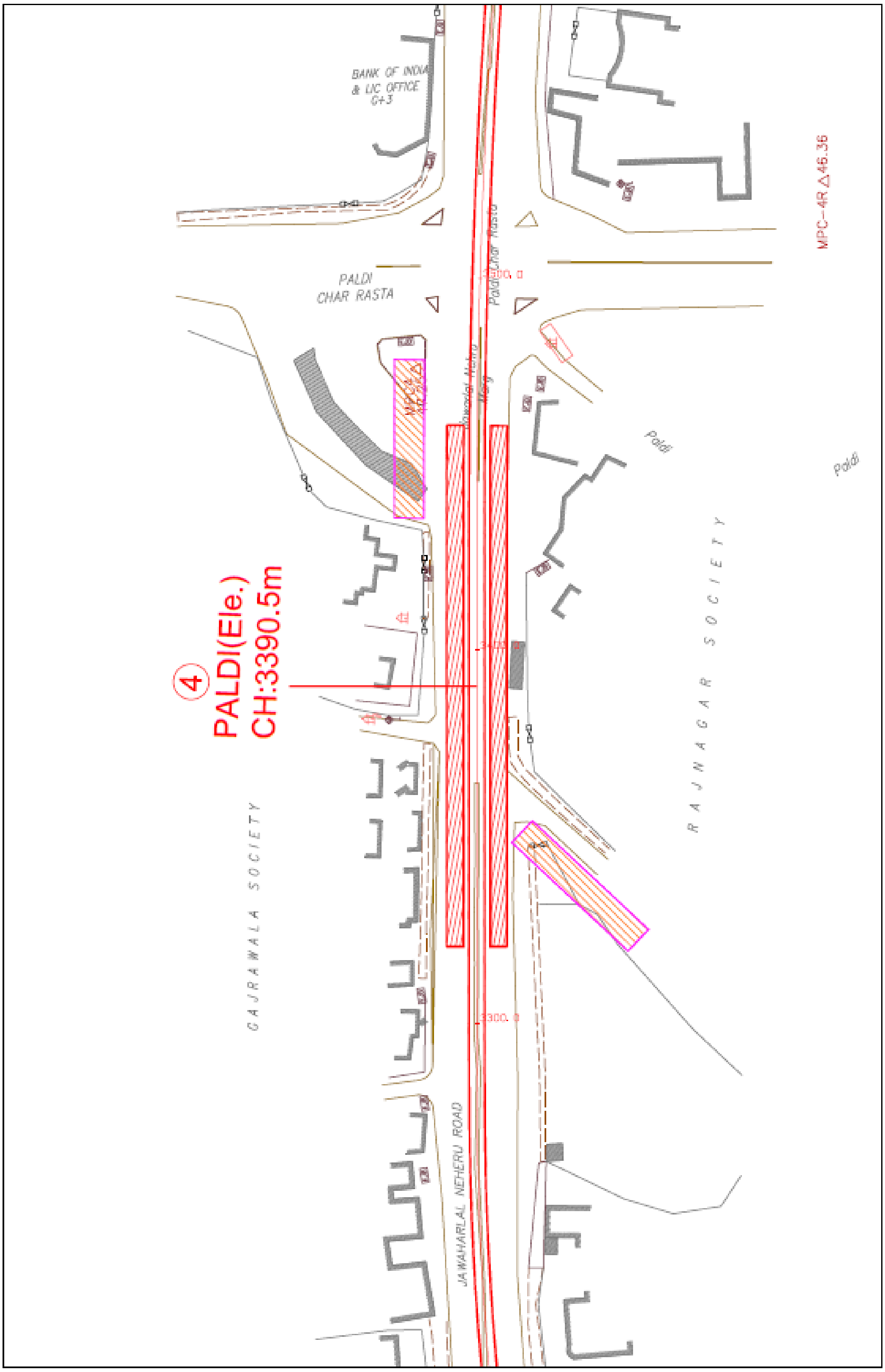

VASTRAL GAM(Ele.)
CH:19721.4m
18
OPEN PLOT
SERVICE ROAD
<<< S P RING ROAD >>>
WAY TO ODHAV >>>
<<< WAY TO EXPRESS WAY
PUSHP RESIDENCY
G + 4
SHASWAT - 2
G + 4
TRIVENI BANGLOW
G + 1
WAY TO VASTRAL

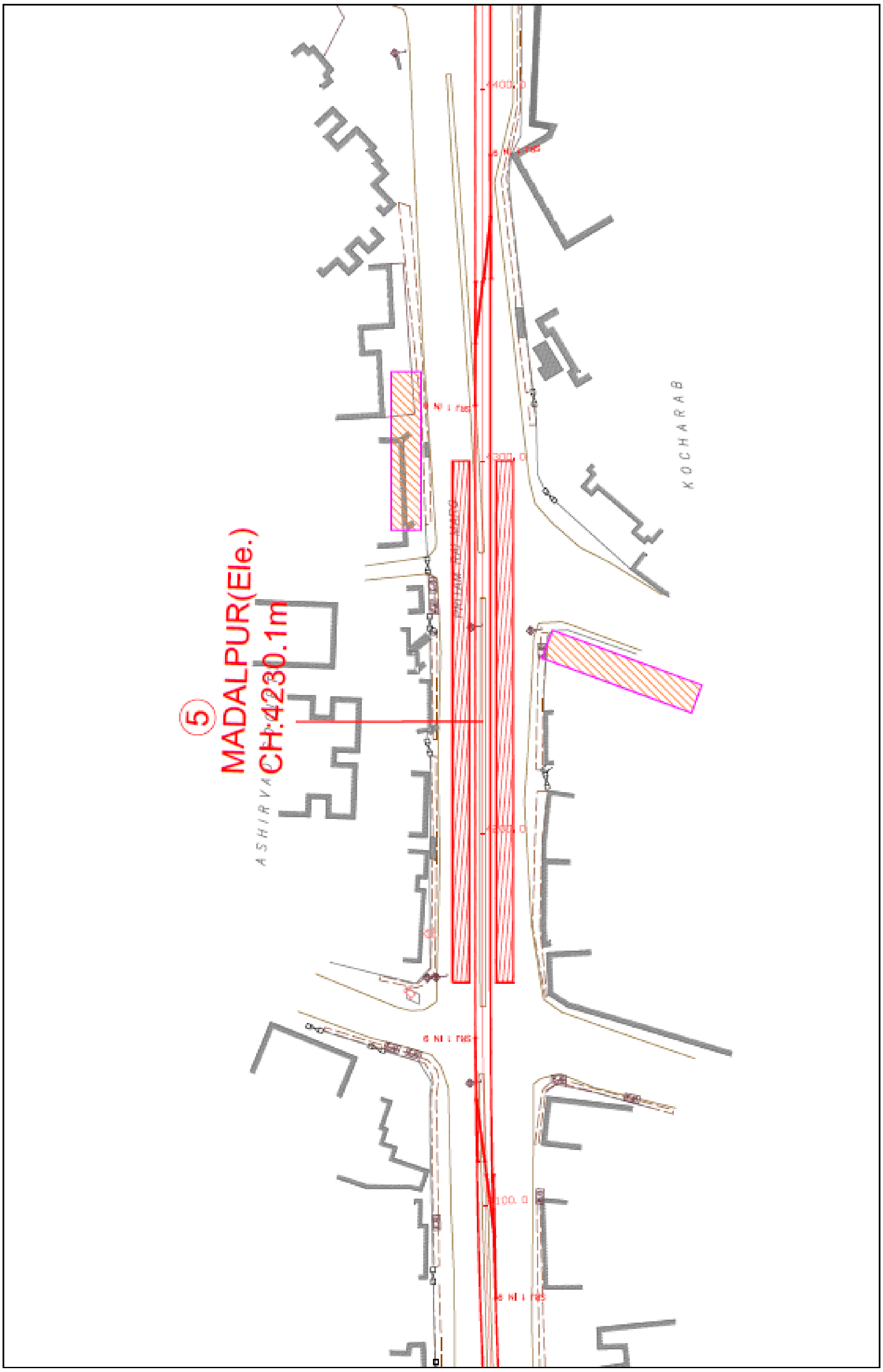

1
APMC(Ele.)
CH:0.0m
JAWAHARLAL NEHRU ROAD
GUPTA NAGAR SOCIETY
GUPTA NAGAR
132 Ft. RING ROAD
Gupta Nagar Circle
SANTBAD SOCIETY
SOCIETY

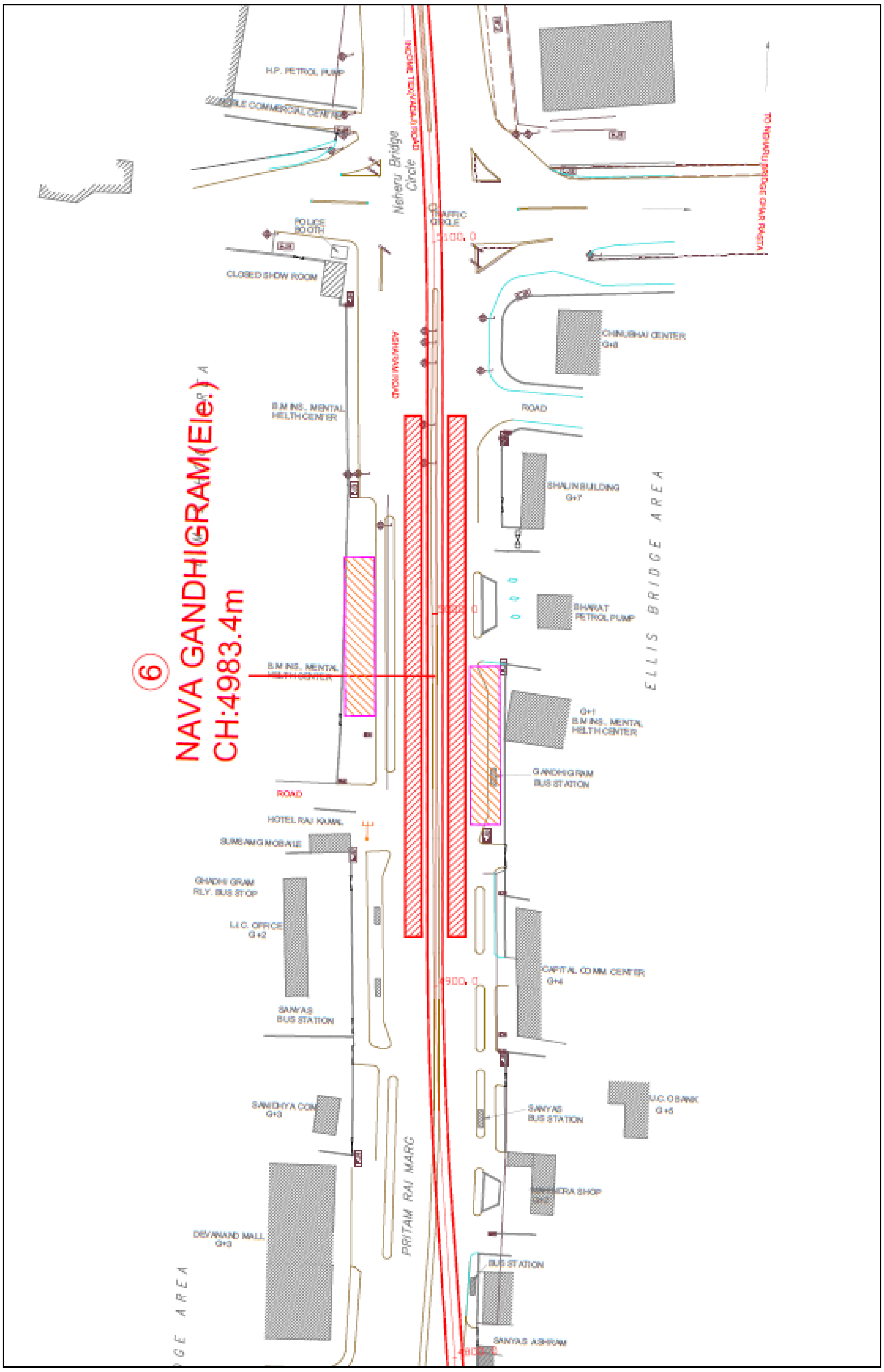

② VASNA(Ele.)
CH:1114.8m
JAWAHARLAL NEHRU ROAD
Temple
V A S N A
KRUPA SOCIETY
GARDEN

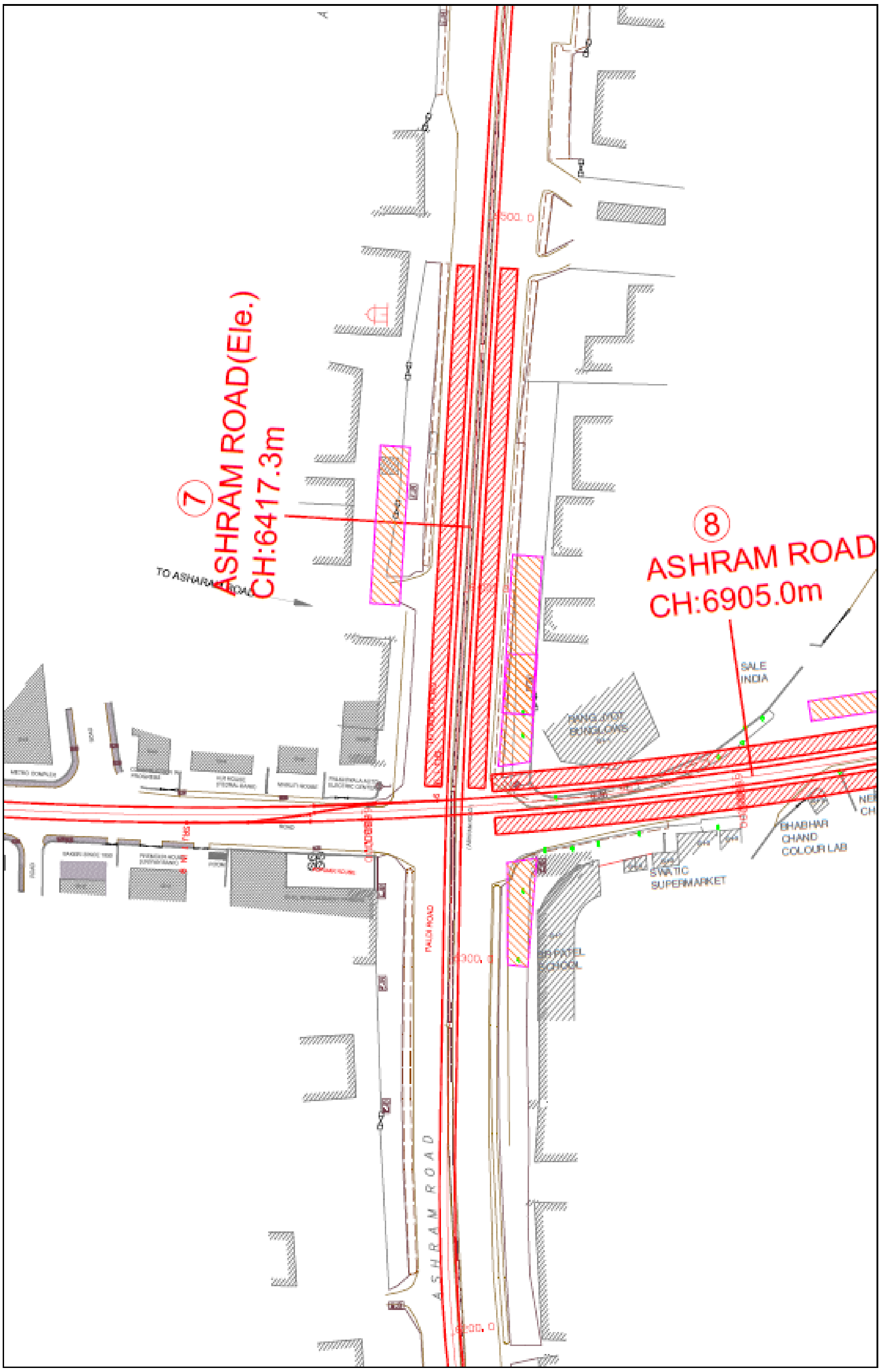


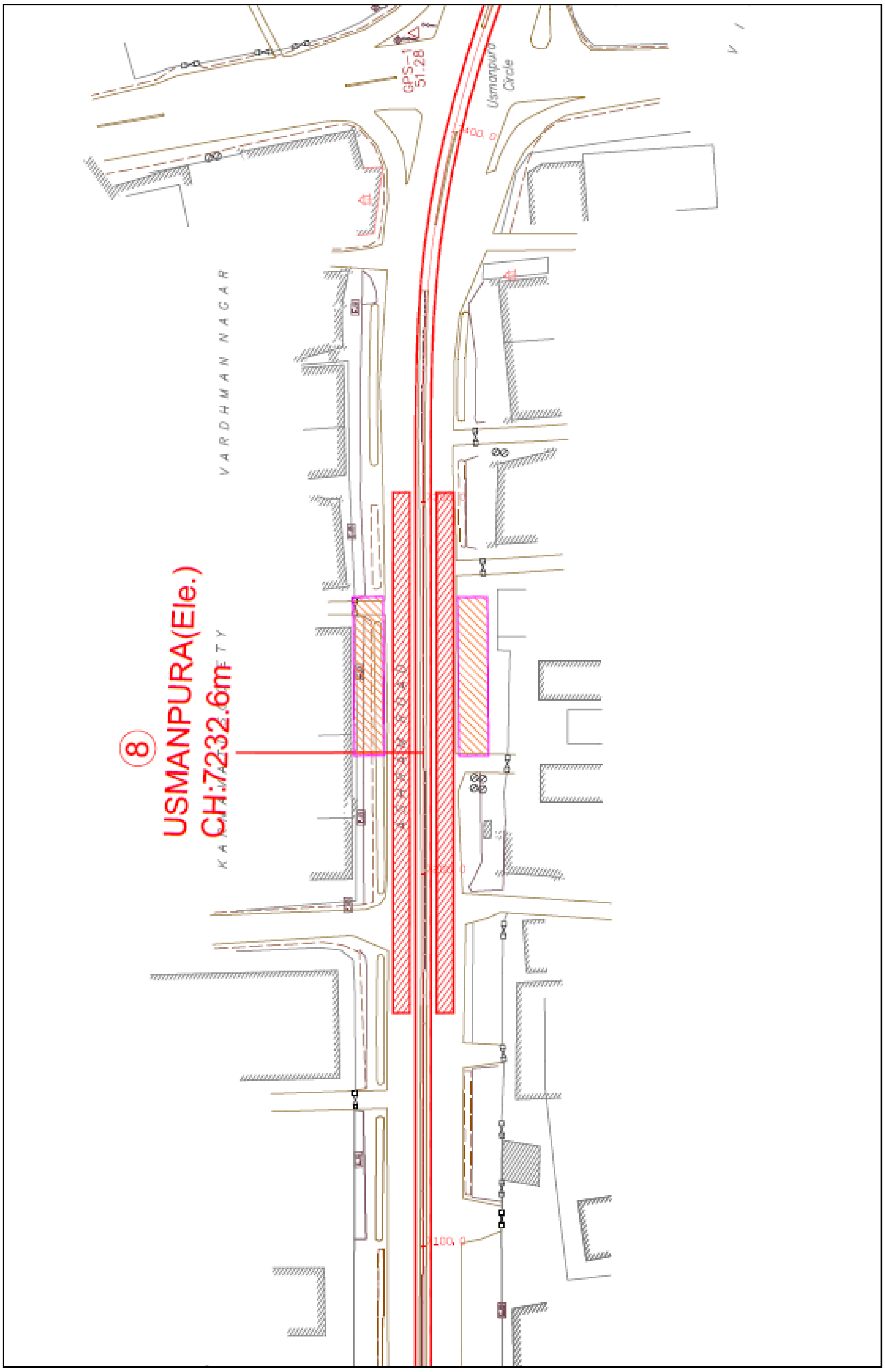
3
ANJALI(Ele.)
CH: 2006.9m
JAWAHARLAL NAHERU ROAD
YOGESHWAR NAGAR
PANKAJ SOCIETY
Anjali Char Rasta
MEGA MSC POINT 10
MSC-10A
47.55

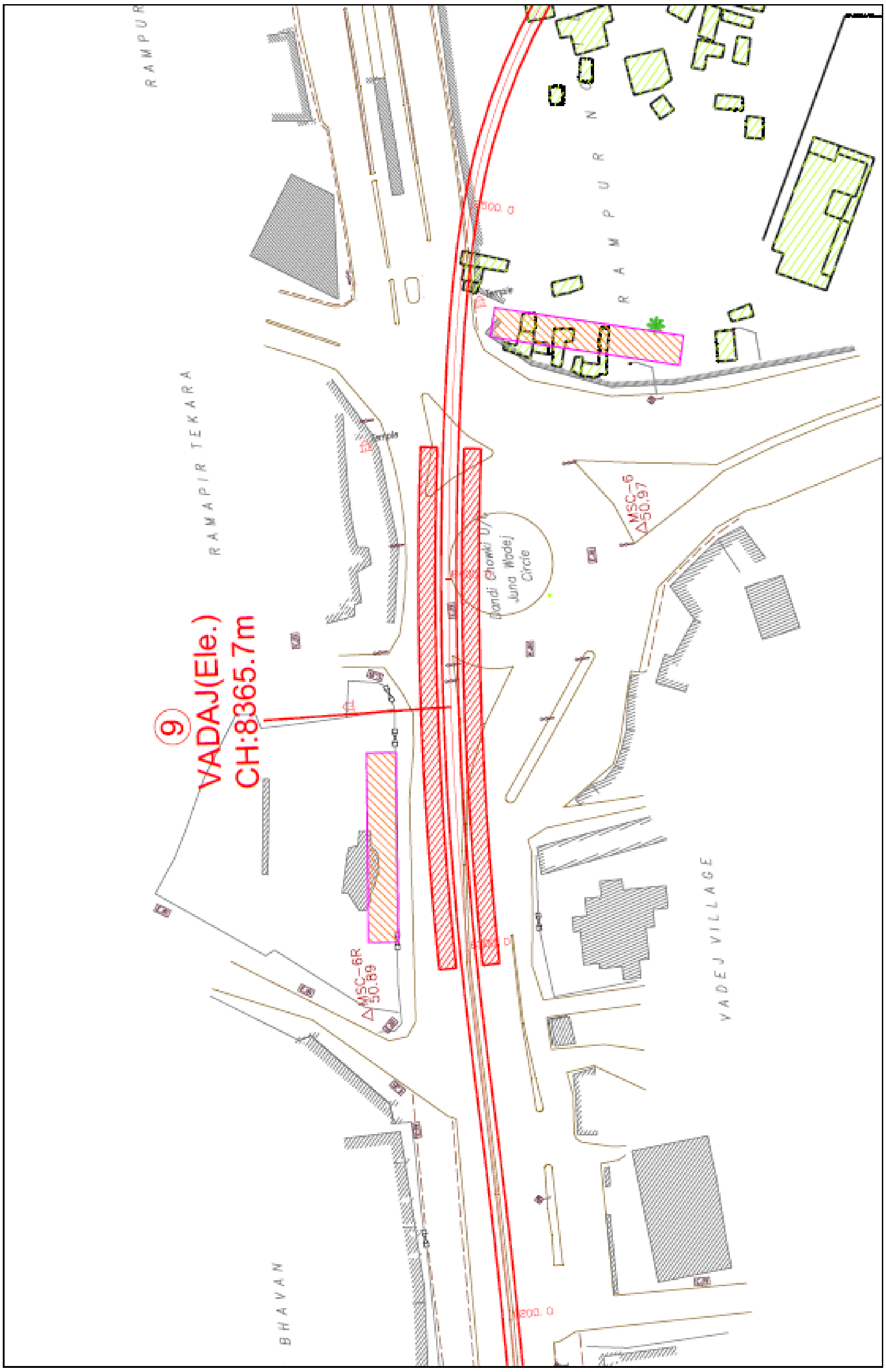

BANK OF INDIA
& LIC OFFICE
G+3
PALDI
CHAR RASTA
4
PALDI(Ele.)
CH:3390.5m
GAJRAWALA SOCIETY
RAJNAGAR SOCIETY
JAWAHARLAL NEHERU ROAD
Paldi
MPC-4R △46.36

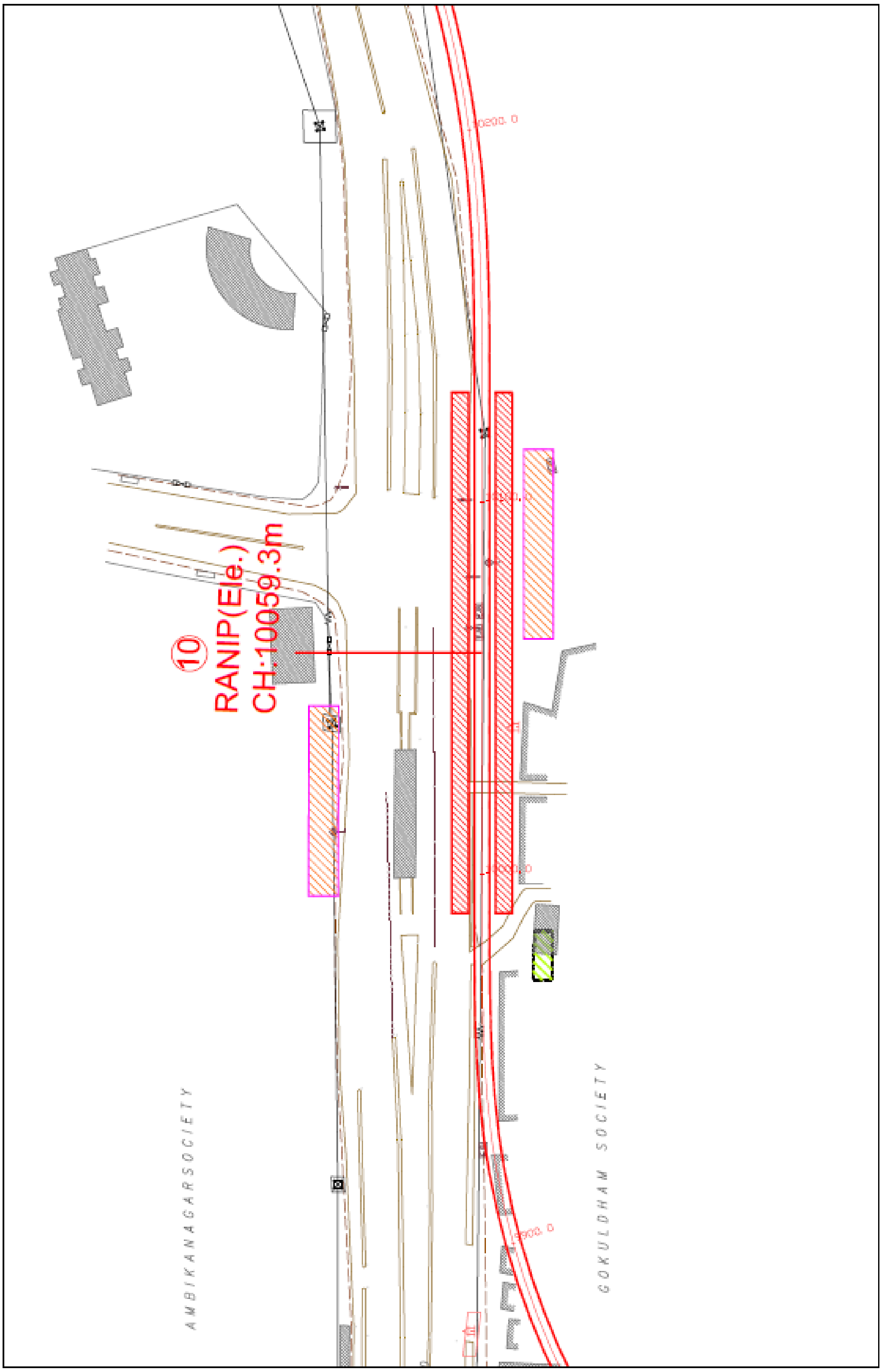

5
MADALPUR(Ele.)
CH:4230.1m
ASHIRVAD
KOCHARAB

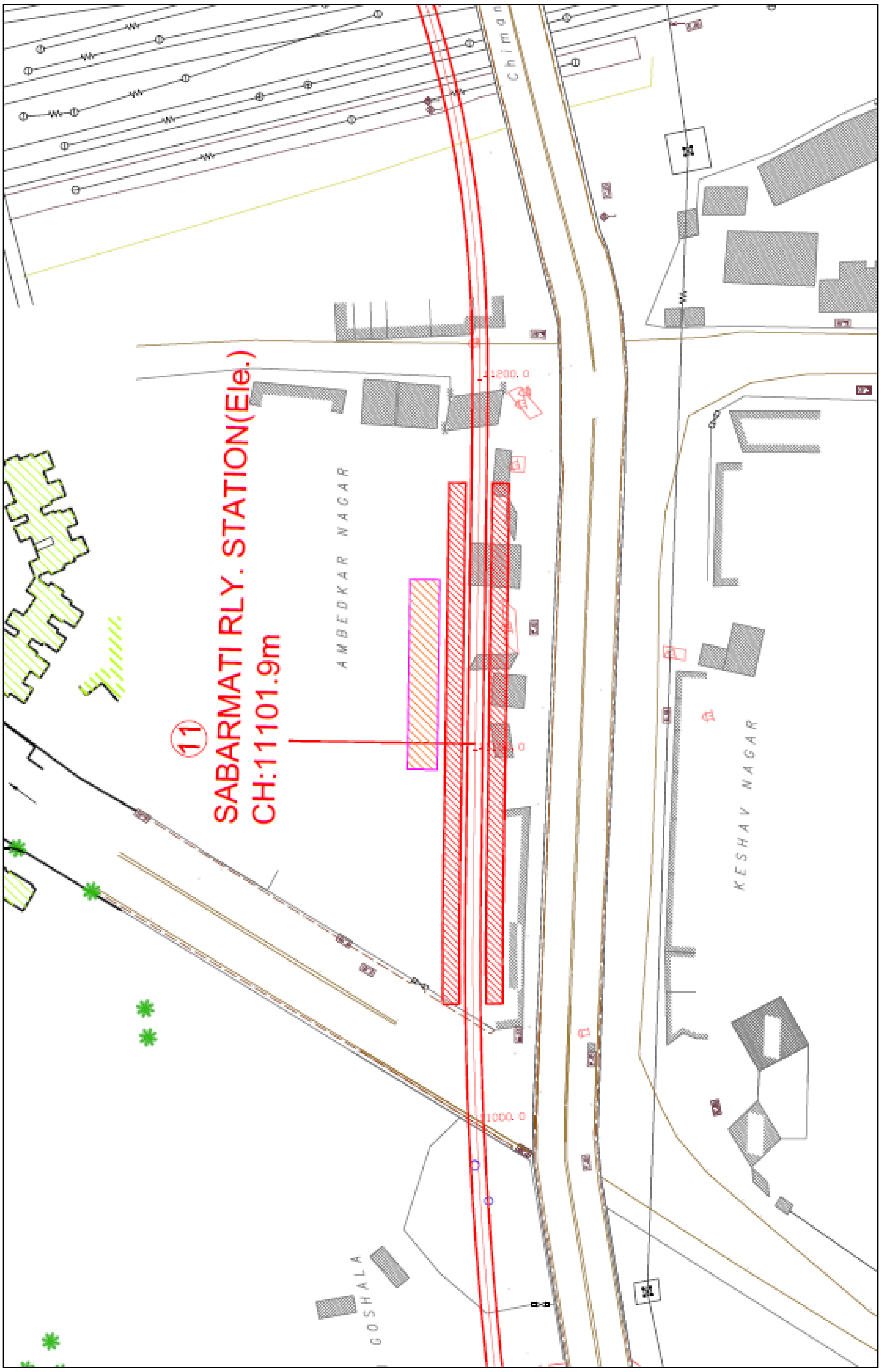

NAVA GANDHIGRAM(Ele:)
CH:4983.4m
6
H.P. PETROL PUMP
Nehru Bridge Circle
TRAFFIC CIRCLE
POLICE BOOTH
CLOSED SHOW ROOM
CHINUBHAI CENTER
B.M INS. MENTAL HELTH CENTER
SHALIN BUILDING G+7
BHARAT PETROL PUMP
ELLIS BRIDGE AREA
GANDHIGRAM BUS STATION
HOTEL RAJ KAMAL
SUMSANG MOBAILE
L.I.C. OFFICE G+2
SANYAS BUS STATION
CAPITAL COMM CENTER G+4
SANDHYA COM G+3
DEVANAND MALL G+3
PRITAM RAI MARG
BUS STATION
SANYAS ASHRAM
ROAD

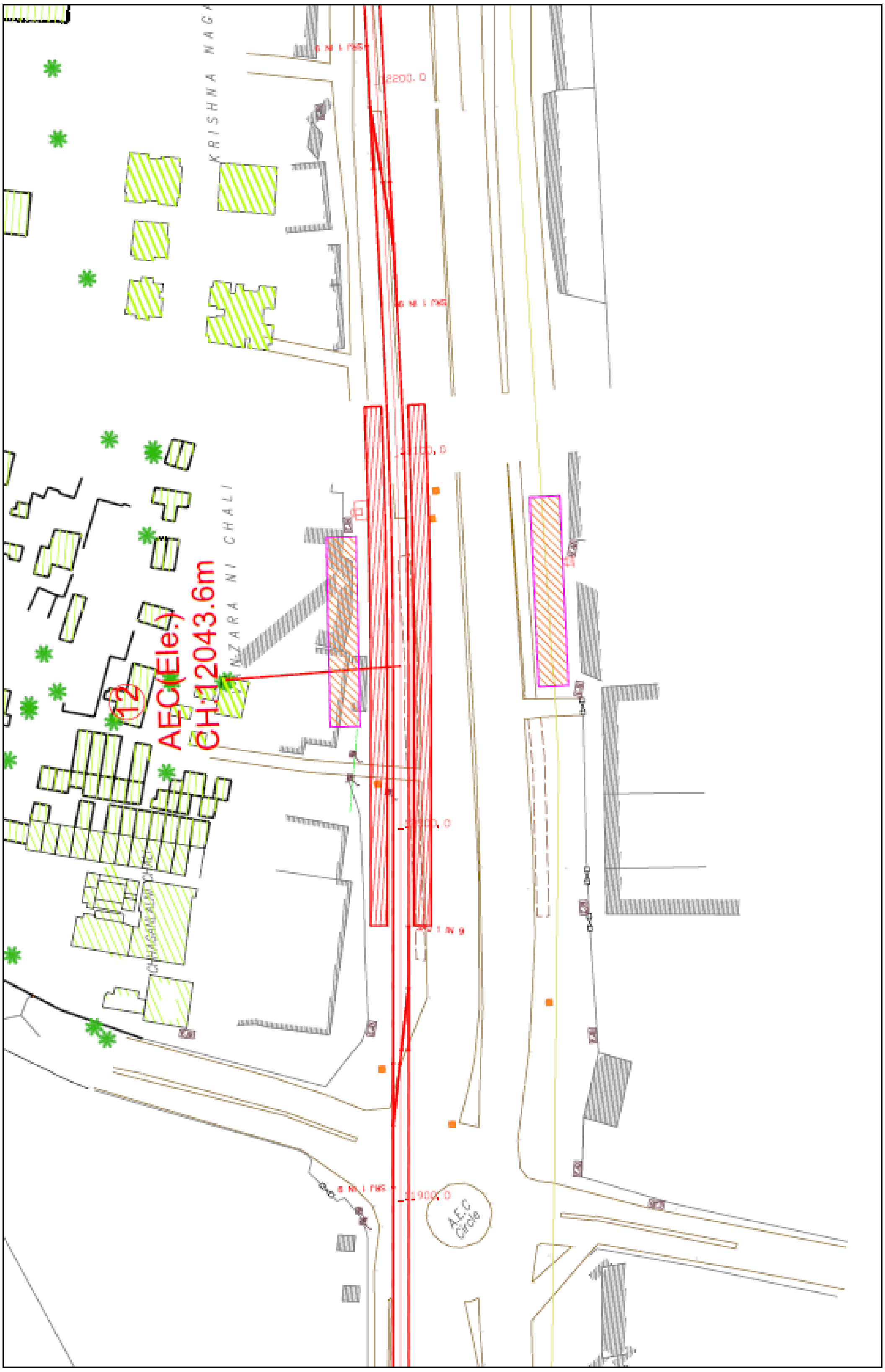

7
ASHRAM ROAD(Ele.)
CH:6417.3m
8
ASHRAM ROAD
CH:6905.0m
TO ASHARAM ROAD
SALE INDIA
BHABHAR CHAND COLOUR LAB
SWATIC SUPERMARKET
ASHRAM ROAD

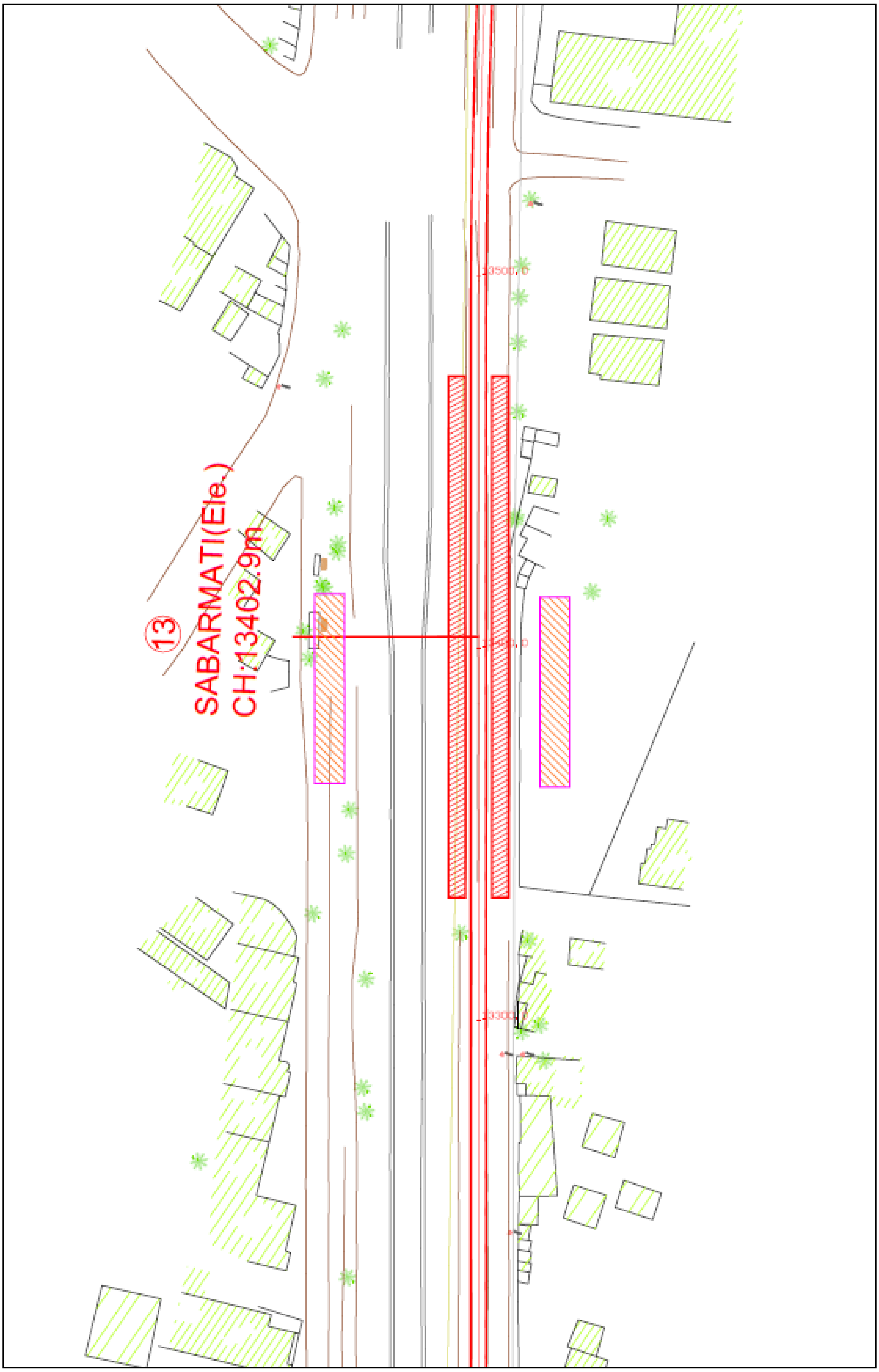

USMANPURA(Ele.)
CH:7232.6m
8
VARDHMAN NAGAR
GPS-1
51.28
Usmanpura Circle

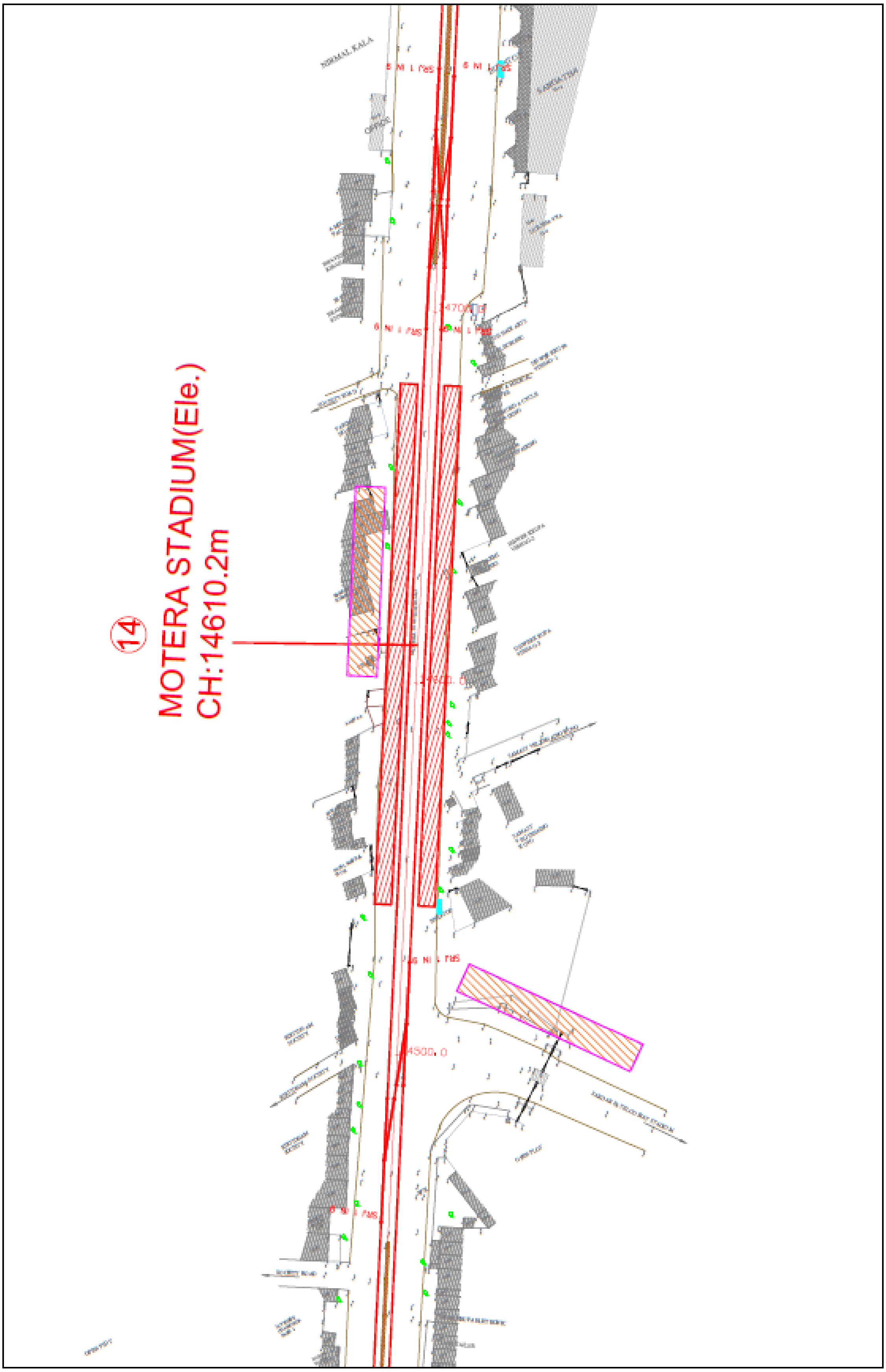

9
VADAJ(Ele.)
CH:8365.7m
RAMAPIR TEKARA
RAMPUR
VADEJ VILLAGE
BHAVAN
MSC-6
Δ50.97
MSC-6R
Δ50.89


10
RANIP(Ele.)
CH:10059.3m
AMBIKANAGAR SOCIETY
GOKULDHAM SOCIETY


11
SABARMATI RLY. STATION(Ele.)
CH:11101.9m
AMBEDKAR NAGAR
KESHAV NAGAR
GOSHALA
11200.0
11000.0


12
AEC(Ele.)
CH:12043.6m
KRISHNA NAGAR
A.E.C Circle


13
SABARMATI(Ele.)
CH:13402.9m


14
MOTERA STADIUM(Ele.)
CH:14610.2m

Chapter – 6

Station Planning

Chapter – 6

STATION PLANNING

6.1 GENERAL

The proposed Ahmedabad Metro consists of two corridors namely:

Corridor I: North-South Corridor (APMC-Motera stadium)

The length of this corridor is 15.420 km. Total 14 no. of stations have been planned on this corridor. All stations on this corridor are planned as an elevated.

Corridor II: East West Corridor (Thaltej Gam – Vastral Gam)

The length of this corridor is 20.536 km. Total 18 no. of stations have been planned on this corridor. Four stations on this corridor are planned to be underground while the rest will be elevated.

The locations of the station have been identified taking into consideration the constraints in land acquisition and congestion issues, linkages with other transport nodes etc. Stations are proposed in such a way so as to attract maximum demand from the traffic nodal points. The below map showing metro corridor along with station locations is presented below.

6.2 STATION TYPES

A total of 32 stations have been proposed across both the corridors. These are mostly elevated stations located at a clear height of 5.5m above the road. The stations shall be accessible from both sides of the road in order to better serve the catchment area. Two side platforms are planned on this type of station. Approximately 6 km of alignment in the E-W corridor is located underground. This alignment will include four underground stations. These underground stations will be island types in configuration.

The Ashram Road station is planned as an important metro interchange providing interchange between North-South & East-West lines. Other interchange stations include those interconnecting transport nodes such as Railway stations, GSRTC Terminals, BRTS and AMTS stops. The stations would be physically connected to these nodes to ensure comfortable and hassle-free transfers.

The Entry/exit structures to proposed stations have been planned to be located on footpaths to the extent possible. However, where this is not possible, land acquisition would be inevitable.

S.No.	Type	Platform	Name of Station	Chainage (km)	Inter-station Distance (m)	Ground Level (m)	Rail Level (m)	Platform Depth / Height from Ground	Interchange facility
Corridor I (North-South) (APMC to Motera Stadium)									
1	Terminal	Side	APMC	00+000	--	42.500	56.500	15.090	--
2	Elevated	Side	Vasna	01+115	1114.8	42.700	56.300	14.690	--
3	Elevated	Side	Anjali	02+007	892.1	47.100	60.500	14.490	BRTS
4	Elevated	Side	Paldi	03+391	1383.6	46.700	60.100	14.490	AMTS
5	Elevated	Side	Madalpur	04+230	839.6	48.500	62.000	14.590	--
6	Elevated	Side	Nava Gandhigram	04+983	753.3	49.400	63.000	14.690	Indian Railway
7	Interchange	Side	Ashram Road	06+417	1433.9	51.400	70.350	20.040	Metro Corridor II
8	Elevated	Side	Usmanpura	07+233	815.3	51.550	65.200	14.740	--
9	Elevated	Side	Vadaj	08+366	1133.1	50.100	64.000	14.990	AMTS,GSRTC,BRTS
10	Elevated	Side	Ranip	10+059	1693.6	52.600	66.000	14.490	GSRTC,BRTS
11	Elevated	Side	Sabarmati Rly. Stn.	11+102	1042.6	50.700	64.000	14.390	Indian Railway
12	Elevated	Side	AEC	12+044	941.7	53.300	66.700	14.490	BRTS
13	Elevated	Side	Sabarmati	13+403	1359.3	56.200	69.500	14.390	BRTS
14	Terminal	Side	Motera Stadium	14+610	1207.3	57.800	71.100	14.390	--

S.No.	Type	Platform	Name of Station	Chainage (km)	Inter-station Distance (m)	Ground Level (m)	Rail Level (m)	Platform Depth / Height from Ground	Interchange facility
Corridor II (East-West) (Thaltej Gam to Vastral Gam)									
1	Terminal	Side	Thaltej Gam	00+000	--	44.591	61.500	17.999	--
2	Elevated	Side	Thaltej	01+114	1114.4	55.700	68.700	14.090	--
3	Elevated	Side	Doordarshan Kendra	01+961	846.7	52.670	65.600	14.020	--
4	Elevated	Side	Gurukul Road	03+082	1121.3	49.600	63.500	14.990	--
5	Elevated	Side	Gujarat University	03+989	906.8	49.900	65.000	16.190	BRTS
6	Elevated	Side	Commerce Six Rd.	05+054	1064.6	49.050	62.700	14.740	--
7	Elevated	Side	Stadium	05+946	891.8	49.000	62.600	14.690	--
8	Interchange	Side	Ashram Road	06+905	959.4	48.700	62.100	14.490	Metro Corridor I
9	U/G	Island	Shahpur	08+124	1219	49.500	34.500	-13.910	--
10	U/G	Island	Ghee Kanta	09+624	1500.3	51.200	28.000	-22.110	--
11	U/G	Island	Kalupur Rly. Stn.	11+779	2155	51.800	37.500	-13.210	Indian Railway
12	U/G	Island	Kankaria East	13+097	1317.5	48.600	33.000	-14.510	--
13	Elevated	Side	Apparel Park	14+381	1284.2	47.550	58.722	12.262	--
14	Elevated	Side	Amraiwadi	15+783	1402	46.900	60.500	14.690	--
15	Elevated	Side	Rabari Colony	16+611	828.2	47.700	61.200	14.590	BRTS
16	Elevated	Side	Vastral	18+129	1517.5	55.650	69.500	14.940	--
17	Elevated	Side	Nirant Cross Road	19+050	921.5	52.500	66.740	15.330	--
18	Terminal	Side	Vastral Gam	19+721	671.2	51.700	64.600	13.990	--

Corridor I (North – South) : Motera Stadium to APMC	
1. APMC	
Chainage	00+000
Inter-station Distance	-
Rail Level	56.500
Platform Height from Ground Lvl	15.090
Location	Terminal station on N-S Corridor located on the median of road. It is located on the junction of 132' Ring Road and Jawaharlal Nehru Road (Vasna Road). Station building located near the Agricultural produce market building.
Entry / Exit stairs	The entry exit structures are located on both sides of the station as per proposed section and in proximity to the junction to increase catchment.
Catchment Area	Residential area around station and would extend to New Vejalpur, Gupta Nagar, APMC area, Juhapura area, Sarkhej&Makarba as corridor ends at this station. Sarkhej provides direct connectivity towards West (Sanand, Viramgan), South (Dholera and Changodar) as well as in the North (Gandhinagar).



2. Vasna	
Chainage	01+115
Inter-station Distance	1114.8 m
Rail Level	56.300
Platform Height from Ground Lvl	14.690
Location	Station is located at Vasna Cross Road and traversing from Vasna AMTS bus stand.
Entry / Exit stairs	Located both side of station, Western structures within AMTS Bus Terminal, eastern entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Vasna AMTS Station, Vasna Village including Chintan park, Prajapati park area Vasna Colony, P&T Colony,Jawahar Nagar,KundanTenament, PratapKunj Society, Shreyas Society etc. & other societies along both sides of the alignment near VasnaAMTS Bus Terminal.



3. Anjali	
Chainage	02+007
Inter-station Distance	892.1 m
Rail Level	60.500
Platform Height from Ground Lvl	14.490
Location	Located on the center line of road, near Anjali Cross Road. Station footprint lies in front of Damubhai Colony.
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Part of Vasna&Paldibhattha area, Fatehpura Gam, Pankaj Society, Yogi nagarsociety, Ashoknagar society, ChandranagarGeeta area, Damubhai Colony, Dungarshi Nagar, Neelkanth Plaza, Anand Complex, and Narayan Nagar. Further may extend to Hariom Nagar, Padmaruti Nagar, Yogeshwar Nagar, and Manik Nagar up to Fatehpura Village. The station will provide connectivity options to Anjali BRTS station.

4. Paldi	
Chainage	03+391
Inter-station Distance	1383.6 m
Rail Level	60.100
Platform Height from Ground Lvl	14.490
Location	Located on the center line of Paldi RoadnearPaldi Cross Road. Station building lies in front of Adani petrol pump on west side of alignment and Narshi Bhagat Hostel on east side of alignment.
Entry / Exit stairs	Located both side of station, Western structures within AMC office premises and nearby Bus Terminal, eastern entry exit structures are located on flanking the road as per the proposed road section. These will be located close to Paldi junction to improve catchment and provide connectivity to AMTS terminal and Private regional operators.
Catchment Area	Paldi AMTS terminal, Areas surrounding Paldi village, Shastri Market area, & may extend up to Raj Nagar Society, Jitendra Park area, part of Kochrab Village, in addition to Institutional areas Sanskar Kendra, Krishi Bhavan, NID, Diwan Ballubhai School. Eastern part of the city, through Sardar Bridge, would also use the station. Saurastra region bound GSRTC buses and private bus operators operate from the said location.




5. Madalpur	
Chainage	04+230
Inter-station Distance	839.6 m
Rail Level	62.000
Platform Height from Ground Lvl	14.590
Location	Located on the center line of Paldi Road
Entry / Exit stairs	Western entry exit structures are located flanking the road as per the proposed road section. Eastern stairs to station, planned in front of UCO Bank building.
Catchment Area	Mainly cater toMadalpur village area, VS Hospital & Medical College, part of Kocharab Ashram area, hotels & commercial buildings located along the Paldi Road. May extend till buildings located at Ellis bridge junction. Pritam Nagar, Gujarat College staff quarters, Jain Societies up to Netaji Nagar. Sabarmati Riverfront gate also falls in the catchment area.

6. Nava Gandhigram	
Chainage	04+983
Inter-station Distance	753.3 m
Rail Level	63.000
Platform Height from Ground Lvl	14.690
Location	Located on road median between Nehru Bridge crossing & Ellis Bridge crossing. Station building located in front of Capital Commercial Centre on east side of alignment.
Entry / Exit stairs	Western stairs planned within open space opposite BM Institute & Research Centre, whereas eastern structures in front of Bharat Petroleum Pump adjacent to Shalin Multi-storey building.
Catchment Area	Residential & commercial establishments as well as hotels located between Nehru Bridge and Elis Bridge would be catered by this station. Patang Hotel, Devanand Mall, Chinubhaicentre, Narayan chambers, Capital Commercial center, H.K. Commerce College, TOI Building falling under the catchment area. Station may also cater to nearby Gandhigram Railway Station. Eastern part of city using Ellisbridge would also be catered. Town hall and M. J. Library falls in the catchment area.



7. Ashram Road	
Chainage	06+417
Inter-station Distance	1433.9 m
Rail Level	70.350
Platform Height from Ground Lvl	20.040
Location	Located On The Center Verge Of Ashram Road, After Income Tax Circle. The Station Footprint Lies In Front of Sales India And Dhanlaxmi Bank On East Side of Alignment
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Major interchange between NS & EW MRTS corridor. Area between Income Tax junction & Times cross road will be benefitted from the station. It includes mainly Institutional areas likeAayakarBhawan, All India radio, Old High Court, RBI, Bharti House, Nirma House, Embassy Market, Popular House, Torrent Pharma, Dinesh Hall,Jivraj Chambers, NTC House, Popular House and Navrang Colony. May also cater to Mount Carmel School, HUDCO, C.U.Shah College, nearby Sports Club of Gujarat, Haridas Colony, Sakar III.



8. Usmanpura	
Chainage	07+233
Inter-station Distance	815.3 m
Rail Level	65.200
Platform Height from Ground Lvl	14.740
Location	On the median of Ashram road after Usmanpura crossing. Station located in front of AUDA Bhavan on east of alignment &VisanagarNagarik Bank on west if alignment
Entry / Exit stairs	Entry/exits along Ashram Road on flanking the road as per the proposed road section.
Catchment Area	Mainly cater to AMC west zone office & AUDA Bhavan, NABARD building, Institution buildings like Gujarat Vidyapith, Vidyanagar High School, Navgujarat College, Fortune Landmark Hotel. It will also cater to flats and bunglows located nearby Usmanpura crossing. Usmanpura Village, Narayan Nagar, Shanti Nagar, Ayodhya Nagar, Sumati Nagar and catchment may extend to Gokul Nagar, Shripal Nagar, Kailash Colony and Chandra Nagar.



9. Vadaj	
Chainage	08+366
Inter-station Distance	1133.1 m
Rail Level	64.000
Platform Height from Ground Lvl	14.990
Location	At JunaVadaj Crossing, Station footprint runs parallel to Vadaj AMTS station
Entry / Exit stairs	Located both side of station, Western structures within AMTS Vadaj Bus Terminus, Eastern entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	The station will connects to Vadaj AMTS terminal & BRTS station. Mainly cater to New Vadaj& Old Vadaj Village, Bhimajipura including Tilak Nagar, Parikhsit Nagar, Girdhar Park, Udhav Nagar, Subhash Nagar, Tulsi Nagar, Sindhu Nagar and may extend to part of Chandra Nagar &Riddhishwar Society. Gandhi Ashram also falls into the catchment area.



10. Ranip	
Chainage	10+059
Inter-station Distance	1693.6 m
Rail Level	66.000
Platform Height from Ground Lvl	14.490
Location	At junction of Radhaswami Road and 132' Ring Road, center line of station lies on the service road located at left side. Metro station partly runs parallel with Ranip BRTS station
Entry / Exit stairs	Western entry/exits planned adjacent to GSRTC bus stop and eastern stairs structures are located on flanking the road as per the proposed road section.
Catchment Area	Mainly cater to RTO building, Collector Office, Sabarmati Central Jail, Ambedkar Library, upcoming GSRTC bus station, Ranip BRTS station, Vyas wadi. It will also cater to residential buildings located on Radhaswami Road (Ranip road). This area is dense residential area.




11. Sabarmati Railway Station	
Chainage	11+102
Inter-station Distance	1042.6 m
Rail Level	64.000
Platform Height from Ground Lvl	14.390
Location	Near Subhash Bridge.
Entry / Exit stairs	Western approaches adjacent to Sabarmati Railway Stationand Chimanbhai Bridge.
Catchment Area	Mainly Caters to Sabarmati Railway Station along with surrounding AmbedkarNagar,KeshavNagar, Sabaramati Jail. The catchment area falls near north India bound private bus operators.



12. AEC	
Chainage	12+044
Inter-station Distance	941.7 m
Rail Level	66.700
Platform Height from Ground Lvl	14.490
Location	Near AEC Cross Road in front of Torrent Power House gate.
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	AEC Thermal Power Plant, Sabarmati Railway Station, AEC colony and societies located on the west side of alignment mainly includes Dharmanagar, Krishnanagar, Rathi building.



13. Sabarmati	
Chainage	13+403
Inter-station Distance	1359.3 m
Rail Level	69.500
Platform Height from Ground Lvl	14.390
Location	Opposite to Sabarmati Police Station, located on the service lane at right side of BRTS. Metro station is parallel to Sabamarti BRTS Station.
Entry / Exit stairs	On Eastern side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Mainly include residential and commercial area located on both side of Sabarmati RAmbica Nagar, Keshavbag Colony, Jain Nagar, Ram Nagar, municipal swimming pool. Station catchment area may extend to Visat and Railway Colony.

14. Motera Stadium	
Chainage	14+610
Inter-station Distance	1207.3 m
Rail Level	71.100
Platform Height from Ground Lvl	14.390
Location	Near Motera Stadium entry gate on the median of Stadium Road.
Entry / Exit stairs	Entry/exits along Stadium Road on flanking the road as per the proposed road section.
Catchment Area	Low rise to medium rise buildings located along Motera Stadium Road. Station mainly caters Bhawani Tenement, Sangath flats, Ishwarkrupa Society,Shantogram flats. It may further extend to areas around AsaramBapu Ashram Road and Motera Village.



Corridor II (East – West) : Thaltej to Vastral GAM	
1. ThaltejGaam	
Chainage	00+000
Inter-station Distance	-
Rail Level	61.500
Platform Height from Ground Lvl	17.999
Location	First station on the corridor, located on Thaltej – Shilaj road, opposite to Heritage Homes & Heritage Residency
Entry / Exit stairs	Entry exit stairs provided on the road adjacent to open Govt. plot.
Catchment Area	Residential building located along Thaltej-Shilaj Road. Mainly includes AadityaBunglows, ShubhBunglows, SuryadeepBunglow, Ravish Bunglow, Heritage Residency. There are number of party plots coming up in the catchment area. This line may extend to Ambali road railway station.



2. Thaltej	
Chainage	01+114
Inter-station Distance	1114.4 m
Rail Level	68.700
Platform Height from Ground Lvl	14.090
Location	Located opposite to Acropolis Mall on Thaltej-Ambali Road.
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Residential, commercial and religious properties located near by the station area. In addition to that, localities like, Bhaikaka Nagar, Hari Om park, Vasant Nature Cure, Commercial building located aroundThaltej Crossing on SG Highway.

3. Doordarshan Kendra	
Chainage	01+961
Inter-station Distance	846.7 m
Rail Level	65.600
Platform Height from Ground Lvl	14.020
Location	In front of Doordarshan Kendra building on Drive-in Road. Station building lies on the median of road after crossing SAL hospital cross road.
Entry / Exit stairs	Northern Structures in front of JJ tower along the road towards SAL hospital, southern stairs on open plot near Doordarshan Kendra.
Catchment Area	Commercial & Residential properties located around Drive-in Road, Goyal Intercity, Jai Ambe Nagar, Eskimo Enclave, Sagar flat, St. Kabir School, Drive-in Cinema, SAL Hospital,Country Inn Hotel, Surdhara Circle &Bodakdev area.



4. Gurukul Road	
Chainage	03+082
Inter-station Distance	1121.3 m
Rail Level	63.500
Platform Height from Ground Lvl	14.990
Location	On the median of Drive-in road after Gurukul cross road. Station located near to Swaminarayan Gurukul Temple.
Entry / Exit stairs	Northern entry/exits along the road in front of commercial offices whereas southern approaches located within the Agricultural Office premises.
Catchment Area	Residential and commercial areas located at Gurukul road. Himalaya Mall, Indraprasth Tower, Swaminarayan Gurukul and temple, SarkariVasahat, Sunrise park, BahumaaliBhawan, Sterling Hospital, Saumil society will get benefit from the station. Catchment area may extend up to SubhashChowk, Vastrapur lake, Alpha one mall



5. Gujarat University	
Chainage	03+989
Inter-station Distance	906.8 m
Rail Level	65.000
Platform Height from Ground Lvl	16.190
Location	Located after Helmet Junction infront of Adani CNG pump on the median of Drive in Road.
Entry / Exit stairs	Southern approaches located in front of open plot, north stairs to station, located in front of HK Arts & Commerce College grounds.
Catchment Area	Residential & Commercial properties located around Helmet junction, Hospitals and clinic at Helmet junction, Saurabh Society, Vadinath Nagar, NetraBunglows, Gujarat University Convention Hall, Gujarat University Sports complex, ManavMandir, University hostel & staff quarters. May extend to Memnagar Village. Station will also connect to BRTS station located at Helmet junction.



6. Commerce Six Road	
Chainage	05+054
Inter-station Distance	1064.6 m
Rail Level	62.700
Platform Height from Ground Lvl	14.740
Location	Located on Drive-in road between Vijay Cross Road and Commerce six road junctions.
Entry / Exit stairs	Located both side of station along the road, northern structures on space available in front of commercial building, and southern stairs near AMTS bus stop.
Catchment Area	Major Institutions (schools and colleges) located around University area, various Gujarat University Hostels & Departments, residential flats and societies located between Vijay Cross Road & Commerce Six Road. Part of Navarangpura area. May extend till Swastik cross Road, CG Road &Darpan Cross Road. Passengers from university area consisting of professional colleges, research centers & laboratories would also be benefitted from this station.

7. Stadium	
Chainage	05+946
Inter-station Distance	891.8 m
Rail Level	62.600
Platform Height from Ground Lvl	14.690
Location	Located on Sardar Patel Stadium Road towards Stadium Five Roads. Station footprint lies in front of Nidhi Hospital.
Entry / Exit stairs	One set of entry/exits would be provided on both sides of station. Northern entrances near Nidhi Hospital and southern stairs opposite to it.
Catchment Area	Station would cater to commercial areas & business centers along both sides of CG Road, areas around Sardar Patel Stadium five road intersections, Sports club of Gujarat, major part of residential & commercial properties located in Navrangpura area, Hindu Colony, Swastik Society, Nidhi Hospital, Samved Hospital.May extend to Nathalal Colony and Navrangpura village area.



8. Ashram Road	
Chainage	06+905
Inter-station Distance	959.4 m
Rail Level	62.100
Platform from Ground Lvl	14.490
Location	Interchange station for Corridor I & Corridor II. Station located between Sales India Cross Road and Sabarmati Riverfront. Station footprint lies in front of Embassy Market.
Entry / Exit stairs	One set of entry/exits would be provided on both sides of station.
Catchment Area	Office areas, business chambers & residential areas on both sides of Ashram Road. Also office buildings between Gandhi bridge junction & Times cross road will be benefitted from this station. EW&NS corridors intersect at this location resulting in to a combine passenger concourse to both the stations for interchange.

9. Shahpur- (UG)	
Chainage	08+124
Inter-station Distance	1219 m
Rail Level	34.500
Platform depth from Ground Lvl	13.910
Location	Located in eastern Ahmedabad on the median of Kasturba Gandhi Road. Station is planned after crossing ShahpurDarwaza. This road straight connects to Gandhi Bridge. Station footprint passes through low rise shops (Jawagar sawmill, Mahalaxmi works) and HyanYagn Girls Higher Secondary School
Entry / Exit stairs	Located both side of station, northern structures in space available near some shops adjacent to Shahpur tutorial girls high school whereas southern stairs located near space available to vyayamvidyalaya.
Catchment Area	Mainly to old dense 'Pol' areas of Shahpur, Shah Colony, Kalal Nagar, Kiran Nagar, Shakti Nagar, & may also cater to various societies & Residential areas along Sabarmati River front on both side of Gandhi Bridge & part of Khanpur Area.




10. Gheekanta (U/G)	
Chainage	09+624
Inter-station Distance	1500.3 m
Rail Level	28.000
Platform depth from Ground Lvl	22.110
Location	Near cross road of Gheekanta road and relief road.
Entry / Exit stairs	One of the Entry/Exit Provided near old court premises, whereas another near relief road.
Catchment Area	Mainly to Advani market, Madhupura market, Hasumati estate, Haziapura Garden and areas up to Jehangir Textile mill, Govt. press, Bansidhar Mills. The catchment of station may extend up to Cama commercial centre, Krishna complex, Teen Darwaja, Jumma Masjid, Mirzapur, Ghee Kanta area and Gandhi Road.



11. Kalupur Railway Station (U/G)	
Chainage	11+779
Inter-station Distance	2155 m
Rail Level	37.500
Platform depth from Ground Lvl	13.210
Location	Located on the Eastern sideof Kalupur Railway Station in Saraspur area. Station footprint passes through station parking area and Saraspur ITI area.
Entry / Exit stairs	Entry Exit is provided inside abandoned R. C. technical college area and near parking of Kalupur station.
Catchment Area	Mainly passengers interchanging from Ahmedabad Junction to this station. Residential area around station and would extend to Kalupur, Khadia, Sarangpur, Raipur up to Kankaria, Raikhad, Jamalpur part of Dariyapur, ManekChowk, Ghee Kata Area & Commercial areas of Kapasia Bazar, Dhanlaxmi Market, Hari Om Market, Revdi Bazar &Sakar Bazar, whereas on the eastern side of existing station Gomatipur Village, Saraspur, ShaherKotda, and Sahjanand Arcade. Major interchange of proposed Regional, (Sub urban), Metro & Long distance passenger trains.



12. Kankaria East (U/G)	
Chainage	13+097
Inter-station Distance	1317.5 m
Rail Level	33.000
Platform depth from Ground Lvl	14.510
Location	Near Rajpur-Gomtipur road.
Entry / Exit stairs	Entry Exit provided on open space available near St. Joshep High School.
Catchment Area	Mainly Caters to Rajpur and Gomtipur area.



13. Apparel Park	
Chainage	14+381
Inter-station Distance	1284.2 m
Rail Level	58.722
Platform Height from Ground Lvl	12.262
Location	Proposed in open land of Sarangpur Cotton Mill on Amaraiwadi Road. It is located besides GIDC Apparel Park.
Entry / Exit stairs	Entry /Exit provided opposite apparel park on the open area near cross road.
Catchment Area	Industries located in Apparel Park, Ashima Textile Mills & other industries located around. Small rise residential and commercial development at Vikas Nagar, Janata Nagar, Anupam Theatre, Sukharamnagar.

14. Amaraiwadi	
Chainage	15+783
Inter-station Distance	1402 m
Rail Level	60.500
Platform Height from Ground Lvl	14.690
Location	On the central edge of Amaraiwadi Road, after intersection with LalBahadurShashtri Road (Swastik Cross Road).
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Flats, tenements & small scale industries located around station. Ashapuri Nagar, Narsinh Nagar, Jay Bhawani Nagar, Chamunda Nagar, part of Hatkeshwar&Rakhiyal area. May extend to Hatkeshwar Circle.



15. Rabari Colony	
Chainage	16+611
Inter-station Distance	828.2 m
Rail Level	61.200
Platform Height from Ground Lvl	14.590
Location	On the median of Vastral Road, in front of Rabari Colony Gate no. 3. It is planned before Ram Rajya Nagar Cross Road on Narol – Naroda Highway.
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	It is well connected to Rabari Colony BRTS Station. Small scale industries and residential flats & societies located along Vastral Road. Residents of Rabari Colony, located on side of north alignment will be benefitted from station. Narayan nagar society, viral apartment, shiv nagar society.



16. Vastral	
Chainage	18+129
Inter-station Distance	1517.5 m
Rail Level	69.500
Platform Height from Ground Lvl	14.940
Location	Located on Vastral Road after crossing canal. Station footprint lies in front of Marutinandan society
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Residential flats & tenements, school, complexes located in Vastral. Devikrupa Society, Ashirwad Society, Mahadev Nagar society, Kameshwar Park, Dhananjay park, May extend to Arbuda Nagar.

17. NirantCorss Road	
Chainage	19+050
Inter-station Distance	921.5 m
Rail Level	66.740
Platform Height from Ground Lvl	15.330
Location	Located after Nirant Cross Road. Station footprint lies in front of Kankubag party plot at south side of alignment and SwapnaSrushti society at north side of alignment.
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Societies & commercial areas located along road. Tejendra park, Shiv Sukhnagar, Karnavati Homes, Sundarwan Tenement.

18. Vastral Gam	
Chainage	19+721
Inter-station Distance	671.2 m
Rail Level	64.600
Platform Height from Ground Lvl	13.990
Location	Located on Vastral Road before crossing S.P. Ring Road (Vastral Cross Road). Station lies towards Push Residency.
Entry / Exit stairs	On either side the entry exit structures are located on flanking the road as per the proposed road section.
Catchment Area	Vastral Gam, Ratanpura Gam, Commercial, Industrial &major upcoming Residential properties located around Vastral Cross Road.



6.3 PLANNING AND DESIGN CRITERIA FOR STATIONS

Salient features of a typical station are as follows:

1. The stations can be divided into public and non-public areas (those areas where access is restricted). The public areas can be further subdivided into paid and unpaid areas.
2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
3. The platform level at elevated stations is determined by a critical clearance of 5.50 m under the concourse and above the road intersection, allowing 3.00 m for the concourse height, about 2-m for concourse floor and 2.00 m for structure of tracks above the concourse. Further, the platforms are 1.09 m above the tracks. This would make the platforms in an elevated situation at least 14.0 m above ground.
4. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.
5. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.
6. Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.
7. Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS.
8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station.
9. Tunnel Ventilation fans and ASS in underground stations are provided at platform level/ concourse level depending on availability of land for locating vent shafts.
10. The DG set, bore well pump houses and ground tank would be located generally in one area on ground.
11. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:
    - Minimum distance of travel to and from the platform and between platforms for transfer between lines.
    - Adequate capacity for passenger movements.
    - Convenience, including good signage relating to circulation and orientation.
    - Safety and security, including a high level of protection against accidents.

12. Following requirements have been taken into account:
    - Minimum capital cost is incurred consistent with maximizing passenger attraction.
    - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    - Flexibility of operation including the ability to adapt to different traffic conditions changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.
    - Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
    - Provision of display of passenger information and advertising.
13. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions.
14. In order to transfer passengers efficiently from street to platforms and vice versa, station planning has been based on established principles of pedestrian flow and arranged to minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers.
15. Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

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

Non Public Area – Station Accomodation	
Station Control Room	Cash & Ticket Room
Platform Supervisor's Booth	Fire Tank & Petrol Pump
Station Master's Office	Staff Area
Traction Substation	UPS and Battery Room
Information & Enquiries	Cleaner's Room
Signaling Room	Security Room
Ticket Office	Staff Toilets
Communication Room	Refuse Store
Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	Miscellaneous Operations Room
Station Substation	First Aid Room

6.4 CHARACTERISTICS OF TYPICAL ELEVATED STATION

The station is generally located on the road median, is ~140-m long and is a three level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS & Battery Room, Signaling Room, Train Crew Room & Supervisor's Office, Security Room, Station Store Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid zone, after accommodating passenger movement and other station facilities is earmarked for commercial utilization.

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

a. Station can be made as narrow as 18-19 m, as equipment rooms can be placed along the length of concourse. This station prototype therefore is suitable for narrow streets.
b. Since the station is narrow, it is possible to make it a cantilever structure supported on a single column, leaving the road underneath more flexible for present use as well as future expansion.
c. Construction is easier, less barricading and infringement with utilities
d. More opportunities for locating entrances as the station has along surface area for articulating with surroundings, even at the ends, where skywalks can connect the station to street or adjoining properties
e. Long concourse provides opportunities for locating retail outlets along the movement path within the station

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

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

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

Chapter - 7

Train Operation Plan

Chapter – 7

TRAIN OPERATION PLAN & MAINTENANCE FACILITIES

7.1 OPERATION PHILOSOPHY

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

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- A short train consists of 3 coaches.
- Multi-tasking of train operation and maintenance staff.

7.2 STATIONS

List of stations for the two Corridors of Ahmedabad Metro are given below:

NORTH-SOUTH CORRIDOR				
S. No	**Name of Station**	**Chainage (in m)**	**Inter – Station Distance (in m)**	
	DEAD END	**-405.0**		
1	APMC	0.0	405.0	Elevated
2	VASNA	1114.8	1114.8	Elevated
3	ANJALI	1959.5	844.7	Elevated
4	PALDI	3390.5	1431.0	Elevated
5	MADALPUR	4230.1	839.6	Elevated
6	NAVA GANDHIGRAM	4983.4	753.3	Elevated
7	ASHRAM ROAD	6417.3	1433.9	Elevated
8	USMANPURA	7232.6	815.3	Elevated
9	VADAJ	8365.7	1133.1	Elevated
10	RANIP	10059.3	1693.6	Elevated
11	SABARMATI RLY. STATION	11101.9	1042.6	Elevated
12	AEC	12043.6	941.7	Elevated

NORTH-SOUTH CORRIDOR				
S. No	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	
13	SABARMATI	13402.9	1359.3	Elevated
14	MOTERA STADIUM	14610.2	1207.3	Elevated
	DEAD END	15015.3	405.0	

EAST-WEST CORRIDOR				
S. No	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	Station Type
	DEAD END	-405.0		
1	THALTEJ GAM	0.0	405.0	Elevated
2	THALTEJ	1114.4	1114.4	Elevated
3	DOORDARSHAN KENDRA	1961.1	846.7	Elevated
4	GURUKUL ROAD	3082.4	1121.3	Elevated
5	GUJARAT UNIVERSITY	3966.8	884.4	Elevated
6	COMMERCE SIX ROAD	5053.8	1087.0	Elevated
7	STADIUM	5945.6	891.8	Elevated
8	ASHRAM ROAD	6905.0	959.4	Elevated
9	SHAHPUR	8124.0	1219.0	Underground
10	GHEE KANTA	9624.3	1500.3	Underground
11	KALUPUR RLY.STATION	11779.3	2155.0	Underground
12	KANKARIA EAST	13096.8	1317.5	Underground
13	APPAREL PARK	14381.0	1284.2	Elevated
14	AMRAIWADI	15783.0	1402.0	Elevated
15	RABARI COLONY	16611.2	828.2	Elevated
16	VASTRAL	18128.7	1517.5	Elevated
17	NIRANT CROSS ROAD	19050.2	921.5	Elevated
18	VASTRAL GAM	19721.4	671.2	Elevated
	DEAD END	20126.5	405.0	

7.3 TRAIN OPERATION PLAN

7.3.1 Salient Features

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,

- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for these corridors has been assumed as:

North- South Corridor

- APMC to Motera Stadium: 32 kmph
- Madalpur to Motera Stadium: 32 kmph

East-West Corridor

- Thaltej Gam to Vastral Gam: 33 kmph
- Ashram Road to Apparel Park: 37 kmph

7.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the North- South Corridor & East-West Corridor for the year 2018, 2021, 2031 and 2043 for the purpose of planning are indicated in Attachment I/A1, B1, C1 & D1 and Attachment I/A2, B2, C2 & D2 respectively.

7.3.3 Train formation

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

Based on traffic projections, requirement of 3-car trains (2.9 m wide cars) is envisaged even in the Year 2043 for this project. With view to achieve standardization of modern metro rolling stock in India, DMRC has been recommending 2.9 meter wide stock for all medium size metros. Accordingly, 2.9 meter wide stock has been planned for Ahmedabad Metro. Considering that Ahmedabad metro is not a heavy metro, providing 3.2 meter wide rolling stock will not be a cost effective solution and would result in higher axle weight with consequent increased infrastructure cost and also higher energy consumption. Though, use of 3.2 meter wide cars, lesser rakes would be required to cater to traffic demand during peak hour but however, headway will increase further and is not advisable for metro train operations.

Composition

DMC : Driving Motor Car
TC : Trailer Car

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

Driving Motor Car (DMC) - 247 (43 seated + 204 standing)
Trailer Car (TC) - 270 (50 seated + 220 standing)
3 Car Train - 764 (136 seated + 628 standing)

7.3.4 Train Operation Plan

Based on the projected PHPDT demand, Train operation plan with train carrying capacity @ 6 persons per square meter of standee area for the North-South Corridor & East West Corridor for the year 2018, 2021, 2031, 2043 are given below:

7.3.4.1 North –South Corridor

Train Operation Plan for North-South Corridor has been planned in such a way that there are two loops of train operation. In one loop, trains run from 'APMC to Motera Stadium' at a given headway and in other loop trains run from 'Madalpur to Motera Stadium' at the same headway, thus resulting in half the headway in 'Madalpur to Motera Stadium' Section as compared to 'APMC to Madalpur' Section.

For this Train Operation Plan, reversal facility is required at Madalpur.

i) Year 2018:

Train operation in 'APMC to Motera Stadium' Loop at 12 min headway with 3-Car train and in 'Madalpur to Motera Stadium' Loop at 12 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Madalpur to Motera Stadium' Section (Refer Attachment I/A1)

- 6 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7640 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 9730 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 8476 is in the Section between Vadaj to Ranip and demand in the remaining sections is in the range of 8286 to 4548 only. The planned capacity of 7640 (9730 under dense loading) is less than the PHPDT demand in four (zero, with dense loading capacity) sections out of nine sections.

(b) 'APMC to Madalpur' Section (Refer Attachment I/A1)

- 12 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 3820 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 4865 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 3335 is in the Section between Paldi to Madalpur and demand in the remaining sections is in the range of 2564 to 1468 only. The planned capacity of 3820 (4865 under dense loading) is more than the PHPDT demand in four sections.

Traffic demand and train capacity for this corridor is the year 2018 is tabulated and represented on a chart enclosed as Attachment I/A1.

ii) Year 2021:

Train operation in 'APMC to Motera Stadium' Loop at 8 min headway with 3-Car train and in 'Madalpur to Motera Stadium' Loop at 8 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Madalpur to Motera Stadium' Section (Refer Attachment I/B1)

- 4 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 11460 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 14596 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 12097 is in the Section between Vadaj to Ranip and demand in the remaining sections is in the range of 11964 to 6189 only. The planned capacity of 11460 (14596 under dense loading) is less than the PHPDT demand in three (zero, with dense loading capacity) sections out of nine sections.

(b) 'APMC to Madalpur' Section (Refer Attachment I/B1)

- 8 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 5730 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 7298 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 4576 is in the Section between Paldi to Madalpur and demand in the remaining sections is in the range of 3715 to 1831 only. The planned capacity of 5730 (7298 under dense loading) is more than the PHPDT demand in four sections.

Traffic demand and train capacity for this corridor is the year 2021 is tabulated and represented on a chart enclosed as Attachment I/B1.

iii) Year 2031:

Train operation in 'APMC to Motera Stadium' Loop at 6 min headway with 3-Car train and in 'Madalpur to Motera Stadium' Loop at 6 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Madalpur to Motera Stadium' Section (Refer Attachment I/C1)

- 3 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 15280 @ 6 persons per square meter of standee area

- Available Peak Hour Peak Direction Capacity of 19460 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 17778 is in the Section between Vadaj to Ranip and demand in the remaining sections is in the range of 16735 to 8872 only. The planned capacity of 15280 (19460 under dense loading) is less than the PHPDT demand in six (zero, with dense loading capacity) sections out of nine sections.

(b) 'APMC to Madalpur' Section (Refer Attachment I/C1)

- 6 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7640 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 9730 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 6685 is in the Section between Paldi to Madalpur and demand in the remaining sections is in the range of 5050 to 2490 only. The planned capacity of 7640 (9730 under dense loading) is more than the PHPDT demand in four sections.

Traffic demand and train capacity for this corridor in the year 2031 is tabulated and represented on a chart enclosed as Attachment I/C1.

iv) Year 2043:

Train operation in 'APMC to Motera Stadium' Loop at 4 min headway with 3-Car train and in 'Madalpur to Motera Stadium' Loop at 4 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Madalpur to Motera Stadium' Section (Refer Attachment I/D1)

- 2 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 22920 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 29190 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 26484 is in the Section between Vadaj to Ranip and demand in the remaining sections is in the range of 25506 to 11161 only. The planned capacity of 22920 (29190 under dense loading) is less than the PHPDT demand in five (zero, with dense loading capacity) sections out of nine sections.

(b) 'APMC to Madalpur' Section (Refer Attachment I/D1)

- 4 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 11460 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 14595 @ 8 persons per square meter of standee area under dense loading conditions.

- The maximum PHPDT demand of 8532 is in the Section between Paldi to Madalpur and demand in the remaining sections is in the range of 6833 to 3248 only. The planned capacity of 11460 (14595 under dense loading) is more than the PHPDT demand in four sections.

Traffic demand and train capacity for this corridor in the year 2043 is tabulated and represented on a chart enclosed as Attachment I/D1.

7.3.4.2 East –West Corridor

Train Operation Plan for East-west Corridor has been planned in such a way that there are two loops of train operation. In one loop, trains run from 'Thaltej Gam to Vastral Gam' at a given headway and in other loop trains run from 'Ashram Road to Apparel Park' at the same headway, thus resulting in half the headway in 'Ashram Road to Apparel Park' Section as compared to 'Thaltej Gam to Ashram Road' Section & 'Apparel Park to Vastral Gam' Section.

For this Train Operation Plan, reversal facilities are required at Ashram Road and Apparel Park.

i) Year 2018:

Train operation in 'Thaltej Gam to Vastral Gam' Loop at 8.5 min headway with 3-Car train and in 'Ashram Road to Apparel Park' Loop at 8.5 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section (Refer Attachment I/A2)

- 8.5 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 5393 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 6868 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 6797 is in the Section between Stadium to Ashram Road and demand in the remaining sections is in the range of 6120 to 456 only. The planned capacity of 5393 (6868 under dense loading) is less than the PHPDT demand in three (zero, with dense loading capacity) out of twelve sections of 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section.

(b) 'Ashram Road to Apparel Park' Section (Refer Attachment I/A2)

- 4.25 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 10786 @ 6 persons per square meter of standee area

- Available Peak Hour Peak Direction Capacity of 13736 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 10593 is in the Section Ghee Kanta and Kalupur Rly. Station and demand in the remaining sections is in the range of 10183 to 5624 only. The planned capacity of 10786 (13736 under dense loading) is more than the PHPDT demand five sections of 'Ashram Road to Apparel Park' Section.

Traffic demand and train capacity for this corridor in the year 2018 is tabulated and represented on a chart enclosed as Attachment I/A2.

ii) Year 2021:

Train operation in 'Thaltej Gam to Vastral Gam' Loop at <u>6 min</u> headway with <u>3-Car</u> train and in 'Ashram Road to Apparel Park' Loop at <u>6 min</u> headway with <u>3-Car</u> train. This results in following train operation in different section:

(a) 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section (Refer Attachment I/B2)

- 6 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7640 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 9730 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 9202 is in the Section between Stadium to Ashram Road and demand in the remaining sections is in the range of 8369 to 1068 only. The planned capacity of 7640 (9730 under dense loading) is less than the PHPDT demand in three (zero, with dense loading capacity) out of twelve sections of 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section.

(b) 'Ashram Road to Apparel Park' Section (Refer Attachment I/B2)

- 3 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 15280 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 19460 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 15659 is in the Section Ghee Kanta and Kalupur Rly. Station and demand in the remaining sections is in the range of 15479 to 7878 only. The planned capacity of 15280 (19460 under dense loading) is more than the PHPDT demand five sections of 'Ashram Road to Apparel Park' Section.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/B2.

iii) Year 2031:

Train operation in 'Thaltej Gam to Vastral Gam' Loop at 4 min headway with 3-Car train and in 'Ashram Road to Apparel Park' Loop at 4 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section (Refer Attachment I/C2)

- 4 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 11460 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 14595 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 13249 is in the Section between Stadium to Ashram Road and demand in the remaining sections is in the range of 12284 to 2154 only. The planned capacity of 11460 (14595 under dense loading) is less than the PHPDT demand in three (zero, with dense loading capacity) out of twelve sections of 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section.

(b) 'Ashram Road to Apparel Park' Section (Refer Attachment I/C2)

- 2 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 22920 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 29190 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 19251 is in the Section Ghee Kanta and Kalupur Rly. Station and demand in the remaining sections is in the range of 18678 to 11476 only. The planned capacity of 22920 (29190 under dense loading) is more than the PHPDT demand five sections of 'Ashram Road to Apparel Park' Section.

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Traffic demand and train capacity for this corridor in the year 2031 is tabulated and represented on a chart enclosed as Attachment I/C2.

iv) Year 2043:

Train operation in 'Thaltej Gam to Vastral Gam' Loop at 4 min headway with 3-Car train and in 'Ashram Road to Apparel Park' Loop at 4 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section (Refer Attachment I/D2)

- 4 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 11460 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 14595 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 15609 is in the Section between Stadium to Ashram Road and demand in the remaining sections is in the range of 14596 to 3388 only. The planned capacity of 11460 (14595 under dense loading) is less than the PHPDT demand in four (two, with dense loading capacity) out of twelve sections of 'Thaltej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' Section.

(b) 'Ashram Road to Apparel Park' Section (Refer Attachment I/D2)

- 2 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 22920 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 29190 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 22944 is in the Section Ghee Kanta and Kalupur Rly. Station and demand in the remaining sections is in the range of 22183 to 13922 only. The planned capacity of 22920 (29190 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) out of five sections of 'Ashram Road to Apparel Park' Section.

Traffic demand and train capacity for this corridor in the year 2043 is tabulated and represented on a chart enclosed as Attachment I/D2.

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

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

Capacity Provided for North- South Corridor

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
APMC to Madalpur	2018	12	12 Rakes of 3-car	3-car	36	3335	3820 (4865*)
Madalpur to Motera Stadium		6		3-car		8476	7640 (9730*)
APMC to Madalpur	2021	8	17 Rakes of 3-car	3-car	51	4576	5730 (7298*)
Madalpur to Motera Stadium		4		3-car		12097	11460 (14596*)
APMC to Madalpur	2031	6	22 Rakes of 3-car	3-car	66	6685	7640 (9730*)
Madalpur to Motera Stadium		3		3-car		17778	15280 (19460*)
APMC to Madalpur	2043	4	32 Rakes of 3-car	3-car	96	8532	11460 (14595*)
Madalpur to Motera Stadium		2		3-car		26484	22920 (29190*)

* @ 8 persons per square meter of standee area

Capacity Provided for East-West Corridor

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Thaltej Gam to Ashram Road	2018	8.5	17 Rakes of 3-car	3-car	51	6797	5393 (6868*)
Ashram Road to Apparel Park		4.25		3-car		10593	10786 (13736*)
Apparel Park to Vastral Gam		8.5		3-car		4303	5393 (6868*)
Thaltej Gam to Ashram Road	2021	6		3-car	66	9202	7640

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
							(9730*)
Ashram Road to Apparel Park		3	22 Rakes of 3-car	3-car		15659	15280
							(19460*)
Apparel Park to Vastral Gam		6		3-car		6287	7640 (9730*)
Thaltej Gam to Ashram Road	2031	4	32 Rakes of 3-car	3-car	96	13249	11460 (14595*)
Ashram Road to Apparel Park		2		3-car		19251	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		9629	11460 (14595*)
Thaltej Gam to Ashram Road	2043	4	32 Rakes of 3-car	3-car	96	15609	11460 (14595*)
Ashram Road to Apparel Park		2		3-car		22944	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		12135	11460 (14595*)

*@ 8 persons per square meter of standee area

7.3.5 Train frequency

North- South Corridor

Sections	2018		2021		2031		2043	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Madalpur to Motera Stadium	6 min	10 to 30 min	4 min	6 to 20 min	3 min	5 to 15 min	2 min	3 to 10 min
APMC to Madalpur	12 min	20 to 60 min	8 min	12 to 40 min	6 min	10 to 30 min	4 min	6 to 20 min

East-West Corridor

Sections	2018		2021		2031		2043	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Thaltej Gam to Ashram Road	8.5 min	12 to 40 min	6 min	10 to 30 min	4 min	6 to 20 min	4 min	6 to 20 min
Ashram Road to Apparel Park	4.25 min	6 to 20 min	3 min	5 to 15 min	2 min	3 to 10 min	2 min	3 to 10 min
Apparel Park to Vastral Gam	8.5 min	12 to 40 min	6 min	10 to 30 min	4 min	6 to 20 min	4 min	6 to 20 min

No services are proposed between 00.00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

7.3.6 Hourly Train Operation plan

The hourly distribution of daily transport capacity is presented in **Table 1.1A, 1.1B, 1.2A, 1.2B, 1.3A, 1.3B, 1.4A & 1.4B** for 'Madalpur to Motera Stadium' Section and 'APMC to Madalpur' Section (North- South Corridor) and **Table 1.5A, 1.5B, 1.5C, 1.6A, 1.6B, 1.6C, 1.7A, 1.7B, 1.7C, 1.8A, 1.8B & 1.8C** for 'Thaltej Gam to Ashram Road' Section, 'Ashram Road to Apparel Park' Section and 'Apparel Park to Vastral Gam' Section (East- West Corridor) respectively for years 2018, 2021, 2031 & 2043 and enclosed as **Attachment II.**

Number of train trips per direction per day for 'Madalpur to Motera Stadium' Section and 'APMC to Madalpur' Section (North- South Corridor) is worked out as 108 & 54 in the year 2018, 168 & 84 in the year 2021 and 216 & 108 in the year 2031, 336 & 168 in the year 2043 respectively. Number of train trips per directions per day for 'Thaltej Gam to Ashram Road' Section, 'Ashram Road to Apparel Park' Section and 'Apparel Park to Vastral Gam' Section (East- West Corridor) is worked out as 82,164 & 82 in the year 2018, 108, 216 & 108 in the year 2021 and 168, 336 & 168 in the year 2031, 168, 336 & 168 in the year 2043 respectively. The directional splits for North- South Corridor and East- West Corridor is presented in **Table 2.1 and 2.2** enclosed as **Attachment III.**

7.3.7 Vehicle Kilometer

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Ahmedabad Metro Rail Project is given in **Table 3.1** for North-South corridor and **Table 3.2** for East-West Corridor enclosed as **Attachment IV.**

7.4 YEAR WISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as **Attachment V.**

Requirements of coaches is calculated based on following assumptions-

Assumptions –

(i) Train Composition planned as under

3 car Train Composition	: DMC +TC +DMC
Train Carrying Capacity of 3 Car Train (@6 passengers per square meter of standee area)	: 764 passengers @6 standee/sqm

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

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

(iv) Repair and maintenance reserve has been estimated as 8 % of total requirement.

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

(vi) Schedule speed is taken as:

North-South Corridor
- 'APMC to Motera Stadium' Section: 32 kmph
- 'Madalpur to Motera Stadium' Section: 32 kmph

East-West Corridor
- 'Thaltej Gam to Vastral Gam' Section: 33 kmph
- 'Ashram Road to Apparel Park' Section: 37 kmph

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

SUMMARY SHEET (Feb'2014)
AHMEDABAD METRO RAIL PROJECT

1) Corridors:

i) North-South Corridor (APMC- Madalpur- Motera Stadium)

(Train Operation Plan for North-South Corridor has been planned in such a way that there are two loops of train operation. In one loop, trains run from 'APMC to Motera Stadium' at a given headway and in other loop trains run from 'Madalpur to Motera Stadium' at the same headway, thus resulting in half the headway in 'Madalpur to Motera Stadium' Section as compared to 'APMC to Madalpur' Section).

For this Train Operation Plan, reversal facility is required at Madalpur.

ii) East-West Corridor (Thaltej Gam- Ashram Road- Apparel Park- Vastral Gam)

(Train Operation Plan for East-west Corridor has been planned in such a way that there are two loops of train operation. In one loop, trains run from 'Thaltej Gam to Vastral Gam' at a given headway and in other loop trains run from 'Ashram Road to Apparel Park' at the same headway, thus resulting in half the headway in 'Ashram Road to Apparel Park' Section as compared to 'Thaltej Gam to Ashram Road' Section & 'Apparel Park to Vastral Gam' Section).

For this Train Operation Plan, reversal facilities are required at Ashram Road and Apparel Park.

2) Route Length (Centre to Centre):

i) North-South Corridor:

a) APMC to Motera Stadium: 14.61 km
b) Madalpur to Motera Stadium: 10.38 km

ii) East-West Corridor:

a) Thaltej Gam to Vastral Gam: 19.72 km
b) Ashram Road to Apparel Park: 7.48 km

3) Average Interstation Distance:

i) North-South Corridor:

a) APMC to Motera Stadium: 1.12 km
b) Madalpur to Motera Stadium: 1.15 km

ii) East-West Corridor:

a) Thaltej Gam to Vastral Gam: 1.16 km
b) Ashram Road to Apparel Park: 1.49 km

4) Number of Stations:

i) North-South Corridor: 14

a) APMC to Madalpur: 05
b) Madalpur to Motera Stadium: 09 (Excluding Madalpur)

ii) East-West Corridor: 18

a) Thaltej Gam – Ashram Road: 08
b) Ashram Road – Apparel Park: 05(Excluding Ashram Road)
c) Apparel Park – Vastral Gam: 05(Excluding Apparel Park)

5) Gauge: 1435 mm

6) Traction Power Supply

i) Voltage: 750 V dc
ii) Current Collection: Third Rail Bottom Current Collection system

7) Rolling Stock:

i) Coach Size:

Particular	***Length****	***Width***	***Height***
Driving Motor Car (DMC)	21.64m	2.9 m	3.9 m
Trailer Car (TC)	21.34 m	2.9 m	3.9 m

** Maximum length Coach over coupler/buffers = 22.6 m*

ii) Passenger Carrying Capacity (Crush @ 6 passenger/sqm of standee area)

PARTICULAR	***SEATED***	***STANDING***	***TOTAL***
DMC	43	204	247
TC	50	220	270
3-CAR	136	628	764

Seating: Longitudinal

iii) **Passenger Carrying Capacity (Crush @ 8 passenger/sqm of standee area)**

PARTICULAR	*SEATED*	*STANDING*	*TOTAL*
DMC	43	272	315
TC	50	293	343
3-CAR	136	837	973

Seating: Longitudinal

iv) **Weight(T) (Crush @ 6 passenger/sqm of standee area)**

PARTICULAR	*TARE*	*PASSENGER*	*GROSS*
DMC	40	16.055	56.055
TC	40	17.55	57.55
3-CAR	120	49.66	169.66

v) Axle Load: To be designed for 16T

vi) Max Acceleration: 1.0 m/s^2 (with AW3 load)

vii) Max Deceleration: 1.1 m/s^2 (Normal Brake)

>1.3 m/s^2 (Emergency Brake)

viii) Maximum Design Speed: 90 kmph

ix) Maximum Operating Speed: 80 kmph

x) Schedule Speed:

a. North-South Corridor:

- APMC to Motera Stadium: 32 kmph
- Madalpur to Motera Stadium: 32 kmph

b. East- West Corridor:

- Thaltej Gam to Vastral Gam: 33 kmph
- Ashram Road to Apparel Park: 37 kmph

xi) Composition: 3-car = DMC+TC+DMC

xii) Cost per car: Rs. 9.8 Crores exclusive of taxes and duties at Jan' 2014 Price Level.

xiii) Capacity Provided & Rake Requirement:

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Capacity Provided for North- South Corridor							
APMC to Madalpur	2018	12		3-car		3335	3820 (4865*)
Madalpur to Motera Stadium		6	12 Rakes of 3-car	3-car	36	8476	7640 (9730*)
APMC to Madalpur	2021	8		3-car		4576	5730 (7298*)
Madalpur to Motera Stadium		4	17 Rakes of 3-car	3-car	51	12097	11460 (14596*)
APMC to Madalpur	2031	6		3-car		6685	7640 (9730*)
Madalpur to Motera Stadium		3	22 Rakes of 3-car	3-car	66	17778	15280 (19460*)
APMC to Madalpur	2043	4	32 Rakes of 3-car	3-car		8532	11460 (14595*)
Madalpur to Motera Stadium		2		3-car	96	26484	22920 (29190*)
Capacity Provided for East-West Corridor							
Thaltej Gam to Ashram Road	2018	8.5		3-car	51	6797	5393 (6868*)
Ashram Road to Apparel Park		4.25	17 Rakes of 3-car	3-car		10593	10786 (13736*)
Apparel Park to Vastral Gam		8.5		3-car		4303	5393 (6868*)
Thaltej Gam to Ashram Road	2021	6		3-car	66	9202	7640 (9730*)
Ashram Road to Apparel Park		3	22 Rakes of 3-car	3-car		15659	15280 (19460*)
Apparel Park to Vastral Gam		6		3-car		6287	7640 (9730*)
Thaltej Gam to Ashram Road	2031	4		3-car	96	13249	11460 (14595*)
Ashram Road to Apparel Park		2	32 Rakes of 3-car	3-car		19251	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		9629	11460 (14595*)
Thaltej Gam to Ashram Road	2043	4		3-car	96	15609	11460 (14595*)
Ashram Road to Apparel Park		2	32 Rakes of 3-car	3-car		22944	22920 (29190*)
Apparel Park to Vastral Gam		4		3-car		12135	11460 (14595*)

Attachment - I/A1

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
North - South Corridor

Year:	2018	
No. of Cars per Train:	3	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	973	
Headway (min)	12	(In 'APMC to Madalpur' Section)
Headway (min)	6	(In 'Madalpur to Motera Stadium' Section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	APMC	VASNA	1468	3820	4865
2	VASNA	ANJALI	2088	3820	4865
3	ANJALI	PALDI	2564	3820	4865
4	PALDI	MADALPUR	3335	3820	4865
5	MADALPUR	NAVA GANDHIGRAM	4548	7640	9730
6	NAVA GANDHIGRAM	ASHRAM ROAD	5359	7640	9730
7	ASHRAM ROAD	USMANPURA	7721	7640	9730
8	USMANPURA	VADAJ	8286	7640	9730
9	VADAJ	RANIP	**8476**	7640	9730
10	RANIP	SABARMATI RLY. STATION	7772	7640	9730
11	SABARMATI RLY. STATION	AEC	7411	7640	9730
12	AEC	SABARMATI	7266	7640	9730
13	SABARMATI	MOTERA STADIUM	7085	7640	9730

Note: Reversal facility required at Madalpur.

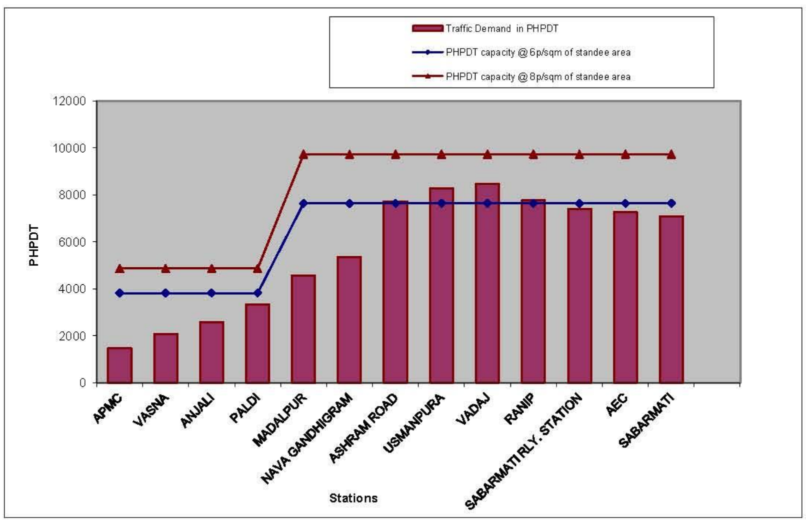


Fig 1.1

Attachment - I/A2

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
East - West Corridor

Year:	2018	
No. of Cars per Train:	3	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	973	
Headway (min)	4.25	(In 'Ashram Road to Apparel Park' Section)
Headway (min)	8.5	(In 'Thal Tej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	THALTEJ GAM	THALTEJ	1130	5393	6868
2	THALTEJ	DOORDARSHAN KENDRA	2185	5393	6868
3	DOORDARSHAN KENDRA	GURUKUL ROAD	3056	5393	6868
4	GURUKUL ROAD	GUJARAT UNIVERSITY	4212	5393	6868
5	GUJARAT UNIVERSITY	COMMERCE SIX ROAD	5678	5393	6868
6	COMMERCE SIX ROAD	STADIUM	6120	5393	6868
7	STADIUM	ASHRAM ROAD	6797	5393	6868
8	ASHRAM ROAD	SHAHPUR	9870	10786	13736
9	SHAHPUR	GHEE KANTA	10183	10786	13736
10	GHEE KANTA	KALUPUR RLY.STATION	10593	10786	13736
11	KALUPUR RLY.STATION	KANKARIA EAST	6543	10786	13736
12	KANKARIA EAST	APPAREL PARK	5624	10786	13736
13	APPAREL PARK	AMRAIWADI	4303	5393	6868
14	AMRAIWADI	RABARI COLONY	3465	5393	6868
15	RABARI COLONY	VASTRAL	2757	5393	6868
16	VASTRAL	NIRANT CROSS ROAD	1151	5393	6868
17	NIRANT CROSS ROAD	VASTRAL GAM	456	5393	6868

Note: Reversal facility required at Ashram Road and Apparel Park.

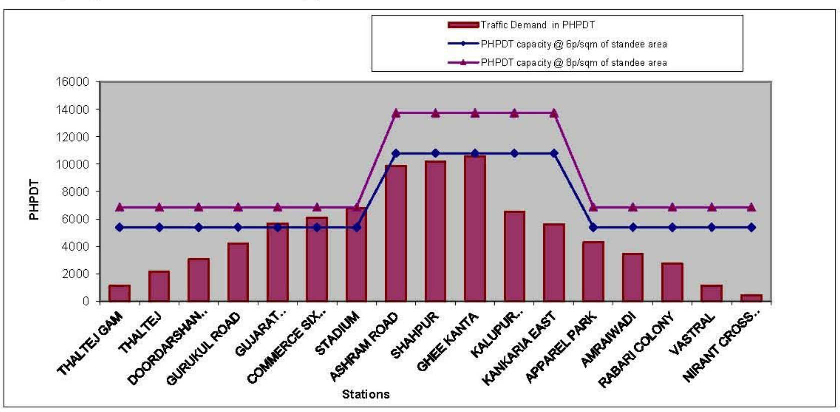


Fig 1.2

Attachment - I/B1

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
North - South Corridor

Year:	**2021**	
No. of Cars per Train:	**3**	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	**764**	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	**973**	
Headway (min)	**8**	(In 'APMC to Madalpur' Section)
Headway (min)	**4**	(In 'Madalpur to Motera Stadium' Section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	APMC	VASNA	1831	5730	7298
2	VASNA	ANJALI	2884	5730	7298
3	ANJALI	PALDI	3715	5730	7298
4	PALDI	MADALPUR	4576	5730	7298
5	MADALPUR	NAVA GANDHIGRAM	6189	11460	14596
6	NAVA GANDHIGRAM	ASHRAM ROAD	7221	11460	14596
7	ASHRAM ROAD	USMANPURA	12096	11460	14596
8	USMANPURA	VADAJ	11964	11460	14596
9	VADAJ	RANIP	**12097**	11460	14596
10	RANIP	SABARMATI RLY. STATION	11180	11460	14596
11	SABARMATI RLY. STATION	AEC	10621	11460	14596
12	AEC	SABARMATI	10359	11460	14596
13	SABARMATI	MOTERA STADIUM	9915	11460	14596

Note: Reversal facility required at Madalpur.

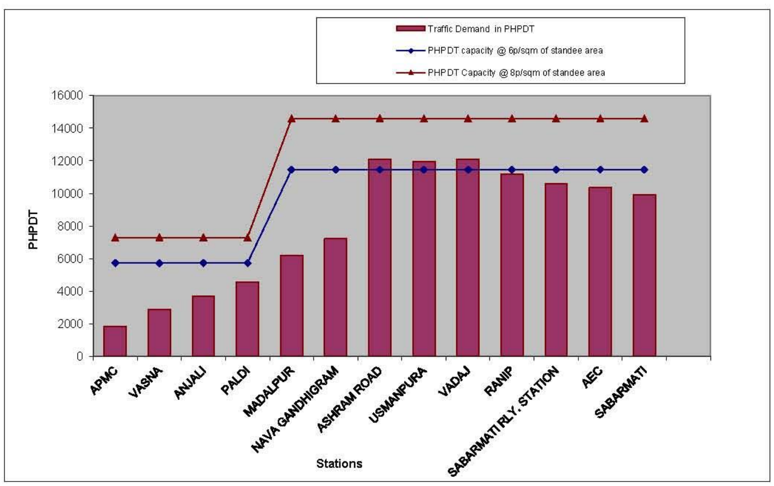


Fig 2.1

Attachment - I/B2

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
East - West Corridor

Year:	2021	
No. of Cars per Train:	3	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	973	
Headway (min)	3	(In 'Ashram Road to Apparel Park' Section)
Headway (min)	6	(In 'Thal Tej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	THALTEJ GAM	THALTEJ	1832	7640	9730
2	THALTEJ	DOORDARSHAN KENDRA	3362	7640	9730
3	DOORDARSHAN KENDRA	GURUKUL ROAD	4586	7640	9730
4	GURUKUL ROAD	GUJARAT UNIVERSITY	6100	7640	9730
5	GUJARAT UNIVERSITY	COMMERCE SIX ROAD	7745	7640	9730
6	COMMERCE SIX ROAD	STADIUM	8369	7640	9730
7	STADIUM	ASHRAM ROAD	9202	7640	9730
8	ASHRAM ROAD	SHAHPUR	15144	15280	19460
9	SHAHPUR	GHEE KANTA	15479	15280	19460
10	GHEE KANTA	KALUPUR RLY.STATION	15659	15280	19460
11	KALUPUR RLY.STATION	KANKARIA EAST	9042	15280	19460
12	KANKARIA EAST	APPAREL PARK	7878	15280	19460
13	APPAREL PARK	AMRAIWADI	6287	7640	9730
14	AMRAIWADI	RABARI COLONY	5334	7640	9730
15	RABARI COLONY	VASTRAL	4396	7640	9730
16	VASTRAL	NIRANT CROSS ROAD	2196	7640	9730
17	NIRANT CROSS ROAD	VASTRAL GAM	1068	7640	9730

Note: Reversal facility required at Ashram Road and Apparel Park.

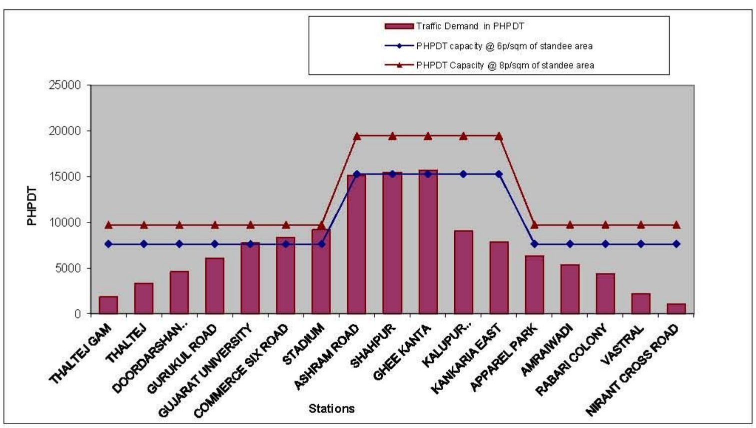


Fig 2.2

Attachment - I/C1

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
North - South Corridor

Year:	2031	
No. of Cars per Train:	3	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	973	
Headway (min)	6	(In 'APMC to Madalpur' Section)
Headway (min)	3	(In 'Madalpur to Motera Stadium' Section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	APMC	VASNA	2490	7640	9730
2	VASNA	ANJALI	4286	7640	9730
3	ANJALI	PALDI	5050	7640	9730
4	PALDI	MADALPUR	6685	7640	9730
5	MADALPUR	NAVA GANDHIGRAM	8872	15280	19460
6	NAVA GANDHIGRAM	ASHRAM ROAD	10382	15280	19460
7	ASHRAM ROAD	USMANPURA	15658	15280	19460
8	USMANPURA	VADAJ	16616	15280	19460
9	VADAJ	RANIP	**17778**	15280	19460
10	RANIP	SABARMATI RLY. STATION	16735	15280	19460
11	SABARMATI RLY. STATION	AEC	15896	15280	19460
12	AEC	SABARMATI	15443	15280	19460
13	SABARMATI	MOTERA STADIUM	15127	15280	19460

Note: Reversal facility required at Madalpur.

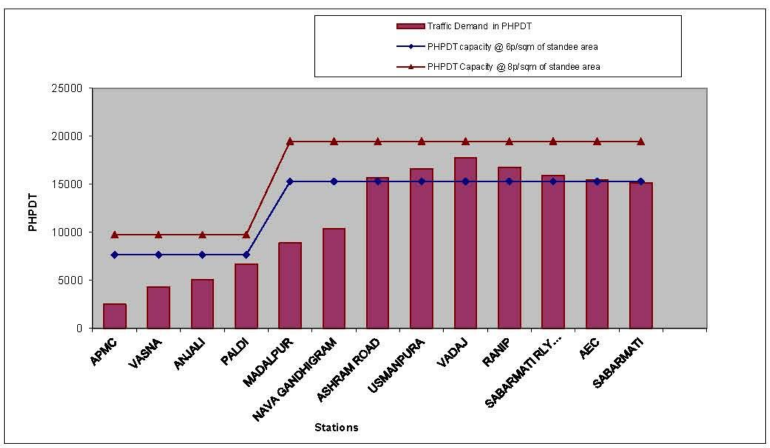


Fig 3.1

Attachment - I/C2

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
East - West Corridor

Year:	**2031**	
No. of Cars per Train:	**3**	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	**764**	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	**973**	
Headway (min)	**2**	(In 'Ashram Road to Apparel Park' Section)
Headway (min)	**4**	(In 'Thal Tej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	THALTEJ GAM	THALTEJ	3726	11460	14595
2	THALTEJ	DOORDARSHAN KENDRA	6145	11460	14595
3	DOORDARSHAN KENDRA	GURUKUL ROAD	7410	11460	14595
4	GURUKUL ROAD	GUJARAT UNIVERSITY	9291	11460	14595
5	GUJARAT UNIVERSITY	COMMERCE SIX ROAD	11475	11460	14595
6	COMMERCE SIX ROAD	STADIUM	12284	11460	14595
7	STADIUM	ASHRAM ROAD	13249	11460	14595
8	ASHRAM ROAD	SHAHPUR	18388	22920	29190
9	SHAHPUR	GHEE KANTA	18678	22920	29190
10	GHEE KANTA	KALUPUR RLY.STATION	19251	22920	29190
11	KALUPUR RLY.STATION	KANKARIA EAST	12862	22920	29190
12	KANKARIA EAST	APPAREL PARK	11476	22920	29190
13	APPAREL PARK	AMRAIWADI	9629	11460	14595
14	AMRAIWADI	RABARI COLONY	8545	11460	14595
15	RABARI COLONY	VASTRAL	7404	11460	14595
16	VASTRAL	NIRANT CROSS ROAD	4127	11460	14595
17	NIRANT CROSS ROAD	VASTRAL GAM	2154	11460	14595

Note: Reversal facility required at Ashram Road and Apparel Park.

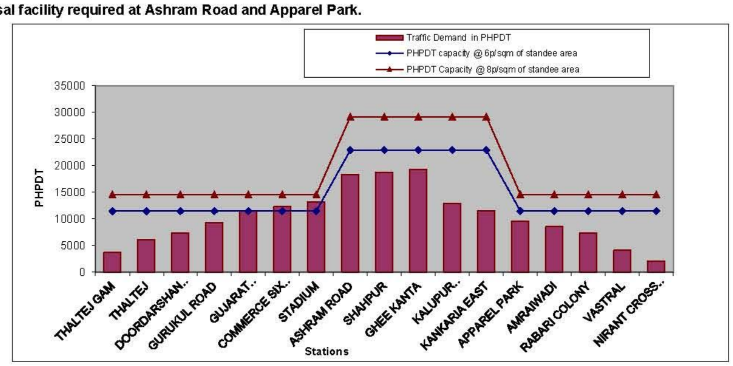


Fig 3.2

Attachment - I/D1

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
North - South Corridor

Year:	2043	
No. of Cars per Train:	3	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	973	
Headway (min)	4	(In 'APMC to Madalpur' Section)
Headway (min)	2	(In 'Madalpur to Motera Stadium' Section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	APMC	VASNA	3248	11460	14595
2	VASNA	ANJALI	5348	11460	14595
3	ANJALI	PALDI	6833	11460	14595
4	PALDI	MADALPUR	8532	11460	14595
5	MADALPUR	NAVA GANDHIGRAM	11161	22920	29190
6	NAVA GANDHIGRAM	ASHRAM ROAD	13194	22920	29190
7	ASHRAM ROAD	USMANPURA	20692	22920	29190
8	USMANPURA	VADAJ	21959	22920	29190
9	VADAJ	RANIP	**26484**	22920	29190
10	RANIP	SABARMATI RLY. STATION	25506	22920	29190
11	SABARMATI RLY. STATION	AEC	24618	22920	29190
12	AEC	SABARMATI	24143	22920	29190
13	SABARMATI	MOTERA STADIUM	24261	22920	29190

Note: Reversal facility required at Madalpur.

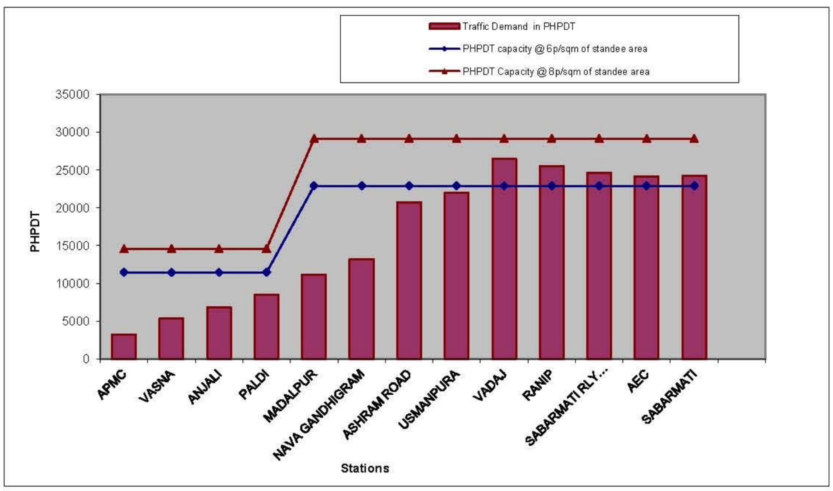


Fig 4.1

Attachment - I/D2

PHPDT Demand and Capacity Chart
Ahmedabad Metro Rail Project
East - West Corridor

Year:	2043	
No. of Cars per Train:	3	
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764	
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	973	
Headway (min)	2	(In 'Ashram Road to Apparel Park' Section)
Headway (min)	4	(In 'Thal Tej Gam to Ashram Road' Section and 'Apparel Park to Vastral Gam' section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	THALTEJ GAM	THALTEJ	5104	11460	14595
2	THALTEJ	DOORDARSHAN KENDRA	7846	11460	14595
3	DOORDARSHAN KENDRA	GURUKUL ROAD	9155	11460	14595
4	GURUKUL ROAD	GUJARAT UNIVERSITY	11079	11460	14595
5	GUJARAT UNIVERSITY	COMMERCE SIX ROAD	13804	11460	14595
6	COMMERCE SIX ROAD	STADIUM	14596	11460	14595
7	STADIUM	ASHRAM ROAD	15609	11460	14595
8	ASHRAM ROAD	SHAHPUR	22011	22920	29190
9	SHAHPUR	GHEE KANTA	22183	22920	29190
10	GHEE KANTA	KALUPUR RLY.STATION	22944	22920	29190
11	KALUPUR RLY.STATION	KANKARIA EAST	15457	22920	29190
12	KANKARIA EAST	APPAREL PARK	13922	22920	29190
13	APPAREL PARK	AMRAIWADI	12135	11460	14595
14	AMRAIWADI	RABARI COLONY	11264	11460	14595
15	RABARI COLONY	VASTRAL	10132	11460	14595
16	VASTRAL	NIRANT CROSS ROAD	5907	11460	14595
17	NIRANT CROSS ROAD	VASTRAL GAM	3388	11460	14595

Note: Reversal facility required at Ashram Road and Apparel Park.

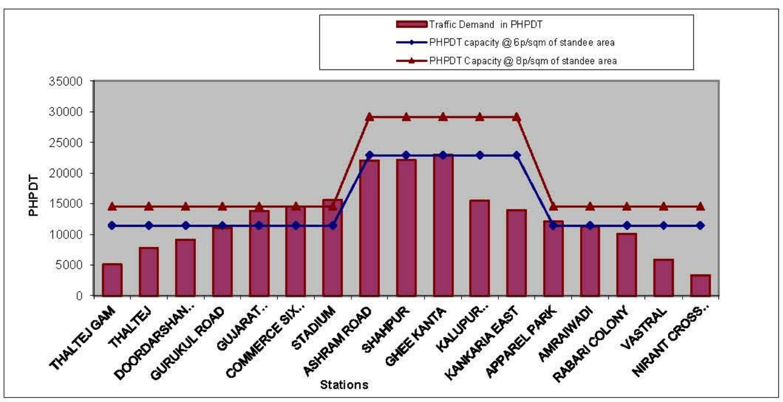


Fig 4.2

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.1 A

Hourly Train Operation Plan for MADALPUR to MOTERA STADIUM

Year: 2018

Configuration: 3 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**108**	**108**

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.2 A

Hourly Train Operation Plan for MADALPUR to MOTERA STADIUM

Year: 2021

Configuration: 3 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	3
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	3	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.3 A

Hourly Train Operation Plan for MADALPUR to MOTERA STADIUM

Year: 2031

Configuration: 3 Car

Headway(min): 3

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3**	**20**	**20**
9 to 10	**3**	**20**	**20**
10 to 11	**3**	**20**	**20**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3**	**20**	**20**
18 to 19	**3**	**20**	**20**
19 to 20	**3**	**20**	**20**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**216**	**216**

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.4 A

Hourly Train Operation Plan for MADALPUR to MOTERA STADIUM

Year: 2043

Configuration: 3 Car

Headway(min): 2

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	7
6 to 7	6	10	10
7 to 8	3	20	20
8 to 9	**2**	**30**	**30**
9 to 10	**2**	**30**	**30**
10 to 11	**2**	**30**	**30**
11 to12	3	20	20
12 to 13	6	10	10
13 to 14	8	8	7
14 to 15	8	7	8
15 to 16	6	10	10
16 to 17	3	20	20
17 to 18	**2**	**30**	**30**
18 to 19	**2**	**30**	**30**
19 to 20	**2**	**30**	**30**
20 to 21	3	20	20
21 to 22	6	10	10
22 to 23	8	7	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**336**	**336**

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.1 B

Hourly Train Operation Plan for APMC to MADALPUR

Year: 2018

Configuration: 3 Car

Headway(min): 12

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	48	1	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	48	1	2
14 to 15	48	2	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	48	1	1
23 to 24	60	1	1
Total No. of train trips per direction per day		**54**	**54**

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.2 B

Hourly Train Operation Plan for APMC to MADALPUR

Year: 2021
Configuration: 3 Car
Headway(min): 8

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**8**	**7**	**8**
9 to 10	**8**	**8**	**7**
10 to 11	**8**	**7**	**8**
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	**8**	**8**	**7**
18 to 19	**8**	**7**	**8**
19 to 20	**8**	**8**	**7**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	2	2
23 to 24	40	1	1
Total No. of train trips per direction per day		**84**	**84**

Attachment II

Ahmedabad Metro Rail Project
North - South Corridor

TABLE 1.3 B
Hourly Train Operation Plan for APMC to MADALPUR

Year: 2031
Configuration: 3 Car
Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	3
14 to 15	24	3	2
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**108**	**108**

Attachment II

Ahmedabad Metro Rail Project

North - South Corridor

TABLE 1.4 B

Hourly Train Operation Plan for APMC to MADALPUR

Year: 2043

Configuration: 3 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment II

Ahmedabad Metro Rail Project
East - West Corridor

TABLE 1.7 A
Hourly Train Operation Plan for THALTEJ GAM to ASHRAM ROAD
Year: 2018
Configuration: 3 Car
Headway(min): 8.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**8.5**	**7**	**8**
9 to 10	**8.5**	**7**	**7**
10 to 11	**8.5**	**8**	**7**
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	1	2
14 to 15	32	2	1
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	**8.5**	**8**	**7**
18 to 19	**8.5**	**7**	**7**
19 to 20	**8.5**	**7**	**8**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	2	2
23 to 24	40	1	1
Total No. of train trips per direction per day		**82**	**82**

Attachment II

Ahmedabad Metro Rail Project

East - West Corridor

TABLE 1.8 A

Hourly Train Operation Plan for THALTEJ GAM to ASHRAM ROAD

Year: 2021

Configuration: 3 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	3
14 to 15	24	3	2
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**108**	**108**

Attachment II

Ahmedabad Metro Rail Project
East - West Corridor

TABLE 1.9 A
Hourly Train Operation Plan for THALTEJ GAM to ASHRAM ROAD
Year: 2031
Configuration: 3 Car
Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment II

Ahmedabad Metro Rail Project

East - West Corridor

TABLE 1.10 A

Hourly Train Operation Plan for THALTEJ GAM to ASHRAM ROAD

Year: 2043

Configuration: 3 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment II

Ahmedabad Metro Rail Project

East - West Corridor

TABLE 1.7 B

Hourly Train Operation Plan for ASHRAM ROAD to APPAREL PARK

Year: 2018

Configuration: 3 Car

Headway(min): 4.25

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

Attachment II

Ahmedabad Metro Rail Project

East - West Corridor

TABLE 1.8 B

Hourly Train Operation Plan for ASHRAM ROAD to APPAREL PARK

Year: 2021

Configuration: 3 Car

Headway(min): 3

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3**	**20**	**20**
9 to 10	**3**	**20**	**20**
10 to 11	**3**	**20**	**20**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3**	**20**	**20**
18 to 19	**3**	**20**	**20**
19 to 20	**3**	**20**	**20**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**216**	**216**

Attachment II

Ahmedabad Metro Rail Project

East - West Corridor

TABLE 1.9 B

Hourly Train Operation Plan for ASHRAM ROAD to APPAREL PARK

Year: 2031

Configuration: 3 Car

Headway(min): 2

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	7
6 to 7	6	10	10
7 to 8	3	20	20
8 to 9	**2**	**30**	**30**
9 to 10	**2**	**30**	**30**
10 to 11	**2**	**30**	**30**
11 to12	3	20	20
12 to 13	6	10	10
13 to 14	8	8	7
14 to 15	8	7	8
15 to 16	6	10	10
16 to 17	3	20	20
17 to 18	**2**	**30**	**30**
18 to 19	**2**	**30**	**30**
19 to 20	**2**	**30**	**30**
20 to 21	3	20	20
21 to 22	6	10	10
22 to 23	8	7	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**336**	**336**

Attachment II

Ahmedabad Metro Rail Project
East - West Corridor

TABLE 1.10 B
Hourly Train Operation Plan for ASHRAM ROAD to APPAREL PARK
Year: 2043
Configuration: 3 Car
Headway(min): 2

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	7
6 to 7	6	10	10
7 to 8	3	20	20
8 to 9	**2**	**30**	**30**
9 to 10	**2**	**30**	**30**
10 to 11	**2**	**30**	**30**
11 to12	3	20	20
12 to 13	6	10	10
13 to 14	8	8	7
14 to 15	8	7	8
15 to 16	6	10	10
16 to 17	3	20	20
17 to 18	**2**	**30**	**30**
18 to 19	**2**	**30**	**30**
19 to 20	**2**	**30**	**30**
20 to 21	3	20	20
21 to 22	6	10	10
22 to 23	8	7	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**336**	**336**

Attachment II

Ahmedabad Metro Rail Project
East - West Corridor

TABLE 1.7 C
Hourly Train Operation Plan for APPAREL PARK to VASTRAL GAM
Year: 2018
Configuration: 3 Car
Headway(min): 8.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**8.5**	**7**	**8**
9 to 10	**8.5**	**7**	**7**
10 to 11	**8.5**	**8**	**7**
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	1	2
14 to 15	32	2	1
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	**8.5**	**8**	**7**
18 to 19	**8.5**	**7**	**7**
19 to 20	**8.5**	**7**	**8**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	2	2
23 to 24	40	1	1
Total No. of train trips per direction per day		**82**	**82**

Attachment II

Ahmedabad Metro Rail Project

East - West Corridor

TABLE 1.8 C

Hourly Train Operation Plan for APPAREL PARK to VASTRAL GAM

Year: 2021

Configuration: 3 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	3
14 to 15	24	3	2
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**108**	**108**

Attachment II

Ahmedabad Metro Rail Project
East - West Corridor

TABLE 1.9 C
Hourly Train Operation Plan for APPAREL PARK to VASTRAL GAM
Year: 2031
Configuration: 3 Car
Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment II

Ahmedabad Metro Rail Project
East - West Corridor

TABLE 1.10 C
Hourly Train Operation Plan for APPAREL PARK to VASTRAL GAM
Year: 2043
Configuration: 3 Car
Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment III

TABLE 2.1
North - South Corridor
PHPDT for the Year 2018

S.No	From Station	To Station	Maximum PHPDT	Directional Split to MOTERA STADIUM	Directional Split to APMC
1	APMC	VASNA	1468	50%	50%
2	VASNA	ANJALI	2088	50%	50%
3	ANJALI	PALDI	2564	50%	50%
4	PALDI	MADALPUR	3335	50%	50%
5	MADALPUR	NAVA GANDHIGRAM	4548	50%	50%
6	NAVA GANDHIGRAM	ASHRAM ROAD	5359	50%	50%
7	ASHRAM ROAD	USMANPURA	7721	50%	50%
8	USMANPURA	VADAJ	8286	50%	50%
9	VADAJ	RANIP	8476	50%	50%
10	RANIP	SABARMATI RLY. STATION	7772	50%	50%
11	SABARMATI RLY. STATION	AEC	7411	50%	50%
12	AEC	SABARMATI	7266	50%	50%
13	SABARMATI	MOTERA STADIUM	7085	50%	50%

TABLE 2.2
East - West Corridor
PHPDT for the Year 2018

S.No	From Station	To Station	Maximum PHPDT	Directional Split to VASTRAL GAM	Directional Split to THALTEJ GAM
1	THALTEJ GAM	THALTEJ	1130	50%	50%
2	THALTEJ	DOORDARSHAN KENDRA	2185	50%	50%
3	DOORDARSHAN KENDRA	GURUKUL ROAD	3056	50%	50%
4	GURUKUL ROAD	GUJARAT UNIVERSITY	4212	50%	50%
5	GUJARAT UNIVERSITY	COMMERCE SIX ROAD	5678	50%	50%
6	COMMERCE SIX ROAD	STADIUM	6120	50%	50%
7	STADIUM	ASHRAM ROAD	6797	50%	50%
8	ASHRAM ROAD	SHAHPUR	9870	50%	50%
9	SHAHPUR	GHEE KANTA	10183	50%	50%
10	GHEE KANTA	KALUPUR RLY.STATION	10593	50%	50%
11	KALUPUR RLY.STATION	KANKARIA EAST	6543	50%	50%
12	KANKARIA EAST	APPAREL PARK	5624	50%	50%
13	APPAREL PARK	AMRAIWADI	4303	50%	50%
14	AMRAIWADI	RABARI COLONY	3465	50%	50%
15	RABARI COLONY	VASTRAL	2757	50%	50%
16	VASTRAL	NIRANT CROSS ROAD	1151	50%	50%
17	NIRANT CROSS ROAD	VASTRAL GAM	456	50%	50%

Attachment IV

TABLE 3.1
Vehicle Kilometer
Ahmedabad Metro Rail Project
North - South Corridor

Year	2018		2021		2031		2043	
Section	*MADALPUR to MOTERA STADIUM*	*APMC to MADALPUR*	*MADALPUR to MOTERA STADIUM*	*APMC to MADALPUR*	*MADALPUR to MOTERA STADIUM*	*APMC to MADALPUR*	*MADALPUR to MOTERA STADIUM*	*APMC to MADALPUR*
Section Length	10.38	4.23	10.38	4.23	10.38	4.23	10.38	4.23
No of cars per Train	3	3	3	3	3	3	3	3
No of working Days in a year	340	340	340	340	340	340	340	340
Number of Trains per day each Way	108	54	168	84	216	108	336	168
Daily Train -KM	2242	457	3488	711	4484	914	6975	1421
Annual Train - KM (10^5)	7.62	1.55	11.86	2.42	15.25	3.11	23.72	4.83
Annual Vehicle - KM (10^5)	**22.87**	**4.66**	**35.57**	**7.25**	**45.74**	**9.32**	**71.15**	**14.50**

Attachment IV

TABLE 3.2
Vehicle Kilometer
Ahmedabad Metro Rail Project
East - West Corridor

Year	2018			2021			2031			2043		
Section	*THALTEJ GAM to ASHRAM ROAD*	*ASHRAM ROAD to APPAREL PARK*	*APPAREL PARK to VASTRAL GAM*	*THALTEJ GAM to ASHRAM ROAD*	*ASHRAM ROAD to APPAREL PARK*	*APPAREL PARK to VASTRAL GAM*	*THALTEJ GAM to ASHRAM ROAD*	*ASHRAM ROAD to APPAREL PARK*	*APPAREL PARK to VASTRAL GAM*	*THALTEJ GAM to ASHRAM ROAD*	*ASHRAM ROAD to APPAREL PARK*	*APPAREL PARK to VASTRAL GAM*
Section Length	6.91	7.48	5.34	6.91	7.48	5.34	6.91	7.48	5.34	6.91	7.48	5.34
No of cars per Train	3	3	3	3	3	3	3	3	3	3	3	3
No of working Days in a year	340	340	340	340	340	340	340	340	340	340	340	340
Number of Trains per day each Way	82	164	82	108	216	108	168	336	168	168	336	168
Daily Train -KM	1132	2452	876	1491	3230	1154	2320	5024	1794	2320	5024	1794
Annual Train - KM (10^5)	3.85	8.34	2.98	5.07	10.98	3.92	7.89	17.08	6.10	7.89	17.08	6.10
Annual Vehicle - KM (10^5)	**11.55**	**25.01**	**8.93**	**15.21**	**32.94**	**11.77**	**23.66**	**51.24**	**18.30**	**23.66**	**51.24**	**18.30**

Attachment -V

Rake Requirement

Ahmedabad Metro Rail Project

North - South Corridor, Year : 2018

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
APMC to Motera Stadium	14.61	32	12	6	1	1	8	3	24
Madalpur to Motera Stadium	10.38	32	12	4	0	0	4	3	12
				10	1	1	12		36

Note: Reversal facility required at Madalpur.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Madalpur to Motera Stadium	6	*12 Rakes of 3 cars*	36
APMC to Madalpur	12		
Total Turn around Time(min)	**6**		

North - South Corridor, Year : 2021

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
APMC to Motera Stadium	14.61	32	8	8	1	1	10	3	30
Madalpur to Motera Stadium	10.38	32	8	6	0	1	7	3	21
				14	1	2	17		51

Note: Reversal facility required at Madalpur.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Madalpur to Motera Stadium	4	*17 Rakes of 3 cars*	51
APMC to Madalpur	8		
Total Turn around Time(min)	**6**		

North - South Corridor, Year : 2031

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
APMC to Motera Stadium	14.61	32	6	11	1	1	13	3	39
Madalpur to Motera Stadium	10.38	32	6	8	0	1	9	3	27
				19	1	2	22		66

Note: Reversal facility required at Madalpur.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Madalpur to Motera Stadium	3	*22 Rakes of 3 cars*	66
APMC to Madalpur	6		
Total Turn around Time(min)	**6**		

North - South Corridor, Year : 2043

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
APMC to Motera Stadium	14.61	32	4	16	1	2	19	3	57
Madalpur to Motera Stadium	10.38	32	4	12	0	1	13	3	39
				28	1	3	32		96

Note: Reversal facility required at Madalpur.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Madalpur to Motera Stadium	2	*32 Rakes of 3 cars*	96
APMC to Madalpur	4		
Total Turn around Time(min)	**6**		

Attachment -V

Rake Requirement

Ahmedabad Metro Rail Project

East - West Corridor, Year : 2018

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Thaltej Gam to Vastral Gam	19.72	33	8.5	10	1	1	12	3	36
Ashram Road to Apparel Park	7.48	37	8.5	4	0	1	5	3	15
				14	1	2	17		51

Note: Reversal facility required at Ashram Road and Apparel Park.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Ashram Road to Apparel Park Section	4.25	*17 Rakes of 3 cars*	51
Thal Tej Gam to Ashram Road Section and Apparel Park to Vastral Gam section	8.5		
Total Turn around Time(min)	**6**		

East - West Corridor, Year : 2021

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Thaltej Gam to Vastral Gam	19.72	33	6	13	1	1	15	3	45
Ashram Road to Apparel Park	7.48	37	6	6	0	1	7	3	21
				19	1	2	22		66

Note: Reversal facility required at Ashram Road and Apparel Park.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Ashram Road to Apparel Park Section	3	*22 Rakes of 3 cars*	66
Thal Tej Gam to Ashram Road Section and Apparel Park to Vastral Gam section	6		
Total Turn around Time(min)	**6**		

East - West Corridor, Year : 2031

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Thaltej Gam to Vastral Gam	19.72	33	4	20	1	2	23	3	69
Ashram Road to Apparel Park	7.48	37	4	8	0	1	9	3	27
				28	1	3	32		96

Note: Reversal facility required at Ashram Road and Apparel Park.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Ashram Road to Apparel Park Section	2	*32 Rakes of 3 cars*	96
Thal Tej Gam to Ashram Road Section and Apparel Park to Vastral Gam section	4		
Total Turn around Time(min)	**6**		

East - West Corridor, Year : 2043

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Thaltej Gam to Vastral Gam	19.72	33	4	20	1	2	23	3	69
Ashram Road to Apparel Park	7.48	37	4	8	0	1	9	3	27
				28	1	3	32		96

Note: Reversal facility required at Ashram Road and Apparel Park.

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Ashram Road to Apparel Park Section	2	*32 Rakes of 3 cars*	96
Thal Tej Gam to Ashram Road Section and Apparel Park to Vastral Gam section	4		
Total Turn around Time(min)	**6**		

Chapter - 8

Rolling Stock

Chapter - 8

ROLLING STOCK

8.1 INTRODUCTION

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

8.2 OPTIMIZATION OF COACH SIZE

The following optimum size of the coach has been chosen for this corridor as mentioned in Table 8.1.

Table 8.1 - Size of the 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*

8.3 PASSENGER CARRYING CAPACITY

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

Therefore, for the Medium Rail Vehicles (MRV) with 2.9 m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 43 seated, 204 standing thus a total of 247 passengers for a Driving motor car, and 50 seated, 220 standing thus a total of 270 for a trailer/motor car is envisaged.

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

Table 8.2 shows the carrying capacity of Medium Rail Vehicles.

Table 8.2 - Carrying Capacity of Medium Rail Vehicles

Particulars	Driving Motor car		Trailer car		3 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush
Seated	43	43	50	50	136	136
Standing	102	204	110	220	314	628
Total	145	247	160	270	450	764

NORMAL-3 Person/sqm of standee area

CRUSH -6 Person/sqm of standee area

8.4 WEIGHT

The weights of driving motor car, trailer car and motor car have been estimated as in Table 8.3, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 8.3 - Weight of Light Rail Vehicles (TONNES)

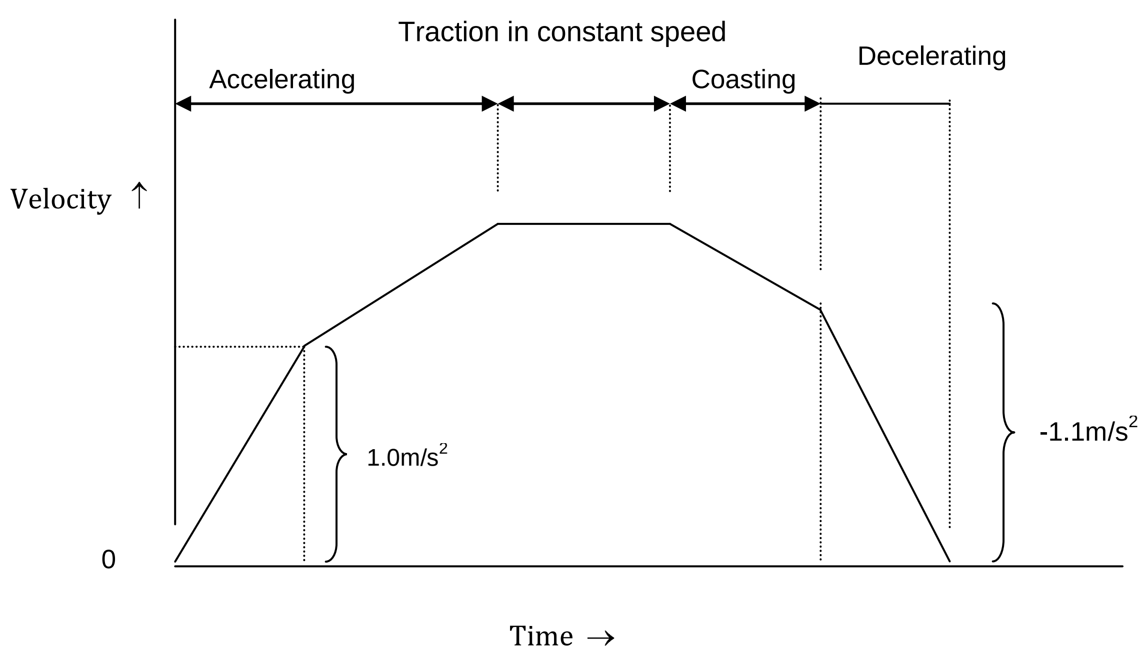
	DMC	TC	3 Car Train
TARE (maximum)	40	40	120
Passenger			
(Normal)	9.425	10.4	29.25
(Crush @6p/sqm)	16.055	17.55	49.66
(Crush @8p/sqm)	20.475	22.295	63.245
Gross			
(Normal)	49.425	50.4	149.25
(Crush @6p/sqm)	56.055	57.55	169.66
(Crush @8p/sqm)	60.475	62.295	183.23
Axle Load @6 person/sqm	14.014	14.388	
Axle Load @8 person/sqm	15.119	15.577	

The axle load @ 6persons/sqm of standing area works out in the range of 14.014T to 14.388T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should, therefore, be designed for **16 T axle** load.

8.5 PERFORMANCE PARAMETERS

The recommended performance parameters are:

Maximum Design Speed: 90 kmph
Maximum Operating Speed: 80 kmph
Max. Acceleration: 1.0 m/s^2 (with AW3 load)
Max. Deceleration 1.1 m/s^2 (Normal brake)
More than 1.3 m/s^2 (Emergency brake)



8.6 COACH DESIGN AND BASIC PARAMETERS

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

(i) Proven equipment with high reliability
(ii) Passenger safety feature
(iii) Energy efficiency
(iv) Light weight equipment and coach body
(v) Optimized scheduled speed

(vi) Aesthetically pleasing Interior and Exterior
(vii) Low Life cycle cost
(viii) Flexibility to meet increase in traffic demand
(ix) Anti-telescopic

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

8.7 SELECTION OF TECHNOLOGY

Low life cycle cost

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

8.7.1 Car body

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

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

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

8.7.2 Bogies

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

8.7.3 Braking System

The brake system shall consist of –

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

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

8.7.4 Propulsion System Technology

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

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

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

The DC voltage from the 3rd Rail is stepped up through a 'STEP up Chopper' to DC link voltage, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using insulated Gate Bipolar Transistors (IGBT). Thus three-phase variable voltage variable frequency output drives the traction motors for propulsion.

Recently advanced IGBT has been developed for inverter units. The advanced IGBT incorporates its own over current protection, short circuit protection; over temperature protection and low power supply detection. The inverter unit uses optical fiber cable to connect the control unit to the gate interface. This optical fiber cable transmits the gate signals to drive the advanced IGBT via the gate interface. The optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in trains of this corridor.

8.7.5 Interior and Gangways

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

Interior View

8.7.6 Passenger Doors

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

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

Passenger Doors

8.7.7 Air–conditioning

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

8.7.8 Cab Layout and Emergency Detrainment Door.

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

Driving cab

An emergency door for easy detrainment of the passenger on the track has been provided at the center of the front side of the each cabin which has a easy operation with one handle type master controller.

8.7.9 Communication

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

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

8.7.10 Noise and Vibration

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

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

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

8.7.11 Passenger Safety Features

(i) ATP

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

(ii) Fire

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

(iii) Emergency door

The rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train,

(iv) Crash worthiness features

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

(v) Gangways

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

Gangways

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

Attachment I

Salient Features of Rolling Stock for MRTS

S.No.	Parameter	Details
1	**Gauge** (Nominal)	1435mm
2	**Traction system**	
2.1	Voltage	750 V dc
2.2	Method of current collection	Third Rail Bottom Current Collection System
3	**Train composition:**	
3.1	3 car trainset	DMC+TC+DMC
4	**Coach Body**	Stainless Steel
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	2.9 m
5.3	Length over body (approx)	
	- Driving Motor Car (DMC)	21.64 m
	- Trailer Car (TC)	21.34 m
	Maximum length of coach over couplers/buffers:	*22 to 22.6 m (depending upon Kinematic Envelop)*
5.4	Locked down Panto height (if applicable)	4048 mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity- @ 6 standees/sqm**	
7.1	Coach carrying capacity	
	DMC	247 (seating - 43 ; standing - 204)
	TC	270 (seating - 50 ; standing - 220)
7.2	Train Carrying capacity	
	3 car train	764 (seating - 136 ; standing - 628)
8	**Weight (Tonnes)**	
8.1	Tare weight (maximum)	
	DMC	40
	TC	40
8.2	Passenger Weight in tons @ 6 standees/sqm	@ 0.065 T per passenger
	DMC	16.055
	TC	17.55
8.3	Gross weight in tons	
	DMC	56.055
	TC	57.55

S.No.	Parameter	Details
9	**Axle load(T)(@ 8 persons per sqm of standee area)**	**16 (System should be designed for 16T axleload)**
10	**Maximum Train Length - Approximate**	
10.1	3 car trainset	≈68
11	**Speed**	
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	Internal (cab and saloon)	L_{pAFmax} 65 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 68 dB(A)
13.2	Running at 85 kmph (Elevated and at grade)	
13.2.1	Internal (cab and saloon)	$L_{pAeq,30}$ 72 dB(A)
13.2.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 85 dB(A)
13.3	Stationary (Underground)	
13.3.1	Internal (cab and saloon)	L_{pAFmax} 72 dB(A)
14	**Traction Motors Ventilation**	Self
15	**Acceleration on level tangent track**	1.0 m/s2 (with AW3 load)
16	**Deacceleration on level tangent track**	1.1 m/sec^2 (>1.3 m/sec^2 during emergency)
17	**Type of Bogie**	Fabricated
18	**Secondary Suspension springs**	Air
19	**Brakes**	- An electro-pneumatic (EP) service friction brake- An electric regenerative service brake- Provision of smooth and continuous blending of EP and regenerative braking- A fail safe, pneumatic friction emergency brake- A spring applied air-release parking brake- The brake actuator shall operate a Wheel Disc Brake- Brake Electronic Control Unit (BECU) - Independent for each bogie
20	**Coupler**	Auto
	Front cab end of DMC car	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
21	**Detrainment Door**	Front

S.No.	Parameter	Details
22	**Type of Doors**	Sliding
23	**Passenger Seats**	Stainless Steel
24	**Cooling**	
24.1	Transformer	Forced
24.2	CI & SIV	Self/Forced
24.3	TM	Self ventilated
25	**Control System**	Train based Monitor & Control System (TCMS/TIMS)
26	**Traction Motors**	3 phase VVVF controlled
27	**Temperature Rise Limits**	
27.1	Traction Motor	Temperature Index **minus** 70 deg C
27.2	CI & SIV	10 deg C temperature margin for Junction temperature
27.3	Transformer	IEC specified limit **minus** 20 deg C
28	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load.
29	**PA/PIS including PSSS (CCTV)**	Required
30	**Passenger Surviellance**	Required
31	**Battery**	Lead Acid Maintenance free
32	**Headlight type**	LED
33	**Coasting**	8% (Run time with 8% coasting shall be the 'Run Time in All out mode **plus** 8%')
34	**Gradient (max)**	3.7%
35	**Sharpest Radius**	175 m

Chapter – 8A

Depot

Chapter -8A

DEPOT

8A.1 THE AHMEDABAD METRO RAIL PROJECT COMPRISES OF FOLLOWING CORRIDOR:

Corridor	Gauge (mm)	Route Length (KMs) (center to center)
N-S Corridor	1435	14.61
E-W Corridor	1435	19.72

8A.2 DEPOT- CUM- WORKSHOP

It is proposed to establish one depot- cum- workshop at Vasna for North South Corridor and one depot- cum- workshop at Apparel Park for East West Corridor with following functions:

a) Depot- cum- workshop at Vasna for North South Corridor

(i) Major overhauls of all the trains of N- S Corridor.
(ii) All minor schedules and repairs of N- S Corridor.
(iii) Lifting for replacement of heavy equipment and testing thereafter of N- S Corridor.
(iv) Repair of heavy equipments of N- S Corridor.

b) Depot- cum- workshop at Apparel Park for East West Corridor

(i) Major overhauls of all the trains of E-W Corridor.
(ii) All minor schedules and repairs of E-W Corridor.
(iii) Lifting for replacement of heavy equipment and testing thereafter of E-W Corridor.
(iv) Repair of heavy equipments of E-W Corridor.

The Depot planning at Vasna for North South Corridor and at Apparel Park for East West Corridor is based on following assumptions:

(i) Enough space should be available at Vasna for North South Corridor and at Apparel Park for East West Corridor for establishment of a Depot- Cum- workshop
(ii) All inspection, workshop lines and stabling lines are designed to accommodate two trainsets of 3- car each.

(iii) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere to cater to the required stability facilities.
(iv) Provision of transfer line from one corridor to another corridor.

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

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

8A.3 MAINTENANCE PHILOSOPHY

- Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, "A" checks, "B" type checks, "IOH" and "POH".
- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation is given due attention.

8A.4 ROLLING STOCK MAINTENANCE NEEDS

8A.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 335 kms running per train per day, taking in consideration the passenger load of 2018, 2021, 2031 and 2043 respectively.

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub -systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (approx. 45 days)	Detailed Inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays

Intermediate Overhaul (IOH)	420,000 Km, (3 and half Years approx.)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km, (7 Years approx.)	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.

8A.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	Automatic washing plant & cleaning & washing shed

8A.5 YEAR-WISE PLANNING OF MAINTENANCE FACILITY SETUP AT DEPOT CUM WORKSHOP BASED ON PLANNED ROLLING STOCK REQUIREMENT IN TOP IS TABULATED BELOW

(i) Planned rakes as per TOP:

a) Planned rakes as TOP for N- S Corridor:

Year	No. of Rakes	No. of coaches
2018	12	36
2021	17	51
2031	22	66
2043	32	96

b) Planned rakes as TOP for E- W Corridor:

Year	No. of Rakes	No. of coaches
2018	17	51
2021	22	66
2031	32	96
2043	32	96

(ii) Average earning/day/rake based on TOP:

a) Average earning/day/rake for N- S Corridor:

Year	Average earning/day/rake (KM)
2018	225
2021	247
2031	245
2043	262

b) Average earning/day/rake for E- W Corridor:

Year	Average earning/day/rake (KM)
2018	262
2021	267
2031	286
2043	286

(iii) Requirement of Stabling Lines (SBL),Inspection Lines (IBL) and Workshop Lines(WSL) in the Depot

a) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum –Workshop at Vasna for North South Corridor.

Year	No. of Trains	SBLs	IBLs	WSLs
2018	12	5 lines x two trains of 3-car	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension
2021	17	8 lines x two trains of 3-car	-do-	-do-
2031	22	10 lines x two trains of 3-car	-do-	-do-
2043	32	15 lines x two trains of 3-car	-do-	-do-

All lines shall be suitable for placement of two trains of 3-car trains on each line.

b) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum –Workshop at Apparel Park for East West Corridor.

Year	No. of Trains	SBLs	IBLs	WSLs
2018	17	8 lines x two trains of 3-car	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension
2021	22	10 lines x two trains of 3-car	-do-	-do-
2031	32	15 lines x two trains of 3-car	-do-	-do-
2043	32	15 lines x two trains of 3-car	-do-	-do-

All lines shall be suitable for placement of two trains of 3-car trains on each line.

8A.6 REQUIREMENT OF MAINTENANCE / INSPECTION LINES FOR DEPOT-CUM-WORKSHOP

a) Requirement of maintenance / Inspection lines for depot-cum-workshop Depot -cum–Workshop at Vasna for North South Corridor:

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2018 - Maximum no. of rake holding is 12TS x3 (= 36 Cars)		
'A' Checks (5000 km) approx. 15 days	(12X3) Cars = 36 Cars	1 Line x two trains of 3- cars(with Sunken Floor
'B' Checks (15000 km) approx. 45 days	(12X3) Cars = 36 Cars	1 Line x two trains of 3- cars(with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two trains of 3- cars(with sunken Floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
ii) Year 2021 - Maximum no. of rake holding is (17TS x3 = 51 Cars)		
'A' Checks (5000 km)	(17X3) Cars = 51 Cars	1 Lines X two trains of 3- cars(with

approx. 15 days		sunken floor)
‘B’ Checks (15000 km) approx. 45 days	(17X3) Cars = 51 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iii) Year 2031 -Maximum no. of rake holding is (22x3 = 66 Cars)		
‘A’ Checks (5000 km) 15 days	(22X3) Cars = 66 Cars	2 Lines X two trains of 3- cars(with sunken floor)
‘B’ Checks (15000 km) 45 days And for Unscheduled line & adjustment lines	(22X3) Cars = 66 Cars And For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iv) Year 2041 -Maximum no. of rake holding is (32x3 = 96 Cars)		
‘A’ Checks (5000 km) 15 days	(32X3) Cars = 96 Cars	2 Lines X two trains of 3- cars(with sunken floor)
‘B’ Checks (15000 km) 45 days And for Unscheduled line & adjustment lines	(32X3) Cars = 96 Cars And For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future

All lines shall be suitable for placement of two 3- car trains on same line.

b) Requirement of maintenance / Inspection lines for depot-cum-workshop at Apparel Park for East West Corridor:

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2018 - Maximum no. of rake holding is 17TS x3 (= 51 Cars)		
'A' Checks (5000 km) approx. 15 days	(17X3) Cars = 51 Cars	1 Line x two trains of 3- cars(with Sunken Floor
'B' Checks (15000 km) approx. 45 days	(17X3) Cars = 51 Cars	1 Line x two trains of 3- cars(with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two trains of 3- cars(with sunken Floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
ii) Year 2021 - Maximum no. of rake holding is (22TS x3 = 66 Cars)		
'A' Checks (5000 km) approx. 15 days	(22X3) Cars = 66 Cars	2 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days And for Unscheduled line & adjustment lines	(22X3) Cars = 66 Cars And For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iii) Year 2031 -Maximum no. of rake holding is (32x3 = 96 Cars)		
'A' Checks (5000 km) 15 days	(32X3) Cars = 96 Cars	2 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days And for Unscheduled line & adjustment lines	(32X3) Cars = 96 Cars And For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future

iv) Year 2043 -Maximum no. of rake holding is (32x3 = 96 Cars)		
'A' Checks (5000 km) 15 days	(32X3) Cars = 96 Cars	2 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days And for Unscheduled line & adjustment lines	(32X3) Cars = 96 Cars And For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future

All lines shall be suitable for placement of two 3- car trains on same line.

8A.7 INSPECTION REQUIREMENTS AT DEPOTS AT VASNA FOR NORTH SOUTH CORRIDOR AND AT APPAREL PARK FOR EAST WEST CORRIDOR

Facilities for carrying out inspection activitities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks and "B" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off peak and night. Since "B" checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for "A" checks. For "B" checks, separate line will be nominated where the rakes may be kept for long time.

One dedicated line in the shed will be used for minor repairs and for adjustment and testing after the IOH and POH. There shall be a spare line in inspection bay for this purpose.

8A.8 DESIGN OF DEPOT- CUM- WORKSHOP FACILITIES

8A.8.1 Stabling lines at depots at Vasna for North South Corridor and at Apparel Park for East West Corridor:

As per advised dimensions of the Rolling Stock, the length of 3-Car train would be Approx.67.8 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates lengths have been taken in consideration:

(i) Length of one 3- car rake= 67.8 m

(ii) Gap between two trains 3-car rakes = 10m

(iii) Free length at outer ends of two trains of 3- cars (for cross pathway, Signal and Friction buffers)= 10m each side

(iv) Total length of Stabling lines = (iii)+(i)+(ii)+(i)+(iii)= 10+ 67.8+ 10+ 67.8+ 10= 165.6m ≈ 166m

Looking to the car width of 2900mm on SG, 5m "Track Centre" is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include 1 mt. wide pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection with provision of following facilities:

a) Each Stabling line to have water connection facility so that local cleaning, if required, is facilitated.

b) Platforms at suitable points at each end of stabling lines to enable train operators to board or de- board conveniently.

8A.8.2 Inspection Bay at depot-cum-workshop at Vasna for North South Corridor and at Apparel Park for East West Corridor:

The length of Inspection shed is computed as below:

(i) Length of a 3-car rake= 67.8 m.

(ii) Gap between two trains of 3- cars= 10 m

(iii) Cross- path at each end= 10 m

(iv) Length of Inspection line= (iii)+ (i)+(ii)+ (i)+ (iii) = 10+ 67.8 + 10+ 67.8 + 10= 165.6m ≈ 166m

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the three lines= 7.5 m

(ii) Centre line of outer lines to column of Shed= 3m

(iii) Width of a 3 line Inspection Bay= (ii)+(i)+(i)+(ii)= 3+ 7.5+ 7.5+ 3= 21 m

a) There shall be one inspection bay of 166 m X 21 m size each with provision of accommodating three inspection lines each having sunken floor and overhead roof inspection platforms at each of the depot. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m. For rake requirements in future, there shall be provision of space for extension by one bay of three lines to cater the workload of inspection in future.

b) Roof Inspection platforms and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. The inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

8A.8.3 Workshop Shed depots at Vasna for North South Corridor and at Apparel Park for East West Corridor:

Requirement of workshop lines is planned as under:

a) Requirement of workshop lines at Vasna for North South Corridor:

Year	IOH & POH	Wheel / Bogie storage	Unschedule repairs /lifting	Total	Remarks
2018	1	1 line of 3-car trains and free space of 3-car length for storage of other equipments	1 line x two trains of 3-car	3-lines	The size of workshop shall be the same as inspection bay i.e. 166X21 m with one working bay comprising of two trains lines capable of accommodating two trains 3-car rakes with Bogie turning facility, one line of 3-car rake length with free space of 3-car rake length for storage of wheel/ bogie/ equipments etc.
2021	1	-do-	1	3-lines	
2031	1	-do-	1	3-lines	
2043	1	-do-	1	3-lines	

b) Requirement of workshop lines at Apparel Park for East West Corridor:

Year	IOH & POH	Wheel / Bogie storage	Unschedule repairs /lifting	Total	Remarks
2018	1	1 line of 3-car trains and free space of 3-car length for storage of other equipments	1 line x two trains of 3-car	3-lines	The size of workshop shall be the same as inspection bay i.e. 166X21 m with one working bay comprising of two trains lines capable of accommodating two trains 3-car rakes with Bogie turning facility, one line of 3- car rake length with free space of 3-car rake length for storage of wheel/ bogie/ equipments etc.
2021	1	-do-	1	3-lines	
2031	1	-do-	1	3-lines	
2043	1	-do-	1	3-lines	

(a) There shall be one bay comprising of three lines each (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 166m x 21m.The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 3-Car unit simultaneously for quick change of bogie, thereby saving down time of Rolling Stock. The arrangement of jack system shall be such that lifting of any coach in train formation for replacement of bogie/equipments is also individually possible. One line shall be available for stocking of Bogies and wheels. These lines are to be provided with pits at regular intervals for inspection of undercarriage with turn tables. Each workshop bay shall be equipped with two trains 15T and 3T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be provided space for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AWo (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 166 x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two trains opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops depots at Vasna for North South Corridor and at Apparel Park for East West Corridor:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor
10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs

16. Couplers/Gangways
17. Coach Painting (Applicable only for Aluminum coaches, if any)

8A.9 CAR DELIVERY AREA

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum- Workshop by rail.
However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

8A.10 OPERATIONAL FEATURES

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.
An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

8A.11 INFRASTRUCTURE FACILITIES IN DEPOTS AT VASNA FOR NORTH SOUTH CORRIDOR AND AT APPAREL PARK FOR EAST WEST CORRIDOR

I. Inspection and Workshop facilities:

As indicated in 8A.8.2 & 8A.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 8A.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Para 8A.12.1 (a) & 8A.12.1 (b).

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 3-car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two trains Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two trains wheelers and four wheelers at the following points.
   - i) Close to the depot entry.
   - ii) Close to the stabling lines.
   - iii) Close to the Workshop/IBL.

b) Space for parking of road and re-railing equipments
Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated in Para 8A.12.1 (a) & 8A.12.1 (b). At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given in Para 8A.12.1(a), 8A.12.1 (b), Para 8A.12.2 (a) & 8A.12.2(b).

8A.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop at Vasna for North South Corridor and at Apparel Park for East West Corridor :

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.
b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is 'Live'.
c) Multi level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.
d) Pillars in the inspection bay & workshop should have provision for power sockets.
e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.
f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.
g) Control Centre, PPIO & store depot must be close to Workshop.
h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.
i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior of buildings for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

8A.12 LIST OF BUILDINGS & LIST OF PLANTS & EQUIPMENTS AT DEPOT-CUM-WORKSHOP AT VASNA FOR NORTH SOUTH CORRIDOR AND AT APPAREL PARK FOR EAST- WEST CORRIDOR

8A.12.1 (a) List of Buildings at Depot- Cum- Workshop at Depot Station at Vasna for North South Corridor:

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	166m x 21m • One way of 3 lines (2 trains of 3-cars in each line)	Servicing of Cars for 15 days & 45 days inspection. This shed will have scope of expansion by 3 lines (1 additional bay of 3 lines for future requirement).
	Workshop Shed	166m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	166m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	166m x 30m (initial provision for 12 rakes only)	Additional Earmarking of area as per requirement of stabling of total 32 rakes during year 2043 is to be made.
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M	80m x 30m (partly double	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot.

	repair shop	storey)	For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	40m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	166m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Watch Tower (4 Nos.)	3.6m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.

22.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
23.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

8A.12.1 (b) List of Buildings at Depot- Cum- Workshop at Depot Station at Apparel Park for East West Corridor

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	166m x 21m • One way of 3 lines (2 trains of 3-cars in each line)	Servicing of Cars for 15 days & 45 days inspection. This shed will have scope of expansion by 3 lines (1 additional bay of 3 lines for future requirement).
	Workshop Shed	166m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	166m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	166m x 45m (initial provision for 17 rakes only)	Additional Earmarking of area as per requirement of stabling of total 32 rakes during year 2043 is to be made.
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M	80m x 30m (partly double	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot.

	repair shop	storey)	For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	iii. Close to the depot entry. iv. Close to the stabling lines.
6.	Auto coach washing plant	40m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	166m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	iv. For track maintenance of section and depot. v. To weld rails for construction period only. vi. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Watch Tower (4 Nos.)	3.6m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.

22.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
23.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

8A.12.2 (a) List of Plants & Equipments at Depot-cum-Workshop at Vasna for North South Corridor:

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.

S. No.	Equipment	Qty.	Unit
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools	-	Set
28.	Measuring and testing equipment	-	Set
29.	Tool Kits	-	Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV for carrying of rerailing equipments	1	
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments	-	Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.
38.	Special jigs and fixtures and test benches for Rolling Stock	1	set
39.	Stackers (1T for DCOS)	2	No.
40.	Storage Racks (W/shop & DCOS stores)	1	Set
41.	Test benches	1	Set
42.	Auto panto strip thickness meter		-
43.	Vehicle mounted crane		-
44.	Impulse Tester for TMs		-
45.	Bearing puller		-

8A.12.2 (b) List of Plants & Equipments at Depot-cum-Workshop at Apparel Park for East West Corridor:

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.

S. No.	Equipment	Qty.	Unit
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools	-	Set
28.	Measuring and testing equipment	-	Set
29.	Tool Kits	-	Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV for carrying of rerailing equipments	1	
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments	-	Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.
38.	Special jigs and fixtures and test benches for Rolling Stock	1	set
39.	Stackers (1T for DCOS)	2	No.
40.	Storage Racks (W/shop & DCOS stores)	1	Set
41.	Test benches	1	Set
42.	Auto panto strip thickness meter		-
43.	Vehicle mounted crane		-
44.	Impulse Tester for TMs		-
45.	Bearing puller		-

Chapter - 9

Power Supply and System Parameters

Chapter – 9

POWER SUPPLY ARRANGEMENTS

9.1 POWER REQUIREMENTS

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

(i) Specific energy consumption of rolling stock – 75KWh/1000 GTKM
(ii) Regeneration by rolling stock – 20%
(iii) Elevated/at –grade station load – initially 250KW, which will increase to 400 KW in the year 2043
(iv) Underground station load – initially 2000 KW, which will increase to 2500 KW in the year 2043
(v) Depot auxiliary load - initially 2000 KW, which will increase to 2500 KW in the year 2043.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2018, 2021, 2031 and 2043 are summarized in table below:-

Table 9.1 Power Demand Estimation (MVA)

Corridor		Year			
		2018	**2021**	**2031**	**2043**
Corridor- I: APMC To Motera Stadium (North-South)	Traction	4.74	6.38	8.14	11.43
	Auxiliary	6.79	6.92	8.03	10.01
	Sub-total	**11.53**	**13.30**	**16.17**	**21.44**
Corridor- II: Thaltej Gam To Vastral Gam (East-West)	Traction	6.38	8.47	12.04	12.26
	Auxiliary	17.05	17.66	19.76	22.73
	Sub-total	**23.43**	**26.13**	**31.80**	**34.99**

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

9.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed Ahmedabad metro system is being designed to handle about 29,000 passengers per direction during peak hours when trains are expected to run at 2 minutes intervals. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 132 or 66kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

9.3 SOURCES OF POWER SUPPLY

The high voltage power supply network of Ahmedabad city was studied in brief. The city has 220, 132 and 66kV network to cater to various types of demand in vicinity of the proposed corridor. Series of meetings were held with M/s Torrent Power AEC Limited (Licensee of the area) and various sub-stations sites were inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, Four Receiving Sub-stations (two for N-S line and Two for E-W line) are proposed to be set up. This is an economical solution without compromising reliability. Based on the discussions with M/s Torrent AEC Ltd., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 or 66kV voltage through cable feeders: -

Table 9.2 - Sources of Power Supply

Corridor	Grid sub-station of Torent AEC Ltd. (Input voltage)	Location of RSS of Metro Authority	Approx. length of 132 or 66kV cables
APMC To Motera Stadium (North-South)	Pirana Grid sub-station (132kV)	Vasna Depot	5 km Transmission Line (Double circuit)
	Sabarmati Grid sub-station (132kV)	Sabarmati	1km. (Double circuit)
Thaltej Gam To Vastral Gam (East-West)	Thaltej Grid sub-station (132kV)	Thaltej	1km. (Double circuit)
	Grid sub-station Near Apparel Park	Apparel Park Depot	(Double circuit) To be idendified

M/s Torrent Power AEC Ltd in their letter dated 08/08/2005 & 03/09/2009 (Placed at Annexure-8.2) have asuured that reliable power supply from their 132 kV Sub-station will be provided. In view of this, during the details design stage, the locations of RSS and GSS may be reviewed/ fine tuned and finalized based on the updated status of power supply/ Sub-stations of M/s Torrent Power AEC Ltd. M/s Torrent Power AEC Ltd have been requested to confirm availability of power near Apparel Park Depot. The summary of expected power demand at various sources is given in table below.

Table 9.3 – Power Demand projections for various sources

Corridor	Input Source	Peak demand – Normal (MVA)		Peak demand* – Emergency (MVA)	
		Initial Year (2018)	Year (2043)	Initial Year (2018)	Year (2043)
APMC To Motera Stadium (North-South)	**Vasna RSS**				
	Traction	3.20	6.82	4.74	11.43
	Auxiliary	4.63	6.55	6.79	10.01
	Sub-total (A)	**7.82**	**13.37**	**11.53**	**21.44**
	Sabarmati RSS				
	Traction	1.54	4.61	4.74	11.43
	Auxiliary	2.16	3.46	6.79	10.01
	Sub-total (B)	**3.70**	**8.07**	**11.53**	**21.44**
Thaltej Gam To Vastral Gam (East-West)	**Thaltej RSS**				
	Traction	2.36	5.03	6.38	12.26
	Auxiliary	7.29	9.82	17.05	22.73
	Sub-total (C)	**9.65**	**14.85**	**23.43**	**34.99**
	Apparel Park				
	Traction	4.02	7.23	6.38	12.26
	Auxiliary	9.76	12.91	17.05	22.73
	Sub-total (D)	**13.78**	**20.14**	**23.43**	**34.99**

* **Incase of failure of other source of power**

The 132 kV power supply will be stepped down to 33 kV level at the RSS's of metro authority. The 33kV power will be distributed along the alignment through 33kV Ring main cable network for feeding traction and auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct and tunnel.

Interconnection of 33kV power supply between the two corridors has been planned at the Interchange station of Ashram Road which can be used for transfer of power from One corridor to other in emergency situations. In case of tripping of One RSS of either corridor on fault or input supply failure, train services can be maintained from stand-by source of the same line or RSS of other line the other RSS's. But if one more RSS fails, only curtailed services can be catered to. However, in case of total grid failure, all trains may come to a halt but station lighting, fire and hydraulics & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

Typical High Voltage Receiving Sub-station

The 132 kV cables will be laid through public pathways from Torrent Power AEC Sub-stations to RSS of Metro Authority. RSS at Vasna and Sabarmati RSS shall be provided with 2nos. (one as standby) 132/33 kV, 25 MVA (ONAN) three phase Transformers for feeding Traction as well as auxiliary loads and RSS near Thaltej and Apparel RSS shall be provided with 2nos. (one as standby) 132/33 kV, 40 MVA (ONAN) three phase Transformers. The capacity of transformers may be reviewed considering the load requirement/distribution of both the corridors at the time of detailed design.

Conventional Outdoor type 132 kV Switchgear is proposed for all the RSS to be located in approx. 80 X 60 m (4800 sq. m) land plot as the availability of Land in this area may not be a constraint. If Gas Insulated Switchgear (GIS) type Switchgear will be planned in future due to less space and reduced maintenance the capital cost need to be enhanced. The typical RSS layout is given in figure below:

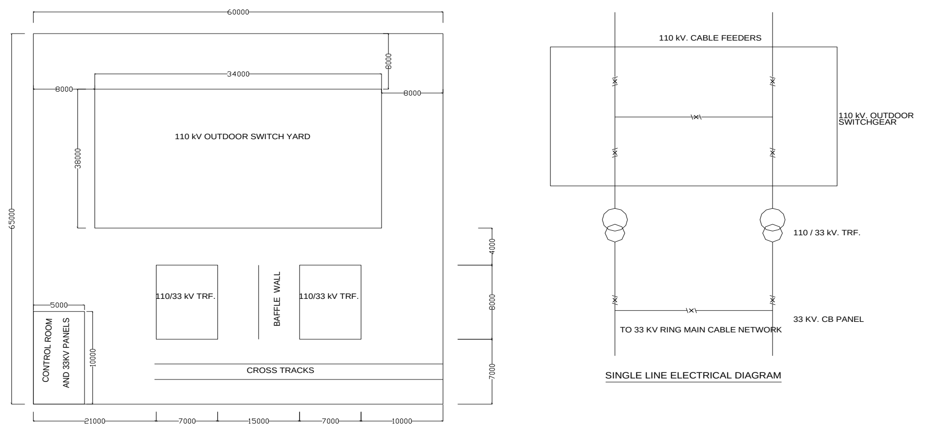
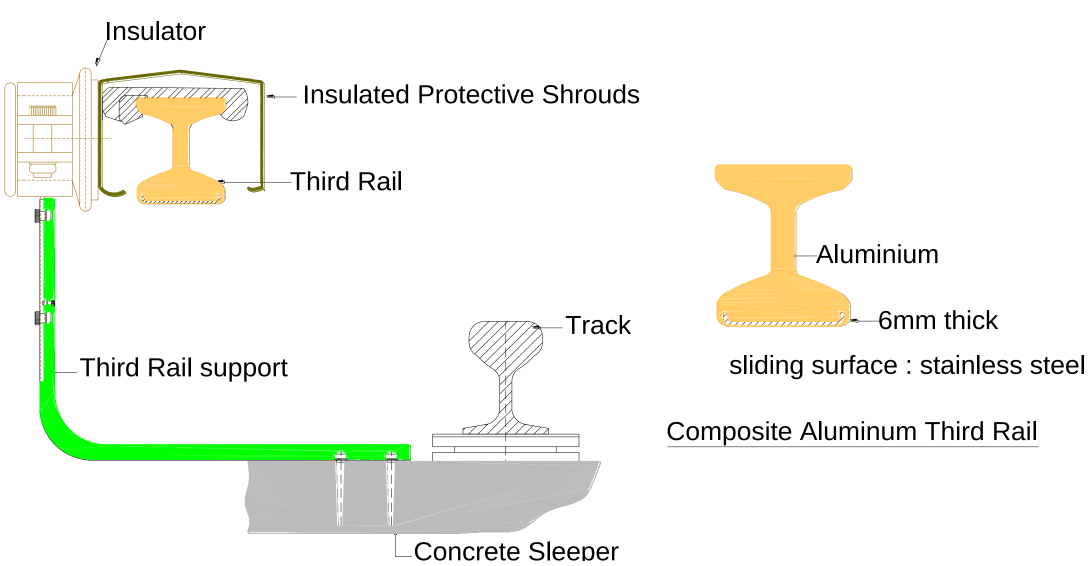


FIGURE 8.1 --TYPICAL 110/33kV RSS LAYOUT

9.4 750V DC THIRD RAIL CURRENT COLLECTION SYSTEM

For the 750V dc Third Rail Current Collection System, Bottom current collection with the use of composite Aluminum steel third rail on main lines is envisaged from reliability and safety considerations (figure below). Low carbon steel third rail available indigenously is proposed for the depot because of reduced current requirements.



750V dc Third Rail Current Collection System

The cross-section of third rail will be about 5000 mm². The longitudinal resistance of composite and steel third rail is about 7 and 20 milli-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

9.5 TRACTION SUB-STATIONS (33KV/750V DC)

Traction sub-stations (33kV/750V dc) are required to be set up for feeding 750V dc power supply to the third rail. In order to cater to traction load as per train operation plan, it is envisaged to provide traction sub-stations (TSS) at alternate stations. The TSS along with Auxiliary Sub-Stations (ASS) will be located at station building itself at mezzanine or platform level inside a room. The typical layouts for TSS & ASS are given in figure below. The requirement comes to 7 TSS for Corridor – 1 and 9 TSS for Corridor – 2. An additional TSS will be located in each maintenance depot. Thus the total requirement of TSS works out to 8 and 10 for the Corridor – 1 and Corridor – 2 respectively.

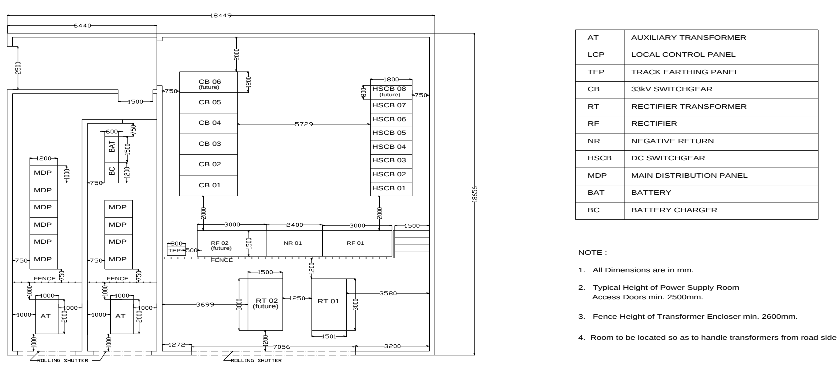


FIGURE 8.2 -- TYPICAL LAYOUT OF TSS-cum-ASS

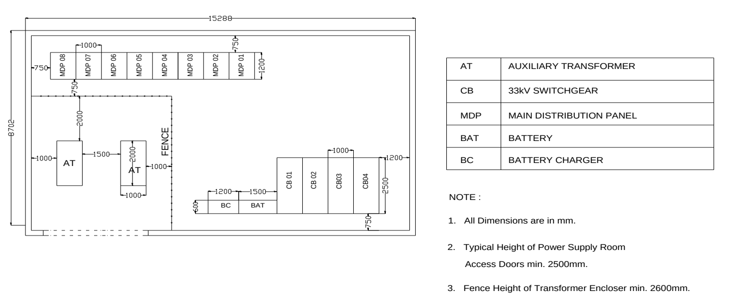


FIGURE 8.3 -- TYPICAL ASS LAYOUT

9.6 STRAY CURRENT CORROSION PROTECTION MEASURES

9.6.1 Concept of dc Stray Current Corrosion

In dc traction systems, bulk of return current finds its path back to the traction sub-station via the return circuit i.e. running rails. The running rails are normally insulated to minimize leakage of currents to the track bed. However, due to leaky conditions, some current leakage takes place, which is known as 'stray current'. The current follows the path of least resistance. Return current deviates from its intended path if the resistance of the unintended path is lower than that of intended path. The stray current may flow through the unintended path of metallic reinforcements of the structure back to the sub-station. It is also possible that part of the stray current may also flow into soil, where it may be picked up by metallic utilities and discharged back to soil and then to near the sub-station.
The dc stray currents cause metal detraction in watery electrolytes as per the following chemical reactions:-

- Stray current enters in the metal
  $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (development of Hydrogen gas)

- Stray current exits from metal
  $Fe \rightarrow Fe^{2+} + 2e^-$ (Fe^{2+} ions migrate away from the metal)

That is how, dc stray currents cause corrosion of metallic structure where it leaves the metal. This is shown in figure below. Pitting and general form of corrosion are most often encountered on dc electrified railways.

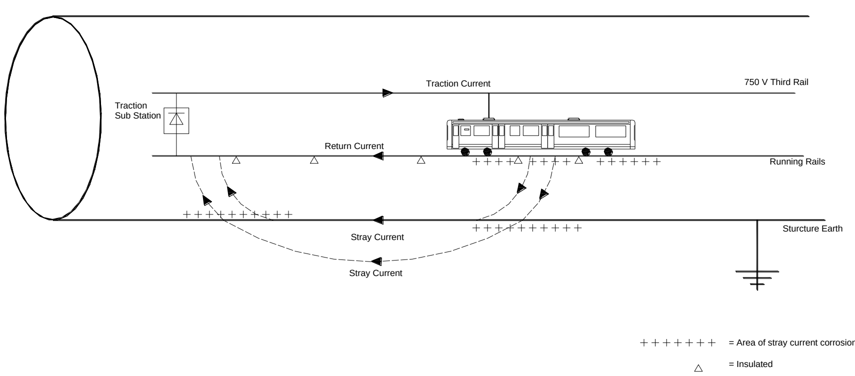


FIGURE 8.4 -- DC TRACTION SYSTEM : STRAY CURRENT CORROSION CONCEPT

9.6.2 Effect of Corrosion

Detraction rate of metals can be calculated by Faraday's First Law:

m	=	c.i.t
Where m	**=**	**mass (kg)**
c	=	Coefficient of detraction (kg/Amp.year)
i	=	Current (Amp)
t	=	time (year)
c	=	2.90 for Aluminium
	=	33.80 for Lead
	=	9.13 for Iron
	=	10.4 for Copper

That means dc stray current of 1 – ampere flowing continuously can eat away approx. 9 kg of steel in a year. If 5000 amperes of current flows for one year to power the trains on a transit system, and that 2 percent of this current (100 amperes) leaks as stray current, the amount of steel metal loss is 0.9 ton per year. Therefore, the safety implications are considerable for structural reinforcements. In addition, corrosion may also affect neighboring infrastructure components such as buried pipelines and cables.

9.6.3 Measures for Protection against Stray Current Corrosion

Earthing & bonding and protection against stray current corrosion are inter-related and conflicting issues. Therefore, suitable measures are required to suppress the stray currents as well as the presence of high touch potentials. Safety of personnel is given preference even at a cost of slightly increased stray currents. Following measures are required to restrict the stay current:-

(i) Decreasing the resistance of rail-return circuit
(ii) Increasing the resistance of rail to ground insulation

Whenever buried pipes and cables are in the vicinity of dc systems, efforts shall be made to ensure that metal parts are kept away as far as practicable to restrict stray current. A minimum distance of 1 meter has been found to be adequate for this purpose.

Generally, three types of earthing arrangements (viz. Earthed System, Floating System & Hybrid Earthing System) are prevalent on metros World over for protection against stray current corrosion. Traditionally, Earthed system was used by old metros. Hybrid earthing system is being tried on experimental basis on few new metros. Floating system has been extensively used by recent metros. As per global trends, floating system (i.e. traction system with floating negative) is preferred. It reduces the dc stray current considerably. The arrangement shall comply with the following latest CENELEC standards:-

- EN 50122-1:- Railway Applications (fixed installations) protective provisions relating to electrical safety & earthing

- EN 50122-2:- Railway Applications (fixed installations) protective provisions against the effects of stray currents caused by dc traction system

The conceptual scheme of the proposed floating system is described as follows:-

i) The running rails shall be adequately insulated as per EN50122-2. The recommended conductance per unit length for single track sections are as under:-

- Elevated section :- 0.5 Siemens/Km
- Tunnel section :- 0.1 Siemens/Km.

ii) Stray Current Collector Cables {commonly known as structural earth (SE) cable} (2x200 mm^2 copper) shall be provided along the viaduct and all the metallic parts of equipment, cable sheath, viaduct reinforcement, signal post etc. shall be connected to SE cable.

iii) The continuity of the reinforcement bars of the viaduct as well as track slabs has to be ensured along with a tapping point for connection with SE cable in order to drain back the stray current. The typical arrangement of connecting the reinforcements of viaduct is shown in figure beow.

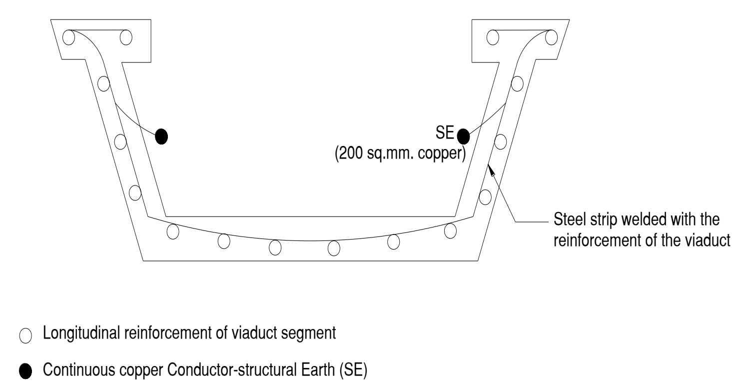


FIGURE 8.5 -- CONNECTION OF SE CONDUCTOR TO STEEL REINFORCEMENT OF VIADUCT SEGEMENT

iv) A provision shall be made to earth the running rail (i.e. negative bus) in case of rail potential being higher than limits prescribed (120V) in relevant standard (EN 50122-1) in order to ensure safety of personnel. This will be achieved by providing track earthing panel (TEP) at stations close to platform and at traction sub-stations.

v) In addition, provisions shall be made for connection of SE cable to negative return path through diode only for the purpose of periodical monitoring of stray currents. Under normal operations, switch provided for this connection will be in normally open (NO) position and switch will be closed for monitoring of stray current once or twice in a year as required.

The proposed scheme is shown in figure below.

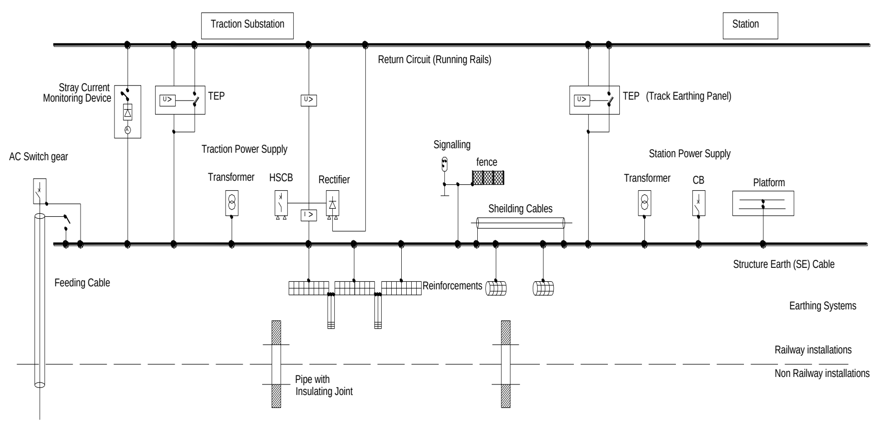


FIGURE 8.6 -- BASIC DIGRAM FOR EARTHING , BONDING AND STRAY CURRENT PROTECTION MEASURES

9.6.4 Special Arrangements in Depot

A separate traction sub-station (TSS) shall be provided for the depot so as to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area. Tracks of Depot area shall also be isolated from mainline through insulated rail joints (IRJ). Remote operated sectionalizing switches shall be provided to feed power from depot to mainline and vice-versa in case of failure of TSS.

The prescribed limit of highest touch potential in depot is 60V as per EN50122-1 and therefore Track Earthing Panels (TEP) shall be provided at suitable locations to earth the rail in case the rail potential exceeds this limit. In areas, where leaky conditions exist (e.g. washing lines, pit wheel lathe etc.), insulated rail joints (IRJ) shall be provided with power diodes to bridge the IRJ to facilitate passage of return current.

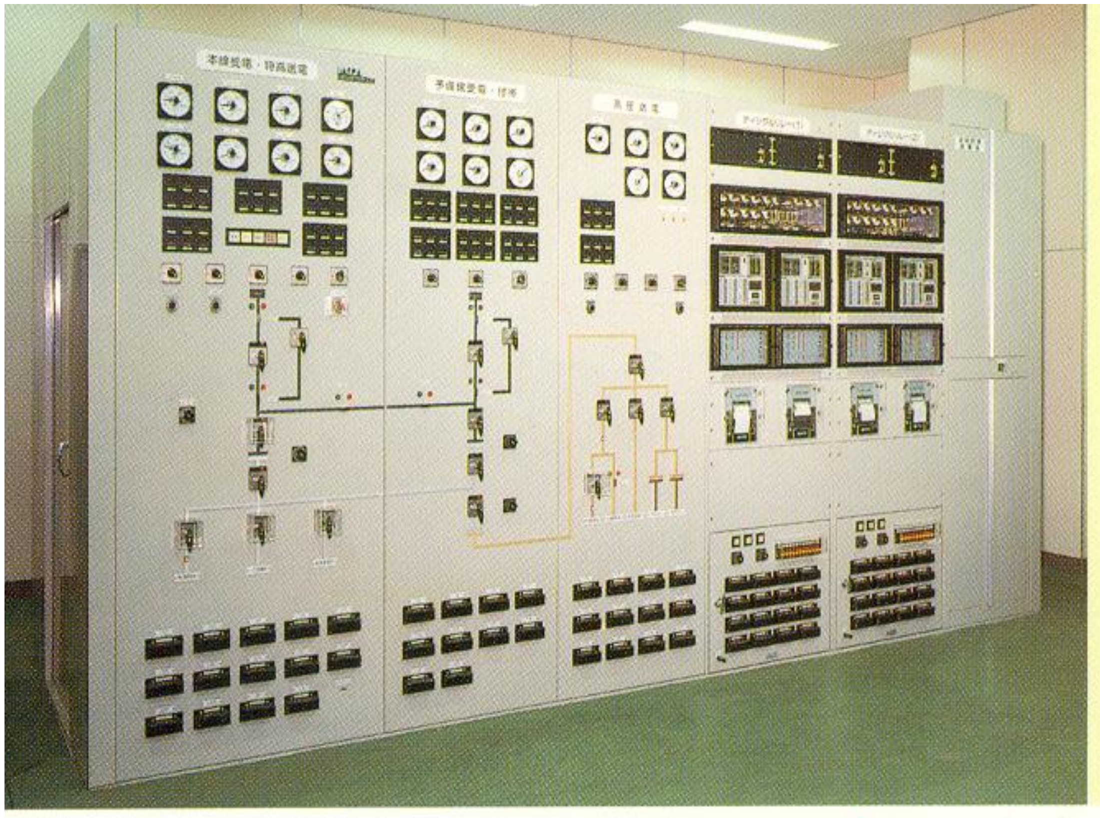
A detailed scheme shall be developed during the design stage.

9.6.5 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. However, dc traction currents do not cause electromagnetic induction effect resulting in induced voltages and magnetic fields.
The rectifier-transformer used in dc traction system produces harmonic voltages, which may cause interference to telecommunications and train control/protection systems. The rectifier-transformer shall be designed with the recommended limits of harmonic voltages, particularly the third and fifth harmonics. 12-pulse rectifier-transformer has been proposed, which reduces the harmonics level considerably. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMC plan will be required to be developed during project implementation stage.

9.6.6 Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. A separate ASS is required at each depot. The ASS will be located at mezzanine or platform level inside a room. Wherever TSS is required, ASS & TSS will be housed together inside a room. The auxiliary load requirements have been assessed at 400 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the stations (one transformer as standby). Both the Depot ASSs will also be provided with 2x2500 kVA auxiliary transformers. For Underground station, the auxiliary load requirements have been assessed at 2500 kW, accordingly, two dry type cast resin transformers (33/0.415kV) of 3200kVA capacity are proposed to be installed at the stations (with one transformer as standby).



Typical Indoor Auxiliary Sub-station

2x2.5MW transformer-rectifier set shall be provided in each TSS with space provisions for an additional set to be accommodated in future as and when train composition is increased. Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. From the traction sub-stations, 750V dc cables will be laid up to third rail and return current cables will be connected to running rails.

9.7 RATING OF MAJOR EQUIPMENT

Based on emergency demand expected at each RSS as shown in Table 9.3 above, and expected power demand during congestion, Vasna and Sabarmati RSS shall be provided with 2nos. of (One to be in service and one as standby) 132kV, 25 MVA three phase transformers for feeding traction and auxiliary loads. RSS near Thaltej and Apparel Park hall be provided with 2nos. of (One to be in service and one as standby) 132/33kV, 40 MVA three phase auxiliary transformers for feeding traction and auxiliary loads. The incoming cable shall be 3-phase single core XLPE insulated with 630mm^2 Aluminum conductor to meet the normal & emergency loading requirements and fault level of the 132kV supply.

Traction transformer-rectifier set (33kV/750V dc) shall be of 2.5MW rated capacity with overload requirement of 150% for 2 hours with four intermittent equally spaced overloads of 300% for 1 minute, and with one 450% full load peak of 15 seconds duration at the end of 2 hour period. The traction transformer - rectifier set shall produce 750V dc nominal output voltage with 12-pulse rectification so as to minimize the ripple content in the output dc voltage. The IEC 850 international standard envisages the minimum and maximum voltages of 500V and 900V respectively for 750V dc traction system and therefore, the dc equipment shall be capable of giving desired performance in this voltage range.

33kV cable network shall be adequately rated to transfer requisite power during normal as well as emergency situations and to meet the fault current requirement of the system. FRLSOH cable for Underground section and FRLS Cable for Elevated section. Accordingly, proposed 33kV cables sizes are as under:-

- 3, Single core x 240 mm^2 Copper conductor XLPE insulated for 33kV ring main cable network for corridor - 1.

- 3, Single core 400 mm^2 Copper conductor XLPE insulated for 33kV ring main cable network for corridor - 2.

Adequate no. of cables are required for transfer of power from TSS to third rail. Single-phase XLPE insulated cables with $300mm^2$ copper conductor are proposed for 750V dc as well as return current circuit. Based on current requirements, 3 cables are required for each of the three circuits to feed power to third rail.
The above capacities of transformers, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised for better accuracy during design stage of project implementation.

9.8 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 200 KVA capacity at the elevated stations and 2 X 1000 KVA at Underground stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system
(vi) Tunnel Ventilation (for Underground Stations).

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

9.9 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 provided for telecommunications will be used as communication carrier for SCADA system.
Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 750V dc switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

9.10 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 Ahmedabad Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

(ii) 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.

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-room less type lifts with gearless drive have been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) have been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

9.11 ELECTRIC POWER TARIFF

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25-35% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 27.83 million units for Corridor – I and 60.45 Million units for Corridor – II in initial years (2018), which will be about 58.95 Million Units and 93.57 Million Units respectively in the year 2043. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for Ahmedabad Metro should be at effective rate of purchase price (at 132 kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 4.50 – 5.00 per unit. It is proposed that Government of Gujrat takes necessary steps to fix power tariff for Ahmedabad Metro at "No Profit No Loss" basis. Similar approach has been adopted for Delhi Metro.

Approximate Energy Consumption	AHMEDABAD METRO																			
CORRIDOR - 1 (North-South)	**APMC To Madalpur**								**Madalpur To Motera Stadium**								**APMC To Motera Stadium**			
Year	**Year 2018**		**Year 2021**		**Year 2031**		**Year 2043**		**Year 2018**		**Year 2021**		**Year 2031**		**Year 2043**		**Year-2016**	**Year-2021**	**Year-2031**	**Year-2043**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17=1+9	18=3+11	19=5+13	20=7+15
LENGTH (KM)	4.68	KM	4.68	KM	4.68	KM	4.68	KM	10.31	KM	10.31	KM	10.31	KM	10.31	KM	14.99	14.99	14.99	14.99
No. of trains per direction in a day*	54		84		108		168		108		168		216		336					
WEIGHT OF TRAIN & PASSENGER	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T				
SFC (NET) with20% regen	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM				
Yearly Traction Energy consumption with 365 days working with 20% regen	**2.03**	**million units**	**3.16**	**million units**	**4.06**	**million units**	**6.32**	**million units**	**8.94**	**million units**	**13.90**	**million units**	**17.87**	**million units**	**27.81**	**million units**				
Station aux power requirement																				
Elevated/at-grade station	0.25	MW	0.25	MW	0.30	MW	0.40	MW	0.25	MW	0.25	MW	0.30	MW	0.40	MW				
U/G station	2.00	MW	2.10	MW	2.40	MW	2.50	MW	2.00	MW	2.10	MW	2.40	MW	2.50	MW				
no. of elevated/at-grade stations	5		5		5		5		9		9		9		9		14	14	14	14
no. of U/G stations	0		0		0		0		0		0		0		0		0	0	0	0
Total Station Aux Power requirement	1.25	MW	1.25	MW	1.50	MW	2.00	MW	2.25	MW	2.25	MW	2.70	MW	3.60	MW	3.50	3.50	4.20	5.60
Depot Aux power requirement	2.0	MW	2.1	MW	2.3	MW	2.5	MW	0.00	MW	0.00	MW	0.00	MW	0.00	MW	2.00	2.10	2.30	2.50
Total Aux Power requirement	3.25	MW	3.35	MW	3.80	MW	4.50	MW	2.25	MW	2.25	MW	2.70	MW	3.60	MW	5.50	5.60	6.50	8.10
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**4.01**	**MVA**	**4.14**	**MVA**	**4.69**	**MVA**	**5.56**	**MVA**	**2.78**	**MVA**	**2.78**	**MVA**	**3.34**	**MVA**	**4.45**	**MVA**	**6.79**	**6.92**	**8.03**	**10.01**
Diversity factor of aux loads	0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40					
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	**9.96**	**million units**	**10.27**	**million units**	**11.65**	**million units**	**13.80**	**million units**	**6.90**	**million units**	**6.90**	**million units**	**8.28**	**million units**	**11.04**	**million units**	**16.86**	**17.17**	**19.93**	**24.83**
Net Annual Energy Consumption (Traction & Aux)	**11.99**	**million units**	**13.43**	**million units**	**15.71**	**million units**	**20.11**	**million units**	**15.84**	**million units**	**20.80**	**million units**	**26.15**	**million units**	**38.84**	**million units**	**27.83**	**34.23**	**41.86**	**58.95**

Annexure 8.1

POWER REQUIREMENTS	AHMEDABAD METRO																			
CORRIDOR - 1 (North-South)	APMC To Madalpur								Madalpur To Motera Stadium								APMC To Motera Stadium			
	Year 2018		Year 2021		Year 2031		Year 2043		Year 2018		Year 2021		Year 2031		Year 2043		Year-2018	Year-2021	Year-2031	Year-2043
Traction power requirements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17=1+9	18=3+11	19=5+13	20=7+15
No of cars	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)				
Passenger weight	63	T	63	T	63	T	63	T	63	T	63	T	63	T	63	T				
Train Tare weight	120	T	120	T	120	T	120	T	120	T	120	T	120	T	120	T				
Total train weight	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T				
Section length	4.68	KM	4.68	KM	4.68	KM	4.68	KM	10.31	KM	10.31	KM	10.31	KM	10.31	KM	14.99	14.99	14.99	14.99
Headway	12	mts	8	mts	6	mts	4	mts	6	mts	4	mts	3	mts	2	mts				
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM				
No. of trains/hr in both directions	10		15		20		30		20		30		40		60					
Peak traction power requirement	0.64	MW	0.97	MW	1.29	MW	1.93	MW	2.83	MW	4.25	MW	5.67	MW	8.50	MW				
Less Regeneration @ 20%	0.13	MW	0.19	MW	0.26	MW	0.39	MW	0.57	MW	0.85	MW	1.13	MW	1.70	MW				
Depot power requirements	1.50	MW	1.6	MW	1.8	MW	2	MW	0.00	MW	0.00	MW	0.00	MW	0.00	MW				
Total traction power requirement	2.01	MW	2.37	MW	2.83	MW	3.54	MW	2.27	MW	3.40	MW	4.53	MW	6.80	MW	4.28	5.77	7.36	10.35
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**2.23**	**MVA**	**2.62**	**MVA**	**3.13**	**MVA**	**3.92**	**MVA**	**2.51**	**MVA**	**3.76**	**MVA**	**5.01**	**MVA**	**7.52**	**MVA**	**4.73**	**6.38**	**8.14**	**11.44**
Aux. power requirements																				
Elevated/at-grade station--power consumption	0.25	MW	0.25	MW	0.30	MW	0.40	MW	0.25	MW	0.25	MW	0.30	MW	0.40	MW				
Underground station--power consumption	2.00	MW	2.10	MW	2.30	MW	2.50	MW	2	MW	2.10	MW	2.40	MW	2.50	MW				
No. of elevated/at-grade stations	5		5		5		5		9		9		9		9		14	14	14	14
No. of Underground stations	0		0		0		0		0		0		0		0		0	0	0	0
Total Station Aux Power requirement	1.25	MW	1.25	MW	1.50	MW	2.00	MW	2.25	MW	2.25	MW	2.70	MW	3.60	MW				
Depot Aux power requirement	2	MW	2.1	MW	2.3	MW	2.5	MW	0	MW	0.00	MW	0.00	MW	0.00	MW				
Total Aux Power requirement	3.25	MW	3.35	MW	3.80	MW	4.50	MW	2.25	MW	2.25	MW	2.70	MW	3.60	MW	5.50	5.60	6.50	8.10
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**4.01**	**MVA**	**4.14**	**MVA**	**4.69**	**MVA**	**5.56**	**MVA**	**2.78**	**MVA**	**2.78**	**MVA**	**3.34**	**MVA**	**4.45**	**MVA**	6.79	6.92	8.03	10.01
Total traction & aux power requirement (MVA)	**6.24**	**MVA**	**6.76**	**MVA**	**7.82**	**MVA**	**9.48**	**MVA**	**5.29**	**MVA**	**6.54**	**MVA**	**8.35**	**MVA**	**11.96**	**MVA**	**11.53**	**13.30**	**16.17**	**21.44**

Note: The requirement of PD load is not consided in estimation of power calculation.

Annexure 8.1

Approximate Energy Consumption	AHMEDABAD METRO																											
CORRIDOR - 2 (East-West)	**Thaltej Gam To Ashram Road**								**Ashram Road To Apparel Park**								**Apparel Park To Vastral Gam**								**Thaltej Gam To Vastral Gam**			
Year	**Year 2018**		**Year 2021**		**Year 2031**		**Year 2043**		**Year 2018**		**Year 2021**		**Year 2031**		**Year 2043**		**Year 2018**		**Year 2021**		**Year 2031**		**Year 2043**		**Year-2018**	**Year-2021**	**Year-2031**	**Year-2043**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25=1+9+17	26=3+11+19	27=5+13+21	28=7+15+23
LENGTH (KM)	7.42	KM	7.42	KM	7.42	KM	7.42	KM	7.31	KM	7.31	KM	7.31	KM	7.31	KM	5.52	KM	5.52	KM	5.52	KM	5.52	KM	20.25	20.25	20.25	20.25
No. of trains per direction in a day'	82		108		168		168		164		216		336		336		82		108		168		168					
WEIGHT OF TRAIN & PASSENGER	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T				
SFC (NET) with20% regen	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM	60	KWH/ 1000 GTKM				
Yearly Traction Energy consumption with 365 days working with 20% regen	**4.88**	million units	**6.43**	million units	**10.0**	million units	**10.0**	million units	**9.62**	million units	**12.67**	million units	**19.72**	million units	**19.72**	million units	**3.63**	million units	**4.78**	million units	**7.44**	million units	**7.44**	million units	18.14	23.89	37.16	37.16
Station aux power requirement																												
Elevated/at-grade station	0.25	MW	0.25	MW	0.30	MW	0.40	MW	0.25	MW	0.25	MW	0.30	MW	0.40	MW	0.25	MW	0.25	MW	0.30	MW	0.40	MW				
U/G station	2.00	MW	2.10	MW	2.40	MW	2.50	MW	2.0	MW	2.10	MW	2.40	MW	2.50	MW	2.00	MW	2.10	MW	2.40	MW	2.50	MW				
no. of elevated/at-grade stations	8		8		8		8		1		1		1		1		5		5		5		5		14	14	14	14
no. of U/G stations	0		0		0		0		4		4		4		4		0		0		0		0		4	4	4	4
Underground Mid Shaft Power Consumption	0	MW	0	MW	0	MW	0	MW	0.30	MW	0.30	MW	0.30	MW	0.30	MW	0	MW	0	MW	0	MW	0	MW				
No. of Mid Shaft	0		0		0		0		1		1		1		1		0		0		0		0					
Total Station Aux Power requirement	2.00	MW	2.00	MW	2.40	MW	3.20	MW	8.55	MW	8.95	MW	10.20	MW	10.70	MW	1.25	MW	1.25	MW	1.50	MW	2.00	MW	11.80	12.20	14.10	15.90
Depot Aux power requirement	0.0	MW	0	MW	0	MW	0	MW	2.0	MW	2.1	MW	2.3	MW	2.5	MW	0.00	MW	0.00	MW	0.00	MW	0.00	MW	2.00	2.10	2.30	2.50
Total Aux Power requirement	2.0	MW	2.0	MW	2.40	MW	3.20	MW	10.55	MW	11.05	MW	12.50	MW	13.20	MW	1.25	MW	1.25	MW	1.50	MW	2.00	MW	13.80	14.30	16.40	18.40
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**2.47**	**MVA**	**2.47**	**MVA**	**2.96**	**MVA**	**3.95**	**MVA**	**13.03**	**MVA**	**13.65**	**MVA**	**15.44**	**MVA**	**16.31**	**MVA**	**1.54**	**MVA**	**1.54**	**MVA**	**1.85**	**MVA**	**2.47**	**MVA**	**17.05**	**17.66**	**20.26**	**22.73**
Diversity factor of aux loads	0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40					
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	**6.13**	**millio n units**	**6.13**	**million units**	**7.36**	**million units**	**9.81**	**million units**	**32.35**	**million units**	**33.88**	**million units**	**38.33**	**millio n units**	**40.47**	**million units**	**3.83**	**million units**	**3.83**	**million units**	**4.60**	**million units**	**6.13**	**million units**	**42.31**	**43.84**	**50.28**	**56.41**
Net Annual Energy Consumption (Traction & Aux)	**11.01**	**millio n units**	**12.56**	**million units**	**17.36**	**million units**	**19.81**	**million units**	**41.97**	**million units**	**46.55**	**million units**	**58.04**	**millio n units**	**60.19**	**million units**	**7.46**	**million units**	**8.62**	**million units**	**12.04**	**million units**	**13.57**	**million units**	**60.45**	**67.73**	**87.44**	**93.57**

Note: The requirement of PD load is not consided in estimation of energy calculation.

Annexure 8.1

POWER REQUIREMENTS	AHMEDABAD METRO																											
CORRIDOR - 2 (East-West)	Thaltej Gam To Ashram Road								Ashram Road To Apparel Park								Apparel Park To Vastral Gam								Thaltej Gam To Vastral Gam			
	Year 2018		Year 2021		Year 2031		Year 2043		Year 2018		Year 2021		Year 2031		Year 2043		Year 2018		Year 2021		Year 2031		Year 2043		Year-2018	Year-2021	Year-2031	Year-2043
Traction power requirements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25=1+9+17	26=3+11+19	27=5+13+21	28=7+15+23
No of cars	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)	3	(2DMC+1TC)				
Passenger weight	63	T	63	T	63	T	63	T	63	T	63	T	63	T	63	T	63	T	63	T	63	T	63	T				
Train Tare weight	120	T	120	T	120	T	120	T	120	T	120	T	120	T	120	T	120	T	120	T	120	T	120	T				
Total train weight	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T	183	T				
Section length	7.42	KM	7.42	KM	7.42	KM	7.42	KM	7.31	KM	7.31	KM	7.31	KM	7.31	KM	5.52	KM	5.52	KM	5.52	KM	5.52	KM	20.25	20.25	20.25	20.25
Headway	8.5	mts	6	mts	4	mts	4	mts	4.25	mts	3	mts	2	mts	2	mts	8.5	mts	6	mts	4	mts	4	mts				
Specific Energy consumption	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM	75	KWhr/ 1000 GTKM				
No. of trains/hr in both directions	14		20		30		30		28		40		60		60		14		20		30		30					
Peak traction power requirement	1.44	MW	2.04	MW	3.06	MW	3.06	MW	2.84	MW	4.02	MW	6.03	MW	6.03	MW	1.07	MW	1.52	MW	2.28	MW	2.28	MW				
Less Regeneration @ 20%	0.29	MW	0.41	MW	0.61	MW	0.61	MW	0.57	MW	0.80	MW	1.21	MW	1.21	MW	0.21	MW	0.30	MW	0.46	MW	0.46	MW				
Depot power requirements	0.00	MW	0	MW	0	MW	0	MW	1.50	MW	1.60	MW	1.80	MW	2	MW	0.00	MW	0.00	MW	0.00	MW	0.00	MW				
Total traction power requirement	1.15	MW	1.63	MW	2.45	MW	2.45	MW	3.77	MW	4.82	MW	6.62	MW	6.82	MW	0.86	MW	1.21	MW	1.82	MW	1.82	MW	5.78	7.66	10.89	11.09
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**1.27**	**MVA**	**1.80**	**MVA**	**2.70**	**MVA**	**2.70**	**MVA**	**4.17**	**MVA**	**5.32**	**MVA**	**7.32**	**MVA**	**7.54**	**MVA**	**0.95**	**MVA**	**1.34**	**MVA**	**2.01**	**MVA**	**2.01**	**MVA**	**6.39**	**8.47**	**12.04**	**12.26**
Aux. power requirements																												
Elevated/at-grade station--power consumption	0.25	MW	0.25	MW	0.30	MW	0.40	MW	0.25	MW	0.25	MW	0.30	MW	0.40	MW	0.25	MW	0.25	MW	0.30	MW	0.40	MW				
Underground station--power consumption	2.00	MW	2.10	MW	2.30	MW	2.50	MW	2.00	MW	2.10	MW	2.30	MW	2.50	MW	2	MW	2.10	MW	2.40	MW	2.50	MW				
Underground Mid Shaft Power Consumption	0	MW	0	MW	0	MW	0	MW	0.30	MW	0.30	MW	0.30	MW	0.30	MW	0	MW	0	MW	0	MW	0	MW				
No. of Mid Shaft	0		0		0		0		1		1		1		1		0		0		0		0					
No. of elevated/at-grade stations	8		8		8		8		1		1		1		1		5		5		5		5		14	14	14	14
No. of Underground stations	0		0		0		0		4		4		4		4		0		0		0		0		4	4	4	4
Total Station Aux Power requirement	2.00	MW	2.00	MW	2.40	MW	3.20	MW	8.55	MW	8.95	MW	9.80	MW	10.70	MW	1.25	MW	1.25	MW	1.50	MW	2.00	MW				
Depot Aux power requirement	0	MW	0	MW	0	MW	0	MW	2.0	MW	2.1	MW	2.3	MW	2.5	MW	0	MW	0.00	MW	0.00	MW	0.00	MW				
Total Aux Power requirement	2.0	MW	2.0	MW	2.40	MW	3.20	MW	10.55	MW	11.05	MW	12.10	MW	13.20	MW	1.25	MW	1.25	MW	1.50	MW	2.00	MW	13.80	14.30	16.00	18.40
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**2.47**	**MVA**	**2.47**	**MVA**	**2.96**	**MVA**	**3.95**	**MVA**	**13.03**	**MVA**	**13.65**	**MVA**	**14.95**	**MVA**	**16.31**	**MVA**	**1.54**	**MVA**	**1.54**	**MVA**	**1.85**	**MVA**	**2.47**	**MVA**	17.05	17.66	19.76	22.73
Total traction & aux power requirement (MVA)	**3.74**	**MVA**	**4.27**	**MVA**	**5.67**	**MVA**	**6.66**	**MVA**	**17.20**	**MVA**	**18.97**	**MVA**	**22.27**	**MVA**	**23.85**	**MVA**	**2.49**	**MVA**	**2.89**	**MVA**	**3.86**	**MVA**	**4.48**	**MVA**	**23.43**	**26.13**	**31.80**	**34.99**

Note: The requirement of PD load is not consided in estimation of power calculation.

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Annexure-8.2

Ref : M2/4/ 416

8th August, 2005.

The Chief Electrical Engr.-II, (Metro Corridor),
Delhi Metro Rail Corpn. Ltd.,
NBCC Place,
Bhishma Pitamaha Marg,
Pragati Vihar,
NEW DELHI-110 003.

Kind Attn : Mr. Sharat Sharma.

Dear Sir,

Sub. : Power supply requirement for the proposed Ahmedabad Metro System.

With reference to yours & Mr. Anil Kumar's visit to our Office on 13th July, 2005, and the discussion held with undersigned, and our senior officers, for power requirement for the proposed Metro Rail System. As informed in phase I, Metro will be between Vishala to Akshardham circle (Vasna) (Gandhinagar) via Ashram Road and from Ahmedabad Railway Station to Thaltej.

Your requirement of power is at three locations viz. Sabarmati, Thaltej and Vishala/Vasana. The total approximate requirement will be about 30 MW @ each of the location.

Our comments are as under :

a) At Sabarmati Thermal Station power can be made available at 132 kv. However, evacuation can be done only through 132 kv cables, as it is not possible to lay 132 kv OH lines.
b) At our Thaltej S/s., power can be made available.
c) At Vishala you have suggested to give supply from our 66 kv Vasana S/s. We had conveyed that at our Vasana S/s, we do not have adequate margin of supply. Requisite power to Vishala supply point can be made available only with supply from our 132 kv Pirana S/s, by installing new 132 kv Line and establishing a new Sub-station near Vishala.

It may be noted that the above addition/ extension will be on chargeable basis only.

If you require any further details, kindly let us know.

Thanking you,

Yours faithfully,
Torrent Power AEC Limited.

(K.K. Shah)
Vice President (T & D)

TORRENT POWER AEC LIMITED
Jubilee House, Shahpur, Ahmedabad-380 001. Phone : 079-25502881, Fax : 079 25501510
Regd. Office:Electricity House, Lal Darwaja, Ahmedabad-380 001. Phone:079 25502881, Fax : 079 25506386
Website : www.torrentpower.com

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Annexure-8.2

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POWER

Electricity House,
Lal Darwaja,
Ahmedabad 380 001
Phone: 079 25502881
Fax: 079 25506386

3rd Sept., 2009

Mr. Sharat Sharma
Executive Director (Electrical)
Delhi Metro Rail Corporation
B-7 Metro Bhavan, Fire Brigade Lane,
Barakhamba Road,
New Delhi 110 001

Dear Sir,

Sub: - Metro Rail System – Ahmedabad / Gandhinagar

This is in reference to the discussions we had with you at our office on 28th August, 2009 for the above. We are thankful to you for providing valuable technical information & briefing on the requirements of metro system.

The three metro rail routes projected for the first phase operations are:

(1) APMC Market - Akshardham
(2) Kalupur –Thaltej and
(3) Airport – Koba – GIFT city

The projected power required for the above routes was indicated as 80 MW (Normal) / 120 MW (Emergency) at four locations on 132 KV Voltage level inclusive of redundancy.

The locations of Torrent Power Limited (TPL) power feed points were suggested near Thaltej, Sabarmati, Koba & Airport with provision of two 132 KV electrical bays at each locations for the metro system.

Considering the above requirements, TPL's present network scenario and non availability of exact implementation schedule and priorities of the routes (and hence power) since it will be planned later on by Gujarat Urban Development Corporation Limited (GUDCL), TPL indicated that the 132 KV SS locations in TPL network such as Pirana, Prahladnagar & ISRO SS on APMC market end side; Naranpura and Dudheshwar on Sabarmati side and IT Park on Koba side are also possible from where either two or one electrical bay can be provided. The power from these substations will also be equally reliable. As explained by TPL during the meeting, TPL's power availability in the network is > 99.86 % and as such even if at a later date the power feed from particular EHV SS is not feasible, TPL is confident of provision of

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torrent POWER

Annexure-8.2

required power from other nearby substation or new switch house and there will not be any constraint on power availability.

DMRC may proceed ahead with the above considerations. TPL will be pleased to provide the required power.

We trust the above will serve the purpose. Should you need any further clarification, please feel free to contact.

Assuring you our best attention,

Yours faithfully,
For Torrent Power Limited

Yatin Dholakia
General Manager (Corporate Services)

CC: Mr. H S Duggal
Adviser (Ahmedabad)
Delhi Metro Rail Corporation
C2-21, Goyal Intercity
Drive in Road, Thaltej
Ahmedabad 380 054.

Chapter - 10

Ventilation & Air Conditioning System

Chapter - 10

VENTILATION AND AIR-CONDITIONING SYSTEM

10.1 INTRODUCTION

This chapter covers the Ventilation and Air-conditioning (VAC) system requirements for the underground sections of the proposed Thaltej Gam to Vastral Gam Corridor. It includes the following:

- Station Air-conditioning System
- Station Smoke Management System
- Tunnel Ventilation System
- Control and Monitoring facilities

10.2 ALIGNMENT

The Thaltej Gam to Vastral Gam East-West corridor is of 20.536 km long and consists of 18 stations out of which 4 stations are underground and 14 stations are elevated. The underground section starts from Shahpur and terminates at Kankaria East underground station. The inter-station distances between underground stations vary from 1493 meters to 2155 meters.

10.3 NEED FOR VENTILATION AND AIR CONDITIONING

The underground stations are 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 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 M.R.T. underground stations cannot be extracted by simple ventilation. 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. In winter months it may not be necessary to cool the ventilating air as the heat generated within the station premises would be sufficient to maintain the comfort requirement.

10.4 DESIGN PARAMETERS FOR VAC SYSTEM

With hot and humid ambient conditions of Ahmedabad during the summer and monsoon months, it is essential to maintain appropriate conditions in the underground stations in order to provide a 'comfort-like' 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 centers and other public utility buildings. The standards used for buildings are not directly applicable for the underground spaces, as the heat load gets added periodically with the arrival of the train.

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 is given out 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 condition in earlier metros, in this criteria comfort is defined as the function of temperature and the air velocity experienced by a person. A new index named RWI (Relative Warmth Index) has been adopted for metro designs worldwide. This index depends upon the transient condition of the metabolic rate and is evaluated based on the changes to the surrounding ambient 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, then RWI is the preferred criterion.

(1) Outside ambient conditions:

This is based upon ASHRAE-2009 recommended design conditions for 1% criteria, as under

1% Criteria

Summer:	40.9°C (DB),	22.9°C (WB)
Monsoon:	32.9°C (DB),	28.1°C (WB)

For this corridor it is suggested to use 1% criteria, which is defined as the conditions, when the DB or WB temperatures are likely to exceed for only 1% of the total time.

(2) Inside design conditions:

Platform areas:	27°C at 55% RH
Concourse:	28°C at 60% RH

(3) Tunnel design conditions:

Normal conditions	Max. DB 40°C
Congested conditions	Max. DB 45°C

(4) Minimum fresh air: 10% or 18 cmh/person (In station public areas)

10.5 DESIGN CONCEPTS FOR VAC SYSTEM

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, platform screen doors etc.

The station premises (public areas) are 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. The TES is installed in the train ways of each station to directly capture heat rejected by the vehicle propulsion, braking, auxiliary and air conditioning systems as the train dwells in the station. 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 Exhaust (OTE) duct. The TES uses ducts formed in the under platform void and over the trackway. Exhaust intakes are to be located to coincide with the train-borne heat sources.

Trackway Exhaust Fan

10.6 STATION AIR CONDITIONING:

The platform and concourse areas will be air-conditioned using supply 'Air Handling Units' located in Environmental Control System (ECS) plant rooms throughout the station. Each Platform and Concourse will be served by at least two air handling units (AHU's) with the distribution systems combined along to ensure coverage of all areas in the event of single equipment failure. Based on the initial estimation about 4 units of 25 m^3/s each would be needed for the full system capacity.

Air Handling Unit

These air conditioning systems mix return air with a desired quantity of outside air. The outside air requirement is based on occupancy, with a minimum of 5 liters 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 AHUs or exhausted as required.

UVC Emitters can also be installed in the AHUs for the reduction of molds and fungus growth on the coil and keeps the surface clean, eliminating need for coil cleaning programme and improve the overall coil efficiency.

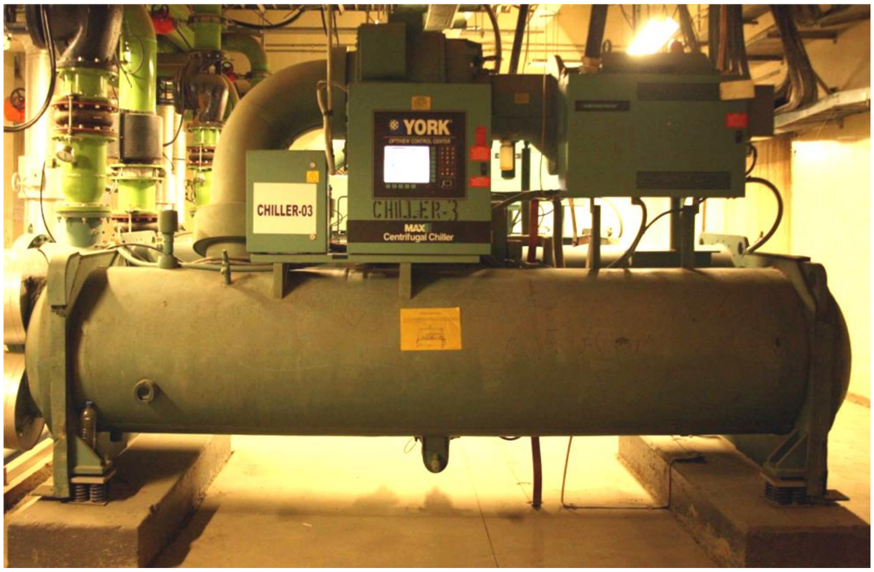
Following are the advantages of UVC emitter:

(a) UVC emitter kills or inactive surface and air borne microorganism that contribute to poor indoor air quality or spread of infectious diseases.

(b) UVC emitter doesn't allow bio film to form on cooling coil surface and lowers HVAC costs by resorting heat transfer and net cooling capacity.

(c) Increase in air flow resulted better air conditioning in the public area hence reduced requirement of additional cooling through AC plant.

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. Based on the initial concept design, the estimated capacity for a typical station would be around 800-900 TR, hence three units of 270 or 300 TR may be required for full system capacity (i.e. design PHPDT traffic requirement). During the detail design stage this estimated capacity might get marginally changed for individual station depending on the heat loads calculated through SES analysis.



Chiller

10.7 VENTILATION AND AIR CONDITIONING OF ANCILLARY SPACES

Ancillary spaces such as Staff Room, Equipment 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 (FCUs) main Chilled Water plant for running during the revenue hours and with Air Cooled Chillers or standby AC units or VRV system for running during the non-revenue hours. Return air will be circulated through washable air filters.

Air Cooled Chiller

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.

10.8 STATION SMOKE MANAGEMENT SYSTEM

The Track way Exhaust and Concourse Smoke Extract Fans will be provided for smoke extract purposes from the public areas and will operate in various modes depending on the location of the fire. The control of this system in fire mode will be fail-safe. These exhaust fans will be provided with "essential" power supplies, with automatic changeover on loss of supply.

Down stand beams will be provided underneath the ceiling around floor openings for stairs and escalators, so that a smoke reservoir is formed on the ceiling. The smoke will be contained in this reservoir at ceiling level and exhausted to atmosphere. By controlling smoke in this manner, it is possible to maintain a relatively smoke clear layer above human head height and to protect the escape route, giving sufficient time for evacuation. The stations will be designed to accommodate the full smoke exhaust volumes and thus prevent the reservoir from completely filling with smoke. To provide an additional barrier against smoke migration, the overall smoke management system would be designed to provide a draught of fresh air through entrances and escape routes, to assist in protecting those routes from smoke.

10.9 SPACE REQUIREMENT FOR VAC SYSTEM

The station air conditioning equipment plant rooms are normally located at each end of the concourse for the two level stations. The approximate area for air handling equipment room would be 600 m^2 to 800m^2 at each end of the station. There shall be supply shafts and exhaust shafts of about 8 m^2 to 10m^2 each at each end of the stations.

10.10 DESIGN CONCEPTS FOR TVS SYSTEM

There are various TVS 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; Use of jet fans; use of mid-shafts; etc.

Under the normal train running 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. Two tunnel ventilation shafts would be provided at the end of the stations. These end-shafts at the stations also serve as Blast Relief Shafts i.e. the piston pressure is relieved to the atmosphere before the train 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 Mode). For the Closed Mode system the shaft dampers can be in closed mode and the displaced air is dumped in the adjacent tunnel.

Generally each tunnel ventilation shaft is connected to a fan room in which there are two 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 tunnel with flows generated by train movements. Dampers are also used to close the connections to tunnels and nozzles under different operating conditions. The details for the shaft sizes, airflow exchange with the atmosphere, fan capacities can be estimated in a more accurate manner with the help of Computer Simulations during the detailed design stage.

Tunnel Ventilation Dampers

10.11 TUNNEL VENTILATION SYSTEMS (TVS)

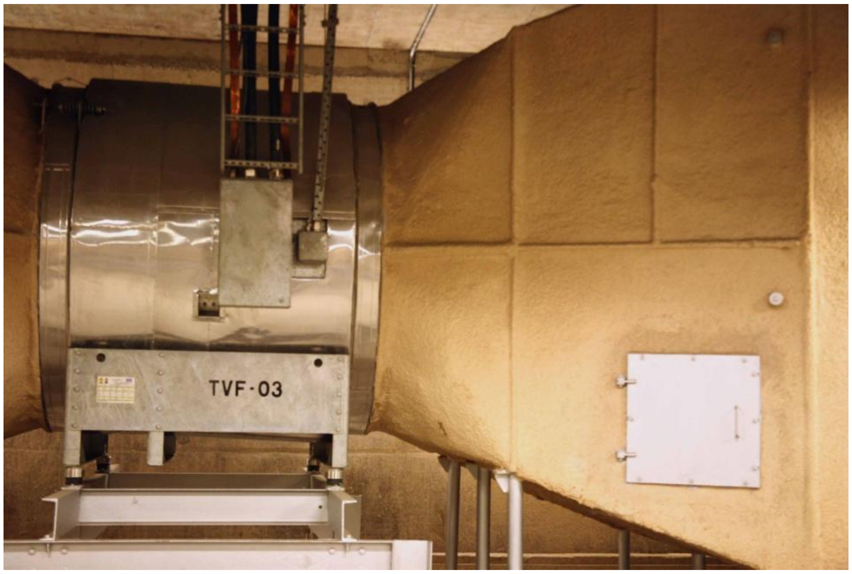
The TVS is provided in a Subway system essentially to carry out the following functions:

(a) Provide a tenable environment along the path of egress from a fire incident in enclosed stations and enclosed train ways.

(b) Produce airflow rates sufficient to prevent back layering of smoke in the path of egress within enclosed trainways.

(c) Be capable of reaching full operational mode within 180 seconds.

(d) Accommodate the maximum number of trains that could be between ventilation shafts during an emergency.



Tunnel Ventilation Fan

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 65 m^3/s to 85 m^3/s depending upon the length and cross section of the tunnel. 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.

Tunnel Booster Fan

The Trackway Exhaust System (part of Tunnel Ventilation System) will have 3 fans of each $15m^3$/sec for each platform. The connections to tunnels and shafts will be through damper units that may be either electrically or pneumatic actuated.

There are various operating modes (scenarios) for the Tunnel Ventilation system. These are described as under:

10.12 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 track way 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 track way 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 track way exhaust system operating. For cold conditions, the closed system or open system mode may be used, but without any station air conditioning. System heating is achieved by the train heat released into the premises.

10.13 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.

10.14 EMERGENCY CONDITIONS

Emergency conditions are when smoke is generated in the tunnel or station track way. 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.

10.15 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. There are two locations of the portal in Thaltej Gam to Vastral Gam Corridor one from Shahpur to Ashram Road and other from Kankaria East to Apparel Park.

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. Although, based on the recent studies, it is assumed that a design train speed of 90 kmph would not be of major concern. 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.

10.16 SPACE REQUIREMENT FOR TUNNEL VENTILATION SYSTEM

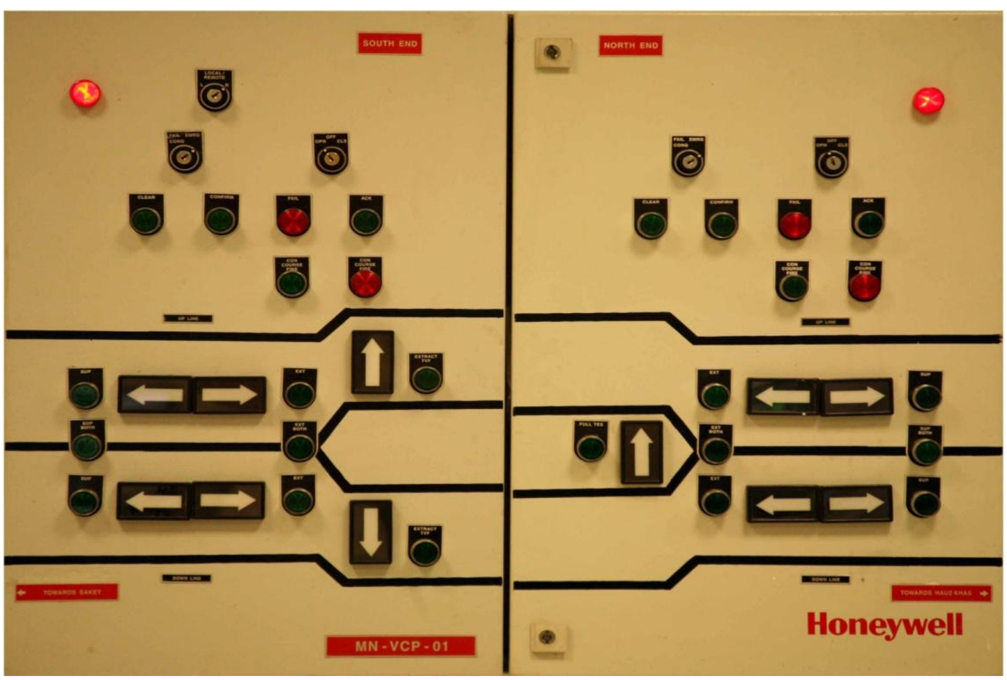
The tunnel ventilation equipment plant rooms are normally located at each end of the concourse for the two level stations. The approximate area for tunnel ventilation fan room would be 600 -700 sq. m. respectively at each end of the station. The tunnel vent shafts of approximately 20 sq. m. area will be constructed at each end of the stations. There shall be supply shaft and exhaust shafts of similar dimensions at the stations.

For designed headway 1.5 minutes and the inter – station separation between underground station shafts is beyond 1.5 Km as per alignment plan, there may be one mid shaft in Thaltej Gam to Vastral Gam corridor between Ghee Kanta and Kalupuram railway station for which additional fund provisions to the tune of Rs. 6.5 Crores (for each mid shaft) for electrical & mechanical works (Ventilation, E&M, BMS, ASS etc) and Rs. 22.5 Crores (for each mid shaft) for civil works and land will be needed for each of these shafts.

10.17 CONTROL AND MONITORING FACILITIES

For the underground stations the control and monitoring of station services and systems such as station air-conditioning, ventilation to plant rooms, lighting, pumping systems, 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 systems 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 (such as FOTS).

There shall be an Auxiliary Power Controller at OCC who will be monitoring these services and systems. The command signals will be initiated at OCC and relayed up to the relevant equipment for operation. The feedback signal is received through SCADA whether the command is implemented or not. The control from OCC is generally performed using ‘Mode Tables’ for each system. This table defines the sequence of the desired equipment that needs to be operated based on the event. The abnormal conditions such as train congestion, emergency, fire in subway would be detected by various components and the emergency response thereto will be activated based on the mode tables. In the event that remote control is not possible due to any reason, the local control via SCR would be performed. In case the control at work station in SCR is also not available, the manual overriding provisions shall be provided through Ventilation Control Panel (VCP) place in the SCR.



Ventilation Control Panel

The OCC will also be used for logging the alarm status, fault occurrences, and other maintenance related data for the above systems.

10.18 CODES AND STANDARDS

The concept VAC design is guided by the following codes and standards:

(a) SEDH – Subway Environment Design Handbook

(b) ASHRAE – Handbook, current series.

(c) CIBSE – relevant document.

(d) NFPA – 130.

(e) ECBC- Energy Conservation Building Code.

Chapter - 11

Signalling & Train Control

Chapter - 11

SIGNALLING AND TRAIN CONTROL

11.0 SIGNALLING

11.1 INTRODUCTION

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

11.2 SIGNALLING AND TRAIN CONTROL

11.2.1 Overview

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

This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation and for bidirectional working.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / and other information in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.

- Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
- Improve maintenance of Signalling and telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours.

Radio for CBTC shall work in License free ISM band.

11.2.2 System Description and Specifications

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

a. Continuous Automatic Train Control

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

(i) Automatic Train Protection (ATP)

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

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

- Maintaining safety distance between trains
- Monitoring of stopping point
- Monitoring of Direction of Travel and Rollback

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

(ii) Automatic Train Operation (ATO)

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

(iii) Automatic Train Supervision (ATS)

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

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

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

b. Interlocking System:

(i) Computer Based Interlocking (CBI)

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

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

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

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

(ii) Track Vacancy Detection

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

(iii) Signals

Line side Signals:

Multi Aspect Colour Light (LED) type Line side signals shall be installed on the Main Line and depot entry/ exit.

At stations with point and crossing for point protection catering for bidirectional working

(iv) Point Machines

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

c. Train Depot: Signalling

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

d. Interface for PSD

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

e. Signalling Scheme Plan

Conceptual Signalling Scheme Plan based on P. Way Plan for Ahmedabad Metro Rail Project from "APMC to Motera Stadium (North – South Corridor)" and "Thaltej Gam to Vastral Gam (East – West) corridor" are enclosed.

11.2.3 Standards

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

Description	Standards
▪ Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for workshop lines, inspection shed lines etc.
▪ Block Working	Moving Block working concept may be followed.
▪ Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
▪ Track Vacancy Detection System	Primary mode for track vacancy detection system on main line and test track in depot may be through radio and for depot and secondary detection it can be through Track circuit / Axle Counter.
▪ Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
▪ UPS (uninterrupted power at stations as well as for OCC)	For Signalling, Telecommunications and AFC.
▪ Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide for redundancy. The system will conform to IEEE 1474 standards.

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

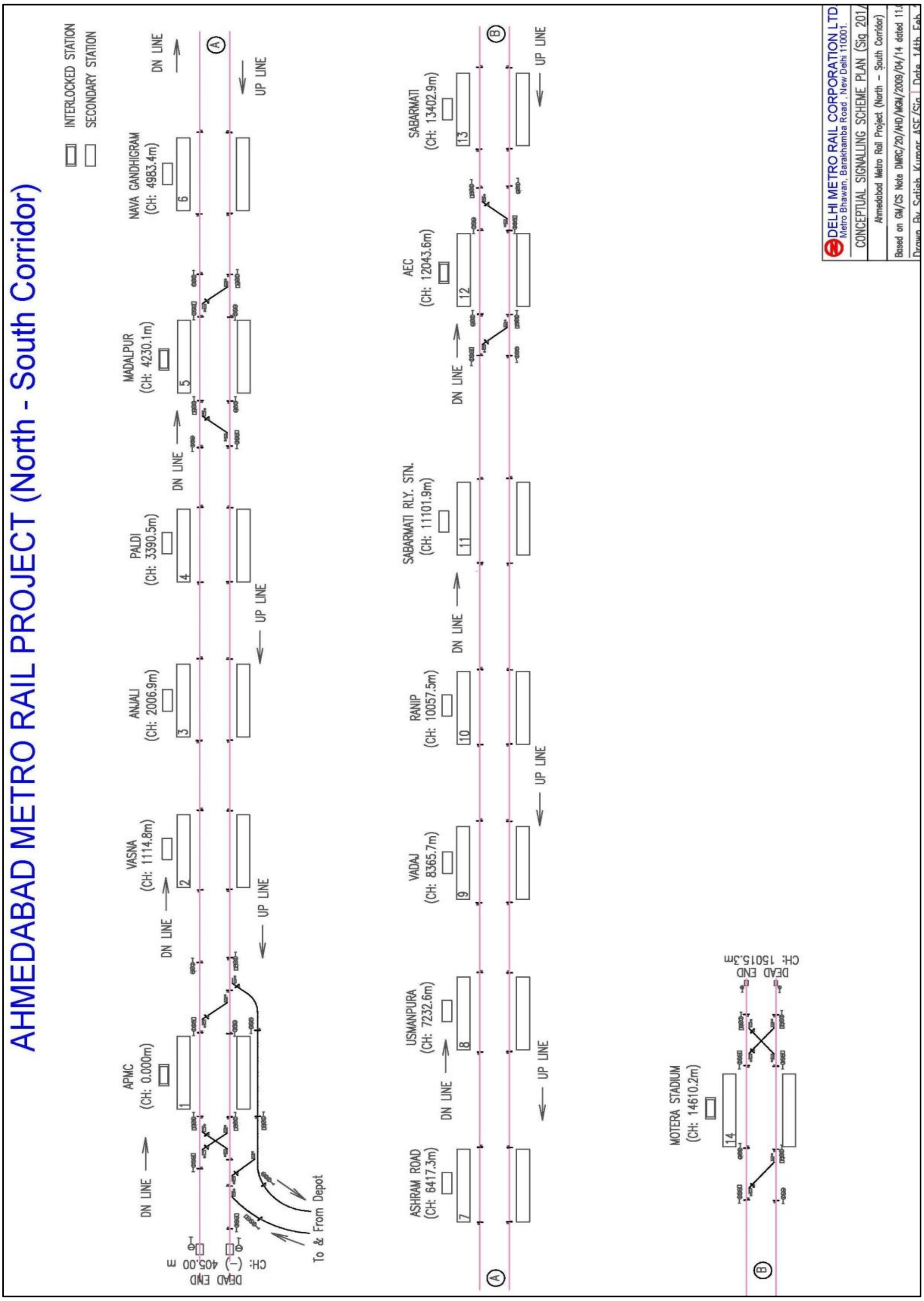
11.3 SPACE REQUIREMENT FOR SIGNALLING INSTALLATIONS

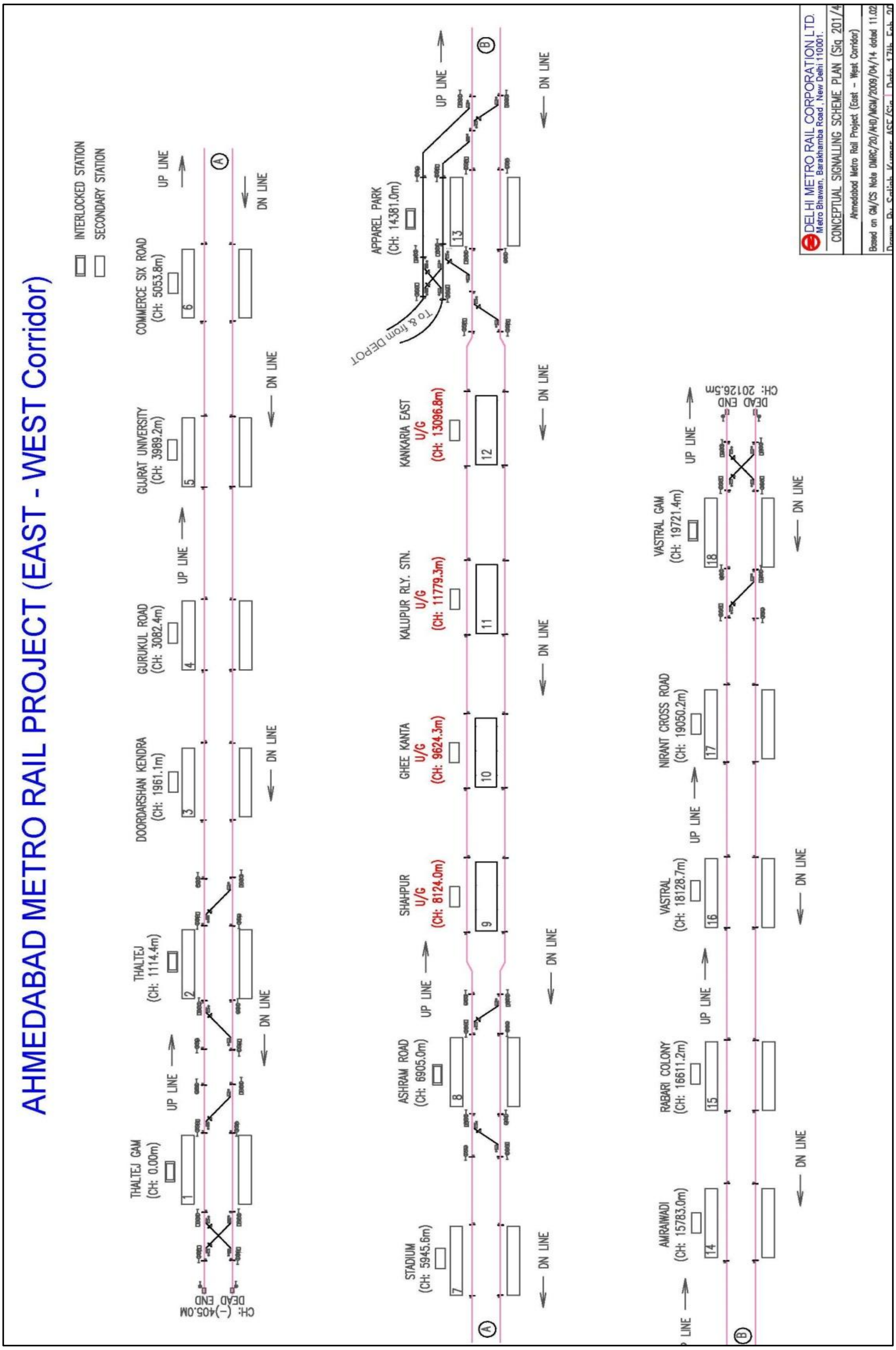
Adequate space for proper installations of all Signalling equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment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

11.4 MAINTENANCE PHILOSOPHY FOR SIGNALLING SYSTEMS

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

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


AHMEDABAD METRO RAIL PROJECT (North - South Corridor)
INTERLOCKED STATION
SECONDARY STATION
DEAD END
CH: (-) 405.00 m
To & From Depot
DN LINE
UP LINE
APMC (CH: 0.000m)
VASNA (CH: 1114.8m)
ANJALI (CH: 2006.9m)
PALDI (CH: 3390.5m)
MADALPUR (CH: 4230.1m)
NAVA GANDHIGRAM (CH: 4983.4m)
ASHRAM ROAD (CH: 6417.3m)
USMANPURA (CH: 7232.6m)
VADAJ (CH: 8365.7m)
RANIP (CH: 10057.5m)
SABARMATI RLY. STN. (CH: 11101.9m)
AEC (CH: 12043.6m)
SABARMATI (CH: 13402.9m)
MOTERA STADIUM (CH: 14610.2m)
DEAD END
CH: 15015.3m
DELHI METRO RAIL CORPORATION LTD
Metro Bhawan, Barakhamba Road, New Delhi 110001.
CONCEPTUAL SIGNALLING SCHEME PLAN
Ahmedabad Metro Rail Project (North – South Corridor)


AHMEDABAD METRO RAIL PROJECT (EAST - WEST Corridor)
INTERLOCKED STATION
SECONDARY STATION
CH: (-)405.0M
DEAD END
THALTEJ GAM
(CH: 0.00m)
THALTEJ
(CH: 1114.4m)
DOORDARSHAN KENDRA
(CH: 1961.1m)
GURUKUL ROAD
(CH: 3082.4m)
GUJRAT UNIVERSITY
(CH: 3989.2m)
COMMERCE SIX ROAD
(CH: 5053.8m)
UP LINE
DN LINE
STADIUM
(CH: 5945.6m)
ASHRAM ROAD
(CH: 6905.0m)
SHAHPUR
U/G
(CH: 8124.0m)
GHEE KANTA
U/G
(CH: 9624.3m)
KALUPUR RLY. STN.
U/G
(CH: 11779.3m)
KANKARIA EAST
U/G
(CH: 13096.8m)
APPAREL PARK
(CH: 14381.0m)
To & from DEPOT
AMRAIWADI
(CH: 15783.0m)
RABARI COLONY
(CH: 16611.2m)
VASTRAL
(CH: 18128.7m)
NIRANT CROSS ROAD
(CH: 19050.2m)
VASTRAL GAM
(CH: 19721.4m)
CH: 20126.5m
DEAD END
DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan, Barakhamba Road, New Delhi 110001.
CONCEPTUAL SIGNALLING SCHEME PLAN
Ahmedabad Metro Rail Project (East - West Corridor)

Chapter - 12

Telecommunication & Automatic Fare Collection

Chapter - 12

TELECOMMUNICATION
&
AUTOMATIC FARE COLLECTION

12.1 INTRODUCTION

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

12.2 OVERVIEW

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

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

The proposed Telecom system will cater to the following requirements:

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

- Integrated Network Control System
- Access Control System

12.3 TELECOMMUNICATION SYSTEM AND TRANSMISSION MEDIA

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

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

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

ii) Telephone Exchange

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

iii) Mobile Radio Communication

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

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

To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 3 sites with 30 meter towers with Base Stations shall be required along the route on North South Corridor (Vasna, Ashram Road, AEC) and minimum 4 Base Stations on East West Corridor (Doordarshan, Commerce Six Road, Apparel, Vastral). For underground coverage, BTS will be required at Ghee Kanta Station, feeding Bi-Directional Amplifiers on the adjacent stations through a net work of Leaky Coxial Cables in the Tunnel/Station Area. Space in underground station shall also be provided to Public Mobile Operators to install their own equipment and LCX / RF cables, to extend their mobile coverage. On the LCX network of the Metro Radio, arrangement shall also be made to extend the Radio Coverage of the Local Police and Fire Services, so that during emergencies their system can work in the Underground environment.

iv) Passenger Announcement System

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

v) Passenger Information Display System

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

vi) Centralised Clock System

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

vii) Closed Circuit Television (CCTV) System

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

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

viii) Access Control System

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

ix) Network Monitoring and Management

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

(x) Technology

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

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

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

(xi) Space Requirement for Telecom Installations

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

(xii) Maintenance Philosophy for Telecom Systems

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

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

12.4 AUTOMATIC FARE COLLECTION

12.4.1 Introduction

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

For Multiple Journey, the Store Value Contactless Smart Card shall be utilized and for the Single Journey, the Smart media shall be as utilized as Contactless Smart Token. System should be compatible with the Contactless Smart Chip supplied by at least 2 Chip OEMs as per ISO 14443 standard.

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

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

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

B) Automatic fare collection systems have the following advantages:

1. Less number of staff required.
2. Less possibility of leakage of revenue due to automatic ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.
4. Efficient and easy to operate, faster evacuation both in normal and emergency.
5. System is amenable for quick fare changes.
6. Management information reports generation easy.
7. System has multi-operator capabilities. Same Smart Card can be used for other applications also, including in other lines of the Metro.
8. Contactless Smarts Card based AFC systems are the worldwide accepted systems for LRT/Metro environment.

The proposed ticketing system shall be that to be of Contactless Smart Card type for multiple journey and Contactless Token for Single Journey. The equipment for the same shall be provided at each station Counter/Booking office and at convenient locations and will be connected to a local area network with a computer in the Station Control room.

C) Choice of Control Gates

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

D) Ticket Vending Machine (TVM)

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

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

E) Ticket Reader/Add Value Machines

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

F) Recharge Card terminal Machine (RCTM)

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

G) AFC equipment Requirement

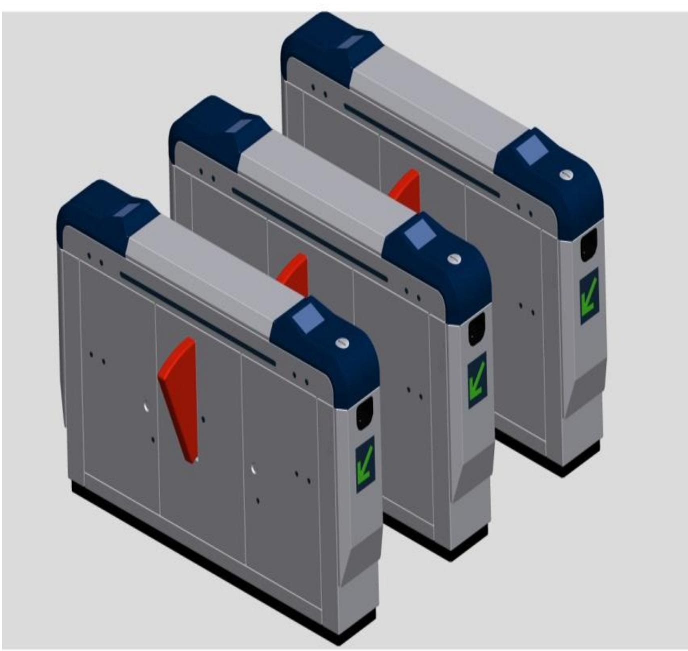
AFC equipment tentative requirement is given in Table attached. The exact number and type shall depend on the final station layout and the traffic being catered to.

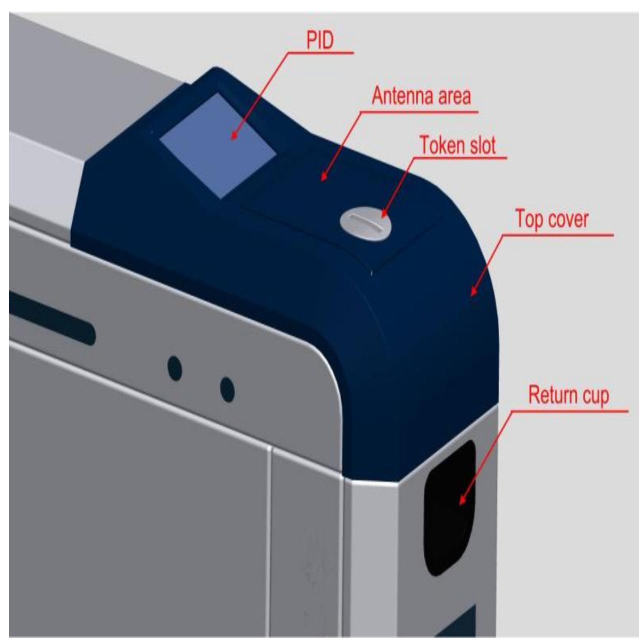
(H) Technology

The technology proposed for AFC systems are as under:

Standards	Description
• Fare media	a) Contactless Smart Card – For multiple journeys. b) Contactless Smart Token –For Single Journey, captured at exit gates for reuse.
• Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: • Entry • Exit • Reversible (if required as per final station layout) – Option to set as entry or exit based on operational requirements
• Station Computer, Central computer and AFC Network	All the fare collection equipment shall be connected in a local area network with a Station Computer controlling the activities of all the equipments installed at Station. These Station Computers will be linked to the Central Computer installed at Operational Control Centre through the optic fibre communication channels. The centralised control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
• Ticket office machine (TOM • Excess Fare Offices	Manned Ticket office machine shall be installed in the stations for selling tickets to the passengers.

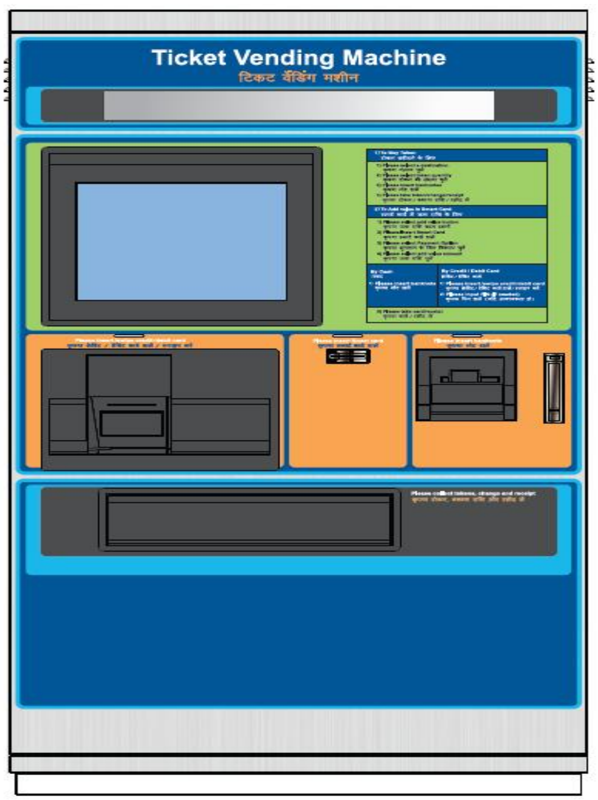
Standards	Description
(EFO)	Excess Fare Offices machines shall be installed for Adjustment of Fare due to various reasons like over stay, excess journey, tailgating etc.
• Ticket Vending Machines (TVM)	Automatic Ticket Vending machines shall be installed in the stations for vending of single journey Smart Token, Add Value in Smart Card using Bank Notes and Credit/debit cards.
• Add Value Machine/ Ticket Reader (AVM/TR)	AVM/TR will be used for recharging the Smart card (payment will be made through Internet Banking/Payment Gateway) as well as to check information stored in the ticket.
• Portable Ticket Decoder (PTD)	PTD will be used to check the Card/Token during travel.
• Recharge Card terminal Machine (RCTM)	RCTM will be used to recharge the card using bank Note/ Credit Card /Debit card /pre Paid card
• UPS (uninterrupted power at stations as well as for OCC).	Common UPS of S&T system will be utilised.





Entry/Exit Gates

Ticket Office Machine



Ticket Vending Machine

Add Value Machine

AFC Equipments Revised DPR Estimate for Ahmedabad Metro
(based on Traffic Projection for 2018)

Sr. No.	Station	Hourly Boarding/ Alighting	Peak min Boarding/Alighting	Gate		TOM	EFO	AVM /TR	TVM
				Entry	Exit				
North-South Line (APMC to Motera Stadium)									
1	APMC	1468	29	2	2	2	2	4	2
2	Vasna	619	12	2	2	2	2	4	2
3	Anjali	712	14	2	2	2	2	4	2
4	Paldi	836	17	2	2	2	2	4	2
5	Madalpur	1329	27	2	2	2	2	4	2
6	Nava Gandigram	878	18	2	2	2	2	4	2
7	Ashram Road	3780	76	3	3	4	2	4	2
8	Usmanpura	688	14	2	2	2	2	4	2
9	Vadaj	3300	66	3	3	3	2	4	2
10	Ranip	890	18	2	2	2	2	4	2
11	Sabarmati Rail Stn	366	7	2	2	2	2	4	2
12	AEC	165	3	2	2	2	2	4	2
13	Sabarmati	350	7	2	2	2	2	4	2
14	Motera Stadium	7085	142	6	6	7	2	4	2
		Total		**34**	**34**	**36**	**30**	**60**	**30**
East - West Line (Thaltej Gam to Vastral Gam)									
1	Thaltej Gam	1130	23	2	2	2	2	4	2
2	Thaltej	1343	27	2	2	2	2	4	2
3	Doodarshan	896	18	2	2	2	2	4	2
4	Gurukul Road	1179	24	2	2	2	2	4	2
5	Gujarat University	1602	32	2	2	2	2	4	2
6	Commerce Six Road	475	10	2	2	2	2	4	2
7	Stadium	792	16	2	2	2	2	4	2
8	Ashram Road	5038	101	4	4	5	2	4	2
9	Shahpur	858	17	2	2	2	2	4	2
10	Relief Road	1513	30	2	2	2	2	4	2
11	Kalupur Rly.Stn.	5882	118	5	5	6	2	4	2
12	Kankaria East	984	20	2	2	2	2	4	2
13	Apparel Park	1461	29	2	2	2	2	4	2
14	Amraiwadi	988	20	2	2	2	2	4	2
15	Rabari Colony	886	18	2	2	2	2	4	2
16	Vastral	1606	32	2	2	2	2	4	2
17	Nirant Cross Rd.	728	15	2	2	2	2	4	2
18	Vastral Gam	456	9	2	2	2	2	4	2
		Total		**41**	**41**	**43**	**36**	**72**	**36**
		Grand Total		**75**	**75**	**79**	**66**	**132**	**66**

Assumptions:

1. Each station has only 2 access
2. Minimum AFC equipments at a station with "2 access- 1 for entry, 1 for exit": 2 entry gates, 2 exit gates, 2 EFO, 2 TOM, 4 AVM/TR,2 TVM
3. Throughput of gate 25 passengers per minute, TOM : One per access.
4. 50 % passenger are assumed on Smart Card and 50% on single journey token.
5. Peak hour traffic = 12% of day traffic . Peak Minute traffic = 2% of peak hour traffic.

Chapter -13

Disabled Friendly Features

Chapter – 13

DISABLED FRIENDLY FEATURES

13.1 INTRODUCTION

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

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

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons", 1998 and 2013 edition (under revision by MoUD), and international best practices / standards

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

13.2 CONTENT

1. **Rail Transport**

2. **Metro Rail Station**

    - Way finding
    - Signage
    - Automated Kiosks
    - Public Dealing Counters
    - Audio-visual Displays

- Public Telephones
- Rest Areas/Seating
- Tactile Paving - Guiding & Warning
- Doors
- Steps & Stairs
- Handrails
- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

3. Street Design

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

4. Alighting and Boarding Area

- Approach
- Car Park
- Drop-off and Pick-up Areas
- Taxi/Auto Rickshaw Stand
- Bus Stand/Stop

13.3 RAIL TRANSPORT

1. General

- Whether over-ground or underground, rail travels is a highly effective mode of transport.
- Every train should contain fully accessible carriages.
- Staff should be trained in methods of assistance and be at hand on request.
- Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways

- Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
- All new railway stations should be designed to be fully accessible.
- For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
- For persons with visual impairments audio system announcing the station names and door location should be available.

2. Accessible Railway Cars

The railway cars should have the following features:

- Railway car doors should be at least 900 mm wide;
- The gap between the car doors and the platform should preferably be less than 12 mm;
- Identification signage should be provided on the doors of wheelchair accessible coach
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

3. Wheel Chair Space

- Space for a wheel chair should be available at the side of the door:-
- The space should be indicated inside and outside the car by using the international symbol of access; and
- Wheel stoppers and ring-strap or other appropriate safety grip should be provided for wheelchair users.

4. Seats

- An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles

- Aisles should be at least 900 mm wide.

13.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

13.5 Metro Railway Stations

1. Level Approach

- Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should a ramp.
- Walkway surfaces should be non-slip.
- Approach walkway should have tactile pavements for persons with visual impairments.

2. Station Entrances and Exits

- These should have a minimum width of 1800mm and is level or ramped.

3. Reservation and Information Counters

- Should have clear floor space of at least 900 mm x 1200 mm in front of the counters;
- There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
- At least one of the counters should have an induction loop unit to aid people with hearing impairments; and
- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

4. Toilet Facilities

- There should be at least one unisex accessible toilet
- Ticket Gates

At least one of the ticket gates should:

- Be minimum 900 mm wide to allow a wheelchair user through; and
- Have a continuous line of guiding paver for people with visual impairments.

5. Platforms

The Platforms should:

- Have a row of warning paver installed 600mm before the track edge (photo 6);
- Have non-slip and level flooring;
- Have seating areas for people with ambulatory disabilities;
- Be well illuminated lux level 35 to 40;
- There should be no gap or difference in level between the train entry door and the platform.

- All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

- Way finding references should be available at decision points.
- Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travelers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille).

8. SIGN DESIGN SPECIFICATIONS

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.

- Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
- The colour of the text should be in a colour that contrasts with the sign board.
- The sign board should also contrast with the wall on which it is mounted.
- The surface of the sign should not be reflective.
- Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
- Illuminated signs should not use red text on a dark background.
- Signs should be supplemented by Braille where possible.

Fig. 13.1 - Way finding signage

Fig. 13.2 - International Symbol of Accessibility

9. AUTOMATED KIOSKS

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. PUBLIC DEALING COUNTERS

- Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.
- Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
- It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.

- Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
- Staff manning the counters should know sign language.
- Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
- Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
- Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
- There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
- One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep .

11. AUDIO-VISUAL DISPLAYS

- Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
- Enable captioning at all times on all televisions and other audiovisual displays that are capable of displaying captions and that are located in any portion of the terminal.
- The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING

- Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
- Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
- Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.
- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of

audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.

- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. TACTILE PAVING- GUIDING & WARNING[1]

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. PLACES TO INSTALL WARNING PAVER

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

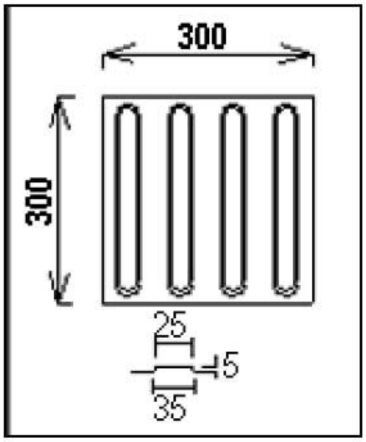


Fig. 13.3 - Guiding paver

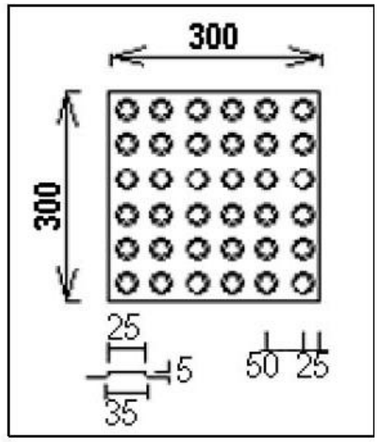


Fig. 13.4 - Warning paver

15. Doors

Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.

- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).
  - Also be fitted with vision panels at least between 900mm and 1500mm from floor level.
  - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
  - Lever handles and push type mechanisms are recommended . When a sliding door is fully open, handles should be usable from both sides.

- Where revolving doors or turnstiles are used, an alternative wheelchair-accessible entrance must also be provided.
- A distance of 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, colour (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor (figure 28).
- Operable devices such as handles, pulls, latches and locks should:

  - Be operable by one hand
  - Not require fine finger control, tight grasping, pinching or twisting to operate

- Glazed doors and fixed glazed areas should be made visible by use of a clear, colour and tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

16. Steps & Stairs

- Steps should be uniform with the tread not less than 300mm and the risers 150mm.
- The risers should not be open.
- The steps should have an unobstructed width of 1200mm minimum.
- All steps should be fitted with a permanent colour and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both

tread and riser.
- Have continuous handrails on both sides including the wall (if any) at two levels
- Warning paver to be placed 300mm at the beginning and at the end of all stairs.
- Nosing to be avoided.
- The staircase should be adequately and uniformly illuminated during day and night (when in use). The level of illumination should preferably fall between 100-150 lux.
- The rise of a flight between landings must be no more than 1200mm.
- There should be no more than 12 risers in one flight run.
- The stair covering and nosing should be slip-resistant, non-reflective, firmly-fixed and easy to maintain.
- Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

17. HANDRAILS

- Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
- The handrail should contrast in colour (preferably yellow/orange) with surrounding surfaces.
- At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
- The handrail should be positioned at two levels- 760mm and 900mm above the pitch-line of a flight of stairs.
- Handrail at foot of the flight of stairs should extend 300mm beyond the stairs in the line of travel and returning to the wall or floor or rounded off, with a positive end that does not project into the route of travel.

18. RAMPS

- Ramps gradient should ideally be 1 in 20 and no greater than 1 in 12.
- Width of the ramp should not be less than 1200mm and preferred width is 1800mm.
- The steeper the gradient, the shorter the length of ramp between landings.
- On long ramps, a horizontal resting space should be provided every 6 meters.
- Surface materials should be slip-resistant, non-reflective, firmly-fixed and easily maintained
- The edge of the ramp should have an edge protection with a minimum height of 100mm.
- Landings every 750mm of vertical rise.
- A tapping or lower rail should be positioned so that its bottom edge is no higher than 200mm above ground level.
- Handrails on the ramps should be on both sides at two levels: upper at 900mm and lower at 760mm; both end to be rounded and grouted; extend 300 mm beyond top and bottom of ramp .

- A row of tactile warning paver should be placed 300mm beginning and end of each run.
- Landings should be provided at regular intervals as indicated in the table below.

Table 13.1 - Specifications for Ramps

Level difference	Minimum gradient of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	√	
≥ 300 mm ≤ 750 mm	1:12	1500 mm	√	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	√	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	√	Landings every 9 meters of ramp run.

19. LIFTS/ELEVATORS

A carefully designed lift makes a huge contribution to the accessibility of a multi-storied terminal building for persons with disabilities.

- Lift locations should be clearly signposted from the main pedestrian route and recognizable through design and location.
- The colour and tone of the lift doors should contrast with the surrounding wall finish to assist in their location. Lift doors with metallic finishes such as steel grey and silver should be avoided as they are difficult to identify by persons with low vision.
- The lift lobby shall be of an inside measurement of 1800mm X 2000mm or more. A clear landing area in front of the lift doors of minimum dimensions 1500mm x 1500mm should be provided.
- By making the landing area distinguishable by floor surface and contrast, it will aid location and recognition of core areas. This could comprise a change in floor finish from thin carpet to vinyl/PVC, or cement/mosaic floor to carpet.
- Changes in floor finish must be flushed. There should be no level difference between lift door and the floor surface at each level; the gap if unavoidable should not be more than 12mm.
- The floor level/location should be indicated on the wall adjacent to or just above the call buttons, and opposite the lift doors where possible.

20. Lift Dimensions

- Provisions of at least one lift shall be made for people using wheelchairs with the following car dimensions:
  - Clear internal depth -1500 mm minimum
  - Clear internal width - 1500 mm minimum
  - Entrance door width - 900 mm minimum

21. Lift Controls

- The lift call button should be wall-mounted adjacent to the lift and should contrast with wall finish, either by using a contrasting panel, or a contrasting border around the button panel.
- The call buttons should be located within the range 800-1000mm above floor finish.
- Buttons should not be touch sensitive, but should require a light positive pressure and should ideally be large enough to be operable by the palm of the hand if required.
- The control buttons inside the lift should be positioned on the side wall rather than front wall to allow access from the back and front of the lift car, by mobility aid users like wheelchair users.
- The control buttons should contrast with their surroundings and illuminate when pressed and should incorporate highly visible tactile embossed (NOT engraved) characters and in Braille.
- Time of closing of an automatic door should be more than 5 seconds and the closing speed should not exceed 25 meters per second. There should be a provision of censor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

22. Car Design

- Internal walls should have a non-reflective, matt finish in a colour and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.

- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, in order to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

13.6 INFORMATION SYSTEMS

- Lifts should have both visual and audible floor level indicators
- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 50 decibel.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

13.7 GENERAL AND ACCESSIBLE TOILETS

1. SIGNAGES

- All signage of general toilets should be in bold and contrasting colors.
- For persons with low vision and vision impairments: male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
- Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.
- Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.

2. ACCESSIBLE TOILETS

- Should have the international symbol of accessibility displayed outside for wheelchair access.
- The toilet door should be an outward opening door or two way opening or a sliding type and should provide a clear opening width of at least 900mm.
- It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.
-

3. WC COMPARTMENT DIMENSIONS

- The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
- Layout of the fixtures in the toilet should be such that a clearing maneuvering space of 1500mm x 1500mm in front of the WC and washbasin.

4. WATER CLOSET (WC) FITTINGS

- Top of the WC seat should be 450-480mm above finished floor level, preferably be of wall hung or corbel type as it provides additional space at the toe level.
- An unobstructed space 900mm wide should be provided to one side of the WC for transfer, together with a clear space 1200mm deep in front of the WC.
- WC should be centred 500mm away from the side wall, with the front edge of the pan 750mm away from the back wall. Have a back support. The WC with a back support should not incorporate a lid, since this can hinder transfer.
- L-shape grab bar at the adjacent wall and on the transfer side (open side) swing up grab bar shall be provided.
- The cistern should have a lever flush mechanism, located on the transfer side and not on the wall side and not more than 1000mm from the floor.

5. GRAB BARS

- Grab bars should be manufactured from a material which contrasts with the wall finish (or use dark tiles behind light colored rails), be warm to touch and provide good grip.
- It is essential that all grab rails are adequately fixed, since considerable pressure will be placed on the rail during maneuvering. Grab bars should sustain weight of 200kgs minimum.
- A hinged type moveable grab bar should be installed adjacent to the WC on the transfer side. This rail can incorporate a toilet tissue holder. A distance of 320mm from the centre line of the WC between heights of 200-250mm from the top of the WC seat. It should extend 100-150mm beyond the front of the WC.
- A fixed wall-mounted L- shape grab bar (600mm long horizontal and 700mm long vertical) on the wall side should be provided. It should be placed at a height of 200-250mm above the WC seat level.

6. WASHBASINS

- Hand washbasins should be fitted on cantilevered brackets fixed to the wall.
- The basin should be fixed no higher than 750mm above the finished floor level.
- Be of dimensions 520mm and 410mm, mounted such that the top edge is between 800-900mm from the floor; have a knee space of at least 760mm wide by 200mm deep by 650-680mm high.

- The position of the basin should not restrict access to the WC i.e. it should be located 900mm away from the WC.
- A lever operated mixer tap fitted on the side of the basin closest to the WC is useful as it allows hot and cold water to be used from a seated position on the WC.
- The hand drying facilities should be located close to the hand washbasin between 1000-1200mm.
- Lever type handles for taps are recommended.
- Mirror’s bottom edge to be 1000mm from the floor and may be inclined at an angle.

7. Fixtures and Fittings

- Contrast between fittings and fixtures and wall or floor finishes will assist in their location. For example, using contrasting fittings, or dark tiles behind white hand washbasins and urinals, contrasting soap dispensers and toilet roll holders. Contrast between critical surfaces, e.g. floors, walls and ceilings helps to define the dimensions of the room.
- Towel rails, rings and handrails should be securely fixed to the walls and positioned at 800-1000mm from the floor.
- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights- 1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.
- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish

8. Signage of Accessible Toilets

- All unisex accessible toilets to have access symbol in contrast colours. A distinct audio sound (beeper/clapper) may be installed above the entrance door for identification of the toilets.

Fig. 13.5 - Signage for accessible washroom

9. Accessible Urinal

- At least one of the urinals should have grab bars to support ambulant persons with disabilities (for example, people using mobility aids like crutches).
- A stall-type urinal is recommended.
- Urinals shall be stall-type or wall-hung, with an elongated rim at a maximum of 430mm above the finish floor. This is usable by children, short stature persons and wheelchair users.
- Urinal shields (that do not extend beyond the front edge of the urinal rim) should be provided with 735mm clearance between them.
- Grab bars to be installed on each side, and in the front, of the urinal.
- The front bar is to provide chest support; the sidebars are for the user to hold on to while standing.

13.8 Drinking Water Units

- Drinking water fountains or water coolers shall have up front spouts and control .
- Drinking water fountains or water coolers shall be hand-operated or hand and foot-operated.
- Conventional floor mounted water coolers may be convenient to individuals in wheelchairs if a small fountain is mounted on the side of the cooler 800mm above the floor.
- Fully recessed drinking water fountains are not recommended.
- Leg and knee space to be provided with basin to avoid spilling of water . This allows both front and parallel access to taps for persons using mobility aids like wheel chair, crutches etc.

13.9 Visual Contrasts

- Visual contrasts means adequate contrast created by difference of at least 30 LRV (Light Reflectance Value) of the two surfaces/ objects and it helps everyone especially persons with vision impairments.
- Visual contrast should be provided between:
  - Critical Surfaces (walls, ceiling and floor),

  - Signage and background sign frame/ wall,
  - Step edges and risers/ treads on steps,
  - Handrails and background walls,
  - Doors and surrounding walls,
  - Switches/ sockets and background wall,
  - Toilet fixtures and critical surfaces in toilet.

- Barriers and hazards should be highlighted by incorporating colours and luminance contrast.

13.10 EMERGENCY EGRESS/EVACUATION

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.
-
- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a 'hotkey' on the phone keypad. This 'hotkey' should be distinct from the rest of the keypad.

13.11 ALERTING SYSTEMS

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.
-
- Consider having audible alarms with 'voice instructions' that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.
-
- Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).
-

Non-auditory alarms include:

- Flashing beacons
- Vibrating pillows and vibrating beds.
- Pagers or mobile phones that give out a vibrating alarm along with a flashing light (these may be issued to persons with vision or hearing impairments at the time of check-in or boarding the vehicle.)

13.12 WRITTEN EVACUATION PROCEDURE

A written evacuation procedure that details the egress plan for people with disability should be installed behind the entrance door in the accessible rest rooms. The evacuation procedure should be detailed in large print letters that contrast strongly against the background. Where possible, it should also incorporate raised letters and Braille. The evacuation route should be displayed on a high contrast tactile map for benefit of persons with vision impairments.

13.13 EMERGENCY EVACUATION ROUTE

- Designate routes that are at least 1200mm wide, to ensure that a person using a wheelchair and a non disabled person are able to pass each other along the route. The route should be free of any steps or sudden changes in level and should be kept free from obstacles such as furniture, coolers, AC units and flower pots.

- Use Exit signage along the route. Orientation and direction signs should be installed frequently along the evacuation route and these should preferably be internally illuminated. The exit door signage should also be internally illuminated.

- A 'way guidance lighting system' consisting of low mounted LED strips to outline the exit route (with frequent illuminated direction indicators along the route) should be installed along the entire length of the evacuation route. Way guidance systems allow persons with vision impairments to walk significantly faster than traditional overhead emergency lighting. Moreover, emergency exit lights in green color and directional signals mounted near the floor have been found to be useful for all people in cases where a lot of smoke is present.

13.14 WAY GUIDANCE SYSTEM

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.
- Install clear illuminated sign above exit and also directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

13.15 FIRE RESISTANT DOORS

- Fire resistant doors and doors used along the emergency evacuation route are generally heavy and the force required to open these is much higher than 25 Newtons, making it difficult for people with disability to negotiate these doors independently. There are, however, magnetic and other types of door holders available that can be connected to fire alarms so that they will hold the doors open normally but will release the doors when the fire alarm is activated.

13.16 STREET DESIGN

(a) Footpath (Sidewalk)

Footpaths should be regarded as a transportation system which is connected and continuous, just like roadways and railways. They should not be sporadically placed where ever convenient, but instead should be provided consistently between all major attractions, trip generators, and other locations where people walk.

Footpath should:

- Be along the entire length of the road;
- Have height of a standard public step riser i.e. 150 mm maximum;
- Be at least 1800 mm wide;
- Have non-slip surface;
- Have tactile guiding paver for persons with visual impairments;
- Preferably have well defined edges of paths and routes by use of different colours and textures;
- Have no obstacles or projections along the pathway. If this is unavoidable, there should be clear headroom of at least 2200 mm from the floor level;
- The minimum 1.8m (width) x 2.2m (Height) Walking Zone should be clear of all obstructions – both horizontally and vertically.

Footpath should have:

- Have kerb ramps where ever a person is expected to walk into or off the pathway; and
- Have tactile warning paver installed next to all entry and exit points from the footpath.

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.
- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

(c) Road Intersections

- Pedestrian crossings should be equipped with traffic control signal.

- Traffic islands to reduce the length of the crossing are recommended for the safety of all road users.
- Warning pavers should be provided to indicate the position of pedestrian crossings for the benefit of people with visual impairments.
- Table tops (raised road level to the sidewalk height) are helpful in reducing the speed of traffic approaching the intersection

(d) Median/Pedestrian Refuge

Raised islands in crossings should:

- Cut through and level with the street; or
- Have kerb ramps on both the sides and have a level area of not less than 1500 mm long in the middle; and
- A coloured tactile marking strip at least 600 mm wide should mark the beginning and end of a median/ pedestrian refuge to guide pedestrian with visual impairments to its location.

13.17 TRAFFIC SIGNALS

- Pedestrian traffic lights should be provided with clearly audible signals for the benefit of pedestrians with visual impairments;
- Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination;
- The installation of two adjacent acoustic devices such as beepers is not recommended in order to avoid disorientation;
- The time interval allowed for crossing should be programmed according to the slowest crossing persons; and
- Acoustical signals encourage safer crossing behaviour among children as well.

13.18 SUBWAY AND FOOT OVER BRIDGE

Subways and foot over bridges should be accessible for people with disabilities. This may be achieved by:

- Provision of signage at strategic location;
- Provision of slope ramps or lifts at both the ends to enable wheelchair accessibility ;
- Ensuring that the walkway is at least 1500 mm wide;
- Provision of tactile guiding and warning paver along the length of the walkway;
- Keeping the walkway; free from any obstructions and projections; and
- Providing for seats for people with ambulatory disabilities at regular intervals along the walkway and at landings.

13.19 ALIGHTING AND BOARDING AREAS

- All areas and services provided in the Mass Rapid Transit System (Metro/subway), bus terminuses, etc. that are open to the public should be accessible.

13.20 APPROACH

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.
- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions or areas requiring maintenance should be white cane detectable.
- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

13.21 CAR PARK

(A) SIGNAGE

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be at a minimum height of 2100 mm .

(B) SYMBOL

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the centre of the lot; and
- The colour of the symbol should be white on a blue background.

(C) CAR PARK ENTRANCE

The car park entrance should have a height clearance of at least 2400 mm.

LOCATION

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.
- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) ACCESSIBLE CAR PARKING LOT

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm;
- Have a firm, level surface without aeration slabs;
- Wherever possible, be sheltered;
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings;
- Two accessible parking lots shall be provided for every 25 no of car spaces.

(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

Chapter -14
EIA & SIA

Chapter – 14

ENVIRONMENT & SOCIAL IMPACT ASSESSMENT

14.1. BACKGROUND

Ahmedabad, in demographic-cum-economic terms, is the most developed region of Gujarat. Ahmedabad a 600 year old city is the district headquarters and the biggest city of the state at present. Gandhinagar is the Capital of Gujarat. Gandhinagar and Ahmedabad are located 32 km from each other, are well connected through highways and are rapidly becoming a contiguous urban area. The twin cities together constitute a buoyant economy.

Manufacturing, trade and service dominate Ahmedabad. It is a national hub for pharmaceutical, chemical and textile sector. Thus, in order to resolve traffic and pollution related issues and considering future growth and development of the city, Government of Gujarat proposes to develop a Metro Rail project to meet the local transport requirements of Ahmedabad.

MEGA (Metro-link Express for Gandhinagar and Ahmedabad), a special purpose vehicle was formed in 2009 for development and operation of Metro Rail facility in the twin cities of Ahmedabad and Gandhinagar. MEGA desires to build the Metro Rail System by adopting adequate environmental standards to provide for the protection of the people and the environment.

It is proposed that the Metro project will be taken up in Phases. Under Phase I, the length of the alignment considered is 35.95 Km and there would be 32 stations. Of the Phase I length, 6.335km, primarily in the eastern old city part of the east west corridor is proposed to be underground. There are two lines of which the East - West corridor is 20.53km and North - South corridor is 15.42km.

14.2. POLICIES, LEGAL AND INSTITUTIONAL FRAMEWORK

The legal framework of India consists of several acts, notifications, rules, and regulations to protect environment and wildlife. Review of Indian legal system has been carried out to identify its applicability to the project.

The following rules, notifications and standards under the Environment (Protection) Act, 1986 are particularly relevant in this case:

- Environment (Protection) Rules, 1986 and its amendments
- EIA Notification, 1994 and its amendments
- Ash Utilization Notification, 1999 and its amendments
- The Forest (Conservation) Act 1980 (Amended 1988) and Rules 1981 (Amended 2003)
- The Wildlife (Protection) Act, 1972 (Amended 1993)

• The Water (Prevention and Control of Pollution) Act 1972 (Amended 1988) and Rules 1974

• The Air (Prevention and Control of Pollution) Act, 1981(Amended 1987) and Rules 1982

• The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2010)

• Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules 2008 (Amended 2009)

• Ancient and Historical Monuments and Archaeological Sites and Remains (Declaration of National Importance) Act, 1951 (No. LXXI of 1951)

Requirement of Environmental Clearance

As per provisions of the EIA Notification, 14 September 2006 as amended up to 1 December 2009, any person who desires to undertake any new project in any part of India or the expansion or modernization of any existing industry or project listed in Schedule-I of the said notification shall submit an application to the Ministry of Environment and Forests (MOEF), Government of India in accordance with the guidelines issued by the Central Government in the Ministry of Environment and Forests from time to time. Metro Rail project is not included in the Schedule-I of the EIA Notification, 2006. Thus, the project does not require an environmental clearance certificate from the Ministry of Environment and Forests, Government of India. However, the client MEGA, being environment conscious, proposed to undertake an Environmental Impact Assessment study for the proposed project so that the environmental impacts stemming from the project can be assessed and mitigated. The EIA study would enable MEGA in dealing with careful planning and designing of the metro alignment and structures from environmental point of view and for making adequate provision of environmental clauses in work contracts so as to eliminate or reduce significantly all possible adverse impacts on the environment.

The MoEF is vested with overall responsibility to set policy and standards for the protection of environment along with Central Pollution Control Board (CPCB) and State Pollution Control Boards. The air, noise and water quality needs to be maintained as per respective standards. These standards are also of significance for the proposed project. More importantly, Consents under the Air Act and Water Act will have to be sought from the Gujarat Pollution Control Board specially for establishing Batching plants, installation of DG sets and discharge of effluents from the Depot. Permission from relevant Government Authorities will be required for water requirements and access to public sewers both during construction and operation of the Metro project.

Forest Clearance

As per Indian “Forests Conservation Act (1980), every project requiring diversion of forest land for non-forestry purposes require forest clearance from MoEF. The forestry clearance is granted through two-stage process: Stage 1, in principle agreement, refers to the project proposal in which usually the conditions relating to transfer, mutation and declaration as RF/PF under the Indian Forest Act, 1972, of equivalent non-forest land for compensatory afforestation and funds for raising compensatory afforestation thereof are stipulated. Stage II involves formal approval under the Act after receipt of compliance report from the State Government in respect of the stipulated conditions.

Since no diversion of forest land is involved in Phase I of MEGA, no forest clearance is required for this project.

Protection of Ancient and Historical Monuments and Archaeological Sites

The Government of India has a long history of protecting its antiquities, ancient monuments and sites which started during the cultural renaissance of early nineteenth century. Table 1.2 lists the relevant and important acts and laws.

The State Legislature of Gujarat passed Gujarat Town Planning and Urban Development Act in 1976 which has been amended a few times. The Act provides power to state to protect ancient monuments, archaeological sites and heritage buildings . The Act empowered the State to acquire rights or enter into agreement to protect and maintain monuments and areas.

Table 14.1: Government of India Laws on the Protection of Ancient Monuments and Sites

Year	Act	Highlight
1810	Bengal Regulation XIX	First antiquarian legislation
1817	Madras Regulation VII	Vested the government with power to intervene whenever public buildings are under threat of misuse
1863	Religious Endowment Act XX	Empowered government to prevent injury to and preserve buildings remarkable for antiquity
1875	Indian Treasure Trove Act (Act No. VI)	Protect and preserve treasure found accidentally but has archaeological or historical value. Prohibits excavation without prior consent of the Archaeological Survey of India (ASI)
1904	Ancient Monuments Preservation Act	Still in force, provides effective preservation and autonomy over the monument
1947	Antiquities Export Control Act (Act No. XXXI)	Regulation over the export of antiquities under license issued by the Director General of ASI
1951	Ancient and Historical Monuments and Archaeological Remains (Declaration of National Importance) Act (No. LXXI)	All monuments identified under the Ancient Monuments Act 1904 were re-declared as monuments and sites of national importance and added 450 monuments in the list.
1956	States Reorganization Act	Additional Monuments and archeological sites were added for preservation
1958	Ancient Monuments and Archaeological Sites and Remains of 1958 (Amended and validated, 2010)	Defined ancient monument to be in existence for at least 100 years. The 2010 amendment stipulates that a minimum area of 100 meters in all directions of the protected monuments and sites shall be declared prohibited for

		purposes of construction and no private or public construction in the prohibited area will be allowed except those undertaken by the Archaeological Survey of India (ASI).
1972	Antiquities and Art Treasures Act (No. 52)	Control of moveable cultural property consists of antiquities and art treasures. Regulate the export and trade of antiquities and art.

14.3. National Environmental Standards

Following sections present the National Environmental Standards for air, noise, wastewater and water quality. The relevant and important standards of air and noise (for MEGA Phase 1) are presented here whereas those of wastewater and water are presented in **Appendix 1**

Ambient Air Quality Standards

Ambient Air Quality Standards have been notified by the CPCB vide Gazette Notification dated 11 April 1994 and also in Schedule VII of the Environmental (Protection) Rules 1986. Table 14.2 presents notified Air Quality Standards (as of 2009 revision).

Table 14.2: National Ambient Air Quality Standards (2009)

Pollutant	**Time**	**Concentration In µg/m3**	
		Industrial /Residential, Rural and Other Area	**Ecologically Sensitive Area (Notified by Central Government)**
Sulphur-di-Oxide (SO_2)	Annual Average/ 24 Hours	50 /80	20 /80
Oxides of Nitrogen as (NO_2)	Annual Average / 24 Hours	40 /80	30 /80
Particulate Matter (size less than 10**µg**) or PM_{10}**µg**	Annual Average / 24 Hours	60 /100	60 /100
Particulate Matter (size less than 2.5**µg**) or $PM_{2.5}$**µg**	Annual Average / 24 Hours	40 /60	40 /60
Lead (Pb)	Annual Average / 24 Hours	0.5 /1.0	0.5 /1.0
Carbon Monoxide (CO) (mg/m3)	8 Hours /1 Hour	02 /04	02 /04

Ambient Noise Standards

Ambient Noise level standards have been notified by MoEF vide Gazette Notification dated 26th December 1989 and also in the Schedule III of the Environmental (Protection) Rules 1986. It is based on the 'A' weighted equivalent noise level (Leq). These are presented in Table 14.3 below.

Table Error! No text of specified style in document.**4.3: National Ambient Noise Standards**

Categories of Zones	Limits in dB(A) Leq	
	Day Time	**Night Time**
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone	50	40

Note-1: Day time is from 6.00 AM to 10.00 PM
Note-2: Night Time is reckoned between 10.00 PM to 6.00 AM
Note-3: Silence Zone is defined as an area up to 100 m around premises of Hospitals, Educational institutions & Courts. Use of vehicle horn, Loud Speakers and Bursting of Crackers is banned in these zones.
Note-4: Mixed categories of areas are declared as one of the four above mentioned categories by the competent Authority and the corresponding standards shall apply.

The following Noise standards in Table 14.4 for permissible exposure in case of continuous Noise as stipulated under the Building and Other Construction Workers (Regulation of Employment and Condition of Service.) Act, 1996 made by the Govt. of Gujarat (Ref: Rule 64 and limits laid down in Schedule – VI) are to be followed.

Table Error! No text of specified style in document.**4.4:Permissible Exposure in case of continuous Noise (GBOCW Rule 64, Schedule VI)**

Total time of exposure (continuous or a number of short term exposure) per day in Hours	Sound level in dB(A)	Total time of exposure (continuous or a number of short term exposure) per day in Hours	Sound level in dB(A)
8	90	1 ½	102
6	92	1	105
4	95	¾	107
3	97	½	110
2	100	¼ or less	115

Notes:1. No exposure in excess of 115 dB(A) is to be permitted. 2. For any period of exposure falling in between any figure and the next higher or lower figure as indicated in column (1), the permissible sound pressure level is to be determined by extrapolation on a proportionate basis.

Wastewater Discharge Standards

The wastewater discharged from domestic sewage need to maintain discharge standards as stipulated under the "Environmental (Protection) Rules 1993". Table A-1 in Appendix 1 summarizes the wastewater discharge standards for disposal of wastewater in Indian Surface Water Bodies.

Water Quality

To ascertain and categories the existing water quality, the result of the analysis of water quality need to be compared with the water quality standards given in Tables A-2 and A-3 in Appendix 1

Indian and WHO Standards for Drinking Water

For comparing the ground water quality of project area, the Indian and WHO standards are reproduced in Tables A-2 and A-3 in Appendix 1.

14.4. Regulatory Permissions Required

For the Phase I of Metro project, required clearances/ permissions related to environment for MEGA Phase I have been summarized in Table given below.

Table 14.5: Permissions/Clearances Related to Environment Required for Phase I Metro Project

Sl. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980). Tree removal will be guided as per state government rules.	District Forest Office/State Forest Department/ District Col-	MEGA
2	Permission for construction within the regulated / prohibited zone	Gujarat Town Planning and Urban Development Act, 1976	Town Planning Department and ASI	MEGA
B. Implementation Stage				
3	Consent to operate hot mix plant, crushers, batching plant	Air (Prevention and Control of Pollution) Act 1981	Gujarat State Pollution Control Board	Contractor
4	Permission for withdrawal of groundwater for construction	Environment (Protection) Act, 1986	Central Ground Water Authority	Contractor
5	Permission for sand mining from river bed	Environment (Protection) Act, 1986	Mining Department , Government of Gujarat	Contractor
6	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 1989	Gujarat State Pollution Control Board	Contractor
7	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 1989	Intimate local civic body to use local solid waste disposal site	Contractor
8	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	Gujarat State Pollution Control Board	Contractor
9	Permission for groundwater extraction.	Environment (Protection) Act, 1986	Central Ground Water Board (CGWB)	Contractor
10	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Ser-	District Labour Commissioner	Contractor
	Setting up of Batching Plants by the Contractors.	Air Consent and Water Consent under Air Act and Water Act	Gujarat Pollution Control Board	Contractor
C. Operations Stage				
	Installation of DG Sets and discharge of Wastewater from Depot.	Air Consent and Water Consent under Air Act and Water Act	Gujarat Pollution Control Board	MEGA

14.5. Why Metro ?

Metro systems have an advantage over other modes because they provide higher carrying capacity, faster, smoother, and safer travel, occupy less space, and are non- polluting and energy-efficient. To summarise the benefits, a Metro system:

- Requires 1/5th energy per passenger km compared to road-based system
- Causes no air pollution in the city
- Causes lesser noise level
- Occupies no road space if underground and only about 2 metres width of the road if elevated
- Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- Is more reliable, comfortable and safer than road based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

The Metro alignment has been carefully planned so that there is no conflict between existing BRTS and proposed Metro. Only 3km of alignment near AEC overlaps which is unavoidable.

The State has implemented Bus Rapid Transport System (BRTS) under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in Ahmedabad which is operating successfully. However, BRTS has its own limitations and constraints. The capacity of a BRTS at best can be 10,000 to 12,000 PHPDT (Peak Hour Peak Direction Trips) and that of a tramway system about 8,000 to 10,000 PHPDT. The BRT takes away two lanes of the road for dedicated use pushing rest of the road vehicles crowded into the remaining road space. Therefore, unless the road widths are more than three lanes in each direction, BRT is not feasible and even then, the non-bus riders will be put to tremendous inconvenience. The Metro has a capacity to handle 40,000 PHPDT and has a smaller environmental footprint compared to BRTS.

14.6. TRAFFIC DEMAND FORECAST

With the horizon year is taken as 2043 and considering 4 traffic growth scenarios, the summary of transport demand forecast is presented in the Table 14.6. The forecasts consider implementation of both phases of the MEGA Project.

Table 14.6: Summary of Transport Demand (Daily Passengers, one side in lakhs)

Scenario	**2018**	**2021**	**2031**	**2043**
N-S Corridor	210928	299824	429074	624492
E-W Corridor	246743	361780	493781	619118
Total	**457671**	**661604**	**922855**	**1243610**

Source – Projections by CoE, CEPT

14.7. HERITAGE STRUCTURES

Both east-west and north-south metro lines are passing near several ASI monuments located in Eastern and Western part of Ahmedabad city. Total 9 Monuments are falling in the vicinity of Metro Alignment, which are ASI protected monuments as per record. It has been ensured by suitable choice of route alignment that none of the declared monuments /heritage properties are within 100m from Metro line to comply with the Heritage Acts.

The details of Heritage Structures along the Metro Alignment are given in Table 14.7

Table 14.7: Details of Heritage Structure along the Metro Alignment

S. No	Name of Monument	Location	Corridor
1	Rauza of Azamkhan and Mouzam-khan	Vasna	North-South
2	Small Stone Mosque (Pani Masjid)	Paldi	North-South
3	Saiyad Usman's Mosque and tomb	Usmanpura	North-South
4	Kazi Mohmed Chisti's Masjid	Walled City	East-West
5	Delhi Darwaza	Delhi Chakla	East-West
6	Qutubuddin Shah's Mosque	Walled City	East-West
7	Rani Rupavati's Mosque	Walled City	East-West
8	Kalupur Darwaza	Kalupur	East-West
9	Brick Minar	Kalupur	East-West

However, road traffic is passing alongside these monuments. By planning a Metro System, the areas shall be decongested and number of vehicles passing will reduce. Thus the life of these structures can be increased. Necessary protection of these Monuments can be ensured during construction with the availability of advanced technologies.

14.8. BASELINE ENVIRONMENT DATA

Identification of environmental attributes, data collection, impact identification and evaluation forms the core of Environmental Assessment process. An environmental scoping checklist has been used for initial assessment from which a matrix has been formulated to identify the attributes likely to be affected due to proposed project. The Matrix is presented in Table below:

Table14.8: Scoping Matrix

Environmental Attribute	Likely Impacts
A. Land Environment	
Construction Phase	-Use of land for labour camps -Problems due to excavated spoils /muck disposal -Solid waste from labour camps -Acquisition of land for various project components
B. Air Pollution	
Construction Phase	-Impacts due to various construction activities -Impacts due to increased vehicular movement -Fugitive emissions from various sources.
Operation Phase	-Less air pollution
C. Noise Pollution	
Construction Phase	-Noise due to operation of various equipment -Noise due to increased movement -Noise due to construction activities
Operation Phase	-Impact on Noise

D. Water Quality	
Construction Phase	-Increase in turbidity of nearby receiving water bodies -Degradation of water quality due to disposal of wastes From construction sites - Impact on groundwater due to tunnelling
E. Terrestrial Ecology	
Construction Phase	-Loss of trees
F. Flora and Fauna	- Impact on species

Based on the matrix, the attributes for baseline environmental data have been selected. The data for the following has been compiled:

a. Land Environment (Physiography, Geology, Seismicity and Land use pattern);
b. Meteorology
c. Air Environment (Ambient Air Quality);
d. Noise Environment (Noise Levels);
e. Water Environment (Water Resources and Water Quality);
f. Ecological Environment (Terrestrial and Aquatic Ecology, Flora and Fauna)

Environmental scoping matrix is utilized to design and generate baseline environmental data. Most of the data has been collected from field studies. Field studies have been carried out to generate data on meteorology, ambient air, noise, vibration, water and soil during October 2012 and December 2013 / January 2014. The study area adjoining rail corridors under the Phase 1 of the Metro project is 500 m on either side of the right of way.

14.9. LAND ENVIRONMENT

Physiography

The terrain along the project alignment is mostly flat. The metro rail corridor runs through densely developed areas within the city. Phase I of Metro corridor runs through the oldest part of the city.

The city is situated on the banks of the river Sabarmati with an area of 190.84 sq. km. Its longitude and latitude are 720º 41' E and 230º 1' N respectively and elevation is 50 m above the sea level. It is the seventh largest urban conglomeration of India.

The river Sabarmati divides Ahmedabad into two physically distinct eastern and western regions. The eastern bank of the river constitutes the old city, which includes the central town of Bhadra. It is packed with bazaars, the clustered and barricaded pole system of old buildings with numerous places of worship. Some landmark establishments like railway station, the General Post Office and buildings of the Muzaffarid and British era are present in this part of the city.

Geology

Ahmedabad lies in Central Gujarat Plateau. Geologically, the project area forms part of the Cambay Sedimentary basin and is underlain by Post-Miocene alluvium, both Aeolian and fluvial, composed of sand, silt, gravel and clay. The surface cover is mainly fine sand and silt of blown nature and has about 25-40 m thickness. Major rock types available in project area are Calcareous sandstone and shales. Topographically, the area is characterised by flat terrain with a very gentle slope towards river Sabarmati. Elevations range from 60 m in north of the city to 40 m towards south of the city.

The Geology of the area is devoid of prominent rock exposures. The subsurface geology consists of soil, sand, alluvium, kankar and clay in Gujarat Alluvium Group' of Holocene age. It is followed by Coarse sand, gravels and greenish clay of Jambusar formation of Post Miocene age. After the Unconformity there are sand shale, clay stone, grey shale with sand stone at large depths.

Seismicity

The Gandhinagar- Ahmedabad region is located in Seismic Zone – III (a zone having moderate damage risk) of the Indian Earthquake Zonal Map according to IS – 1893 (2002) with the corresponding design acceleration coefficient of 0.07. The predominant frequency of the earthquake recorded at Ahmedabad city was around 1.19HZ and 1.4HZ in N-S and E- W directions. Gujarat State Disaster Management Authority has recommended additional precaution norms over and above Zone III requirements for construction purposes.

Meteorology

Ahmedabad experiences a semi-arid hot climate. The weather and climate in Ahmedabad is largely influenced by the Arabian Sea. The average temperature of the city ranges in between 12 degrees to 41 degree Celsius. The southwest monsoon brings a humid climate from mid-June to mid-September. Like most of the other parts in India, the climate in Ahmedabad also revolves round three main important seasons. South western monsoons sweep into Ahmedabad in mid July. During this time weather and climate in Ahmedabad is humid. Monsoon continues till the month of September. The average annual rainfall received by the city is 93.2 cm. The typical climate data for Ahmedabad is presented in Table below:

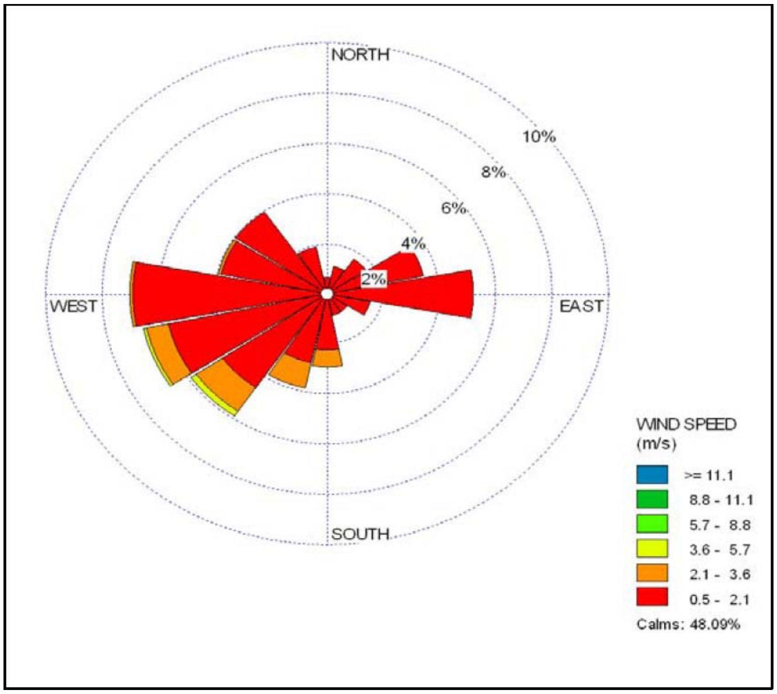
Table 14.9: Monthly mean maximum & minimum temperature and total rainfall

Month	Mean Temperature ^{0}C Maximum	Mean Temperature ^{0}C Minimum	Mean Rainfall, mm
January	28.7	13.1	2.1
February	31.0	14.8	1.2
March	35.9	19.4	1.1
April	39.5	23.5	1.9
May	41.4	26.3	9.1
June	38.5	27.2	97.4
July	33.5	25.7	309.8
August	32.0	24.9	213.8
September	33.5	24.4	126.6
October	35.8	21.9	13.5
November	33.2	17.5	6.1
December	29.9	14.1	1.7

Source: based upon 1901-2000 data, India Meteorological Department

The wind rose diagram derived from field weather monitoring station of year 2012 is shown as Map 14.1

Figure 14-1: Wind Rose Diagram



14.10. AIR ENVIRONMENT

Ambient Air Quality

After preliminary reconnaissance of the metro alignment and taking into account the sensitive receptors along the alignment the monitoring locations were identified. While selecting the monitoring locations Importance was given to sensitive areas such as educational institutions, hospitals, important and sensitive structures, public places, populated areas etc. A total of 10 locations are identified for undertaking the air quality monitoring. When the monitoring of air quality and noise quality is undertaken during the actual construction of the Metro Rail works, the data generated will be compared to the background levels so that the impact of construction activity on the environment can be evaluated and assessed to what extent the background ambient air levels are being affected. The locations identified for air quality monitoring are given in Table 14.10 below and are shown in Map 14.2:

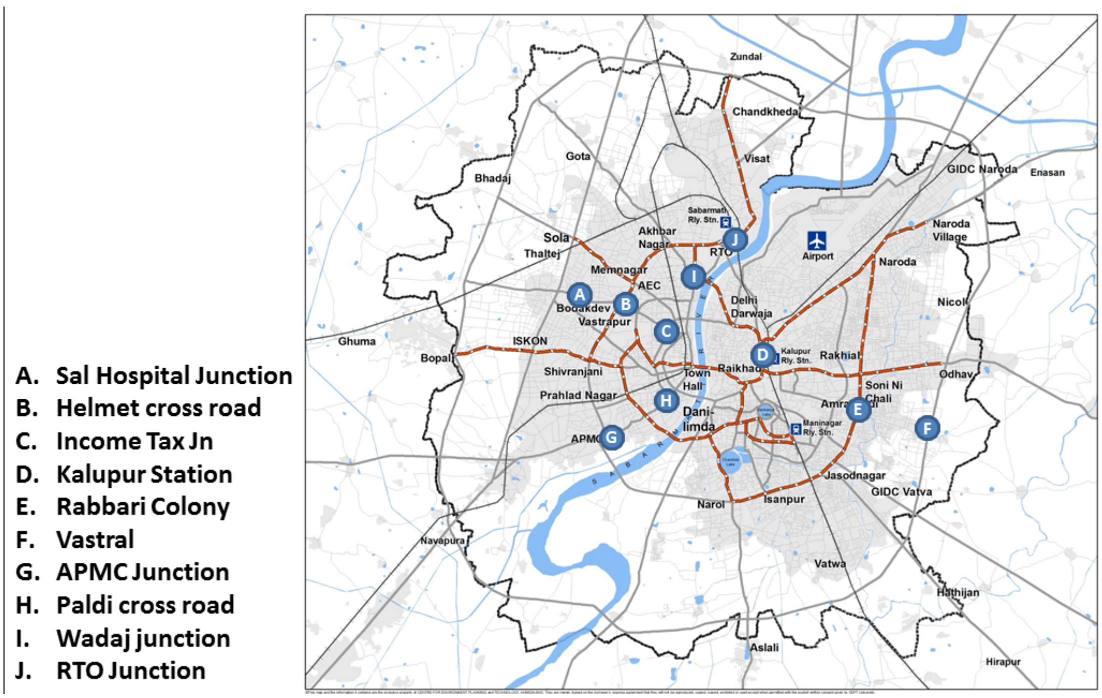
Table 14.10: Ambient Air Quality Monitoring Locations

Code	Location	Latitude	Longitude	Category
AA01	Sal Hospital Junction	23°02'58.55"	72°31'25.74"	Residential, Institutional
AA02	Helmet Cross Road	23°02'42.22"	72°32'30.66"	Residential, Institutional, Commercial
AA03	Income Tax Jn	23°02'20.64"	72°34'09.88"	Institutional, Commercial
AA04	Kalupur Station	23°01'36.96"	72°36'03.24"	Transit, Institutional, Commercial
AA05	Rabbari Colony	22°59'59.58"	72°38'08.92"	Residential, Commercial
AA06	Vastral	22°59'44.97"	72°40'15.47"	Residential, Commercial

AA07	APMC Junction	22°59'47.25"	72°32'09.44"	Transit, Institutional, Commercial
AA08	Paldi Cross Road	23°00'51.83"	72°33'51.51"	Transit, Institutional, Commercial
AA09	Wadaj Junction	23°04'03.94"	72°33'45.74"	Transit, Residential, Commercial
AA10	RTO Junction	23°04'04.24"	72°34.54.80"	Transit, Institutional

Source: Primary sampling carried out in the month of January 2014

Map 14.2 Ambient Air Monitoring Locations



The methodology and criteria followed for fixing the Ambient Air Quality Monitoring (AAQM) stations is as per the recommendations of CPCB (IS: 5182), which are:

a. The sampling station had free exposure so that it did not collect air from stagnant pockets.
b. It was not obstructed by large structures including hills.
c. The sampling point was not directly influenced by any local source of emission.
d. It was located at a minimum height of 1.5 m from the ground level.

Selection of monitoring parameters

The list of parameters and the methodology followed for monitoring is shown in the Table 14.11.

Table 14.11: List of Parameters & Methodology

Sr. No.	Test Parameters	Unit	Sensitivity	Methodology
1	Respirable Particulate Matter (PM10)	$\mu g/m^3$	5 $\mu g/m^3$	Gravimetric IS: 5182 (Part 23) 2006
2	Fine Particulate Matter (PM2.5)	$\mu g/m^3$	3 $\mu g/m^3$	Guideline for the measurement of ambient air pollutant Volume -1 by CPCB, 2011, Gravimetric

3	Sulphur Dioxide	µg/m3	1.7 µg/m3	Colorimetric IS: 5182: (Part II) 2001
4	Oxides of Nitrogen	µg/m3	0.5 µg/m3	Colorimetric IS: 5182: (Part VI) 2006
5	Carbon monoxide	Ppm	1 ppm	As per equipment manual
6	Carbon-dioxide	Ppm	1 ppm	As per equipment manual
7	Lead	Ppm	1 ppm	As per equipment manual

Air Monitoring Results

The observed concentrations of various pollutants at all the sampling stations are presented in the Table 14.12 below. Monitoring commissioned by MEGA was carried out during January 2014. Average concentrations are compared with the National Ambient Air Quality Standards as stipulated by CPCB, stipulated limits are shown in parenthesis in the title row.

Table 14.12: Ambient Air Quality Monitoring Results

Code	Location	Parameters and result						
		PM_{10} (100) [24 Hours]	$PM_{2.5}$ (60) [24 Hours]	SO_2 (80) [24 Hours]	NOx (80) [24 Hours]	CO_2 [Grab Sample]	CO [Grab Sample]	Lead [Grab Sample]
		98 percentile				Measured value		
AA01	Sal Hospital Junction	49.00	48.00	12.26	9.14	1.24	0.62	0.012
AA02	Helmet Cross Road	916.00	32.00	13.60	95.41	0.51	0.95	0.211
AA03	Income Tax Jn	92.00	39.00	11.86	28.99	0.88	0.71	0.043
AA04	Kalupur Station	254.00	58.00	8.52	28.17	1.51	0.87	0.137
AA05	Rabbari Colony	39.00	22.00	8.10	8.23	0.16	0.61	0.016
AA06	Vastral	128.00	27.00	11.05	15.57	0.55	0.700	0.016
AA07	APMC Junction	342.00	78.00	11.00	46.90	0.78	0.85	0.089
AA08	Paldi Cross Road	89.00	31.00	10.72	10.60	1.06	0.74	0.041
AA09	Wadaj Junction	97.00	96.00	9.35	46.82	1.21	0.76	0.034
AA10	RTO Junction	500.00	28.00	20.30	18.88	1.78	0.92	0.127

Source: Primary sampling carried out in the month of January 2014

The air pollutant Parameters monitored are shown as average for 24 hours and 98 percentile except for Lead, CO_2 and CO which are grab samples. **PM_{10}** values are higher than permissible limits at 5 locations, primarily due to the locations being high density traffic junctions. PM_{10} is especially high at Helmet Cross Road, Kalupur Station, APMC Junction and RTO Junction. Shift from road to metro transport has reduced SPM and other pollutants in other cities which make it imperative for Ahmedabad to make the transition from road to metro. **$PM_{2.5}$** is higher than permissible limits at APMC and Wadaj junctions, again due to the locations being high density traffic junctions.

Lead, CO_2 and CO are within permissible limits at all locations. The Monitoring locations fall under the category of Industrial, Commercial, Residential, Rural and other locations and accordingly are compared to the National Ambient Air Quality standards stipulated by the CPCB. None of the sampling locations can be termed to represent ecologically sensitive area.

14.11. NOISE ENVIRONMENT

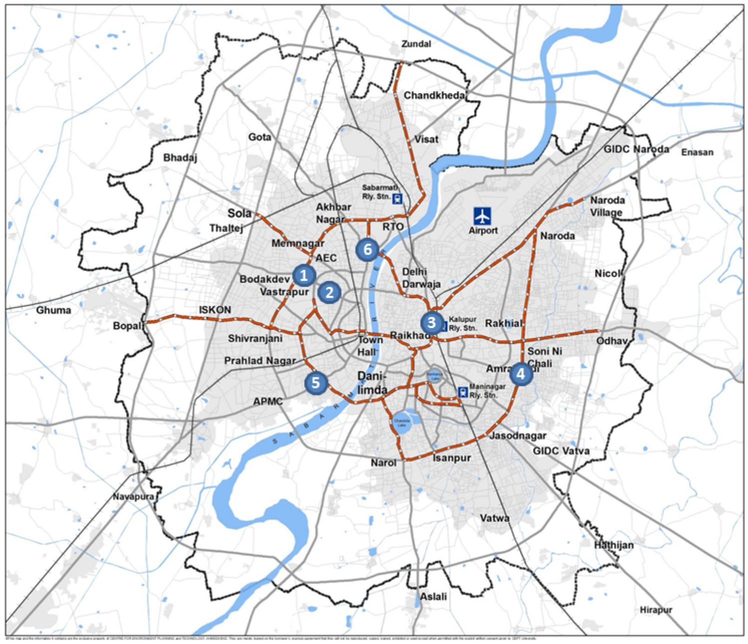
Noise level monitoring commissioned by MEGA was carried out at 6 locations during January 2014, the locations being same as air monitoring stations. Ambient noise monitoring for 24 hours was carried out. The Noise monitoring locations are given in Table 14.13 below and are shown in Map 14.3 :

Table 14.13: Noise level Monitoring Locations

Code	Location	Latitude	Longitude	Category
NL01	Helmet Cross Road	23°02’42.22”	72°32’30.66”	Residential, Institutional, Commercial
NL02	Commerce Six Road	23°02’22.90”	72°33’15.77”	Residential, Institutional
NL03	Kalupur Station	23°01’36.96”	72°36’03.24”	Transit, Institutional, Commercial
NL04	Rabbari Colony	22°59’59.58”	72°38’08.92”	Residential, Commercial
NL05	Anjali	23°00’17.40”	72°33’10.96”	Residential, Commercial
NL06	Wadaj Junction	23°04’03.94”	72°33’45.74”	Transit, Commercial

Map 14.3: Noise monitoring locations

1. **Helmet cross road**
2. **Commerce Six Road**
3. **Kalupur Station**
4. **Rabbari Colony**
5. **Anjali Junction**
6. **Wadaj junction**



Noise Monitoring Results

The Noise levels are measured as per standard scientific practice using a automatic noise level meter. The noise levels so obtained are summarized in Table 14.14 below**.**

Table 14.14: Noise Monitoring Results

Code	Noise Monitoring Location	Category of Area/Zone	Noise Level Standard Limits in dB (A)		Noise Level in dB (A) Leq	
			Day Time	Night Time	Day Time	Night Time
NL01	Helmet Cross Road	Residential, Institutional, Commercial	55.0	45.0	76.2	54.7
NL02	Commerce Six Road	Residential, Institutional	55.0	45.0	81.8	60.2
NL03	Kalupur Station	Transit, Institutional, Commercial	65.0	55.0	85.7	68.8
NL04	Rabbari Colony	Residential, Commercial	55.0	45.0	73.6	59.5
NL05	Anjali	Residential, Commercial	55.0	45.0	80.1	60.2
NL06	Wadaj Junction	Transit, Commercial	65.0	55.0	78.7	56.9

Source: Primary sampling carried out in the month of January 2014

The noise monitoring locations are falling under residential and commercial zones and accordingly the Leq(Day) and Leq (Night)noise levels monitored are compared with the CBCP standards stipulated for Residential and Commercial zones. It can be seen that at all locations both daytime and night noise levels are exceeding the standards Limits. The high noise levels can be attributed to the locations being in urban high traffic density junctions on city main roads. The higher noise levels are understandable as these junctions are busy places with high traffic and other activities and the vehicular movement is very high. Implementation of metro and shift from road to metro transport would definitely mute the high noise levels. During the Metro construction period, it has to be ensured that the construction activities does not cause a further increase in baseline noise levels at these locations where the noise levels are already far exceeding the standard permissible limits.

14.12. WATER ENVIRONMENT

Surface water

Due to non-availability of perennial water during late 50’s in the River Sabarmati, the city started depending on the ground water sources. Apart from the municipal tube wells, a large number of private tube wells have been installed in various parts of the city. This seriously affected the ground water level, which was depleting at the rate of 2 to 3m annually. At this time, the city initiated a new scheme – Raska Wier water supply project, at a cost of Rs. 110 Crores. The pipeline of a length of 43 km carrying 65 million gallons per day water was executed and put to operation within a period of 130 days. In addition, a water treatment plant was also commissioned. The city continued with development of surface water sources. As a result the dependency on ground water reduced from 60% to 5%.

Since many years, the Sabarmati River has been polluted by the fast pace of urban and industrial growth. Though the Sabarmati is a major source of water for the city, the riverfront lay neglected. The storm water outlets perennially polluted the river due to release of sewage into the river. The Sabarmati Riverfront project was undertaken to stop this abuse. It aims to undo the years of human neglect. It diverts waste water from coming into the river, protects river bed, minimizes flood risk, provides alternate housing for poor at safe locations and provides space for public amenities. The project under implementation has been awarded The Prime Minister’s National Award for Excellence in Urban Planning and Design.

The city has 3 urban lakes of Kankaria, Chandola and Vastrapur. Chandola and Vastrapur are a few kilometers from the nearest point of the metro alignment. Kankaria is less than a km away from Kalupur metro station which would be underground. The area between Kankaria and Kalupur metro station is densely built up city area including Ahmedabad main railway station and there is a physical barrier between the lake and metro alignment.

Surface Water Quality Monitoring

The main water body near the north-south alignment of metro is the Sabarmati River. The quality of water in the Sabarmati River is assessed to understand the present status. Two grab samples from Sabarmati River, one in the upstream and one in the downstream was collected. The sampling locations are given in the Table 14.15.

Table14.15: Surface water quality monitoring Locations

Sl. No.	Location	Coordinates	Description of sampling location
SW 01	Tri Junction (Towards Bhat)	N 220 05' 27.7" E 720 37" 43.3"	Sabarmati River upstream to check quality of water before entering into city.
SW 02	Tri Junction (Towards Motera)	N 230 05' 32.4" E 720 37" 06.1"	Sabarmati River; to check quality of the downstream water.

The water samples collected were analysed for various parameters as per CPCB guidelines and the APHA standard methods are followed. The analysis results of Sabarmati river samples are presented in Table 14.16.

Table 14.16: Surface water quality monitoring results, Sabarmati River

Parameters	Unit	Sabarmati upstream SW01 near Tri Junction (Towards Bhat)	Sabarmati Downstream SW02 near Tri Junction (Towards Motera)
pH	pH scale	7.20	7.95
Total Dissolved Oxygen	mg/l	3.90	3.10
BOD	mg/l	<1.0	<1.0
Sodium Absorption Ratio	mg/gm	0.29	0.24
Electrical Conductivity	µmho/c m	238.10	229.90
Free NH_3 (Ammonical)	mg/l	0.16	<0.01
Boron as B	mg/l	<0.03	<0.03
Total Dissolved Solids	mg/l	160.00	152.00
Chlorides (as CL)	mg/l	51.00	48.00
Sulphate	mg/l	1.00	1.00
Colour	Pt.co	3.00	2.00
Nitrate (as NO3)	mg/l	2.73	3.14
Arsenic	mg/l	<0.001	<0.03
Iron	mg/l	0.006	0.82
Fluoride	mg/l	1.47	1.36
Lead	mg/l	<0.04	<0.02
Copper	mg/l	0.009	<0.01
Zinc	mg/l	0.018	0.01
Total Coli form	MPN/ 100ml	<2.0	<2

In both upstream and downstream samples of Sabarmati, Dissolved Oxygen is below minimal level to sustain fish of 4mg/l, Fluoride is on the higher sode but within permissible limits. Rest of the parameters are within limits and are a confirmation that water quality is fit to be used for human consumption after treatment. The surface water analysis results of Sabarmati River indicate that the water quality is comparable to CPCB Class C water quality i.e., best suited for drinking water with conventional treatment followed by disinfection.

CPCB guidelines for designated best use of water are listed in Table 14.17

Table 14.17: Designated Best Use of Water Bodies

Class	Designated Best Use
A	Drinking water source without conventional treatment but after disinfection
B	Outdoor bathing (orgnaised)
C	Drinking water source with conventiol treatment followed by disinfection
D	Propagation of wildlife, fisheries
E	Irrigation, industrial cooling, controlled waste disposal

Source: CPCB website

Groundwater

Groundwater constitutes a major source of water supply for Ahmedabad City. Ahmedabad Municipal Corporation has been operating about 336 tube wells. However, with the recent availability of water from Raska Weir, 75 of the tube wells are going to be decommissioned. Constant and large withdrawals of groundwater have resulted in a rapidly depleting water table level at the rate of 2.0-2.5 meters per year. If groundwater was available at 63 meters underground in 1997 in the city, it is now available at around 100 meters. Increasing extraction of groundwater to cater to domestic and industrial requirements has rendered most of the shallower aquifer (unconfined aquifer) zones dry. The study, conducted by the Central Ground Water Board said that the ground water will have to be recharged artificially to meet the steep water demand from increasing population.

The CGWA under the Ministry of Water Resources is responsible for providing scientific inputs for management, exploration, monitoring, assessment, augmentation and regulation of ground water resources of the country. The Authority regularly publishes State and District hydro-geological reports, ground water year books and atlases, ground water user maps and guides/manuals/pamphlets for proper ground water management. CGWA was constituted under sub-section (3) of Section 3 of the Environment (Protection) Act, 1986 for the purposes of regulation and control of ground water development and management in the country. The Authority is engaged in various activities related to regulation of ground water development to ensure its long-term sustainability.

As per the power granted under Environmental Protection Act, 1986, permission from Central Ground Water Authority is required for extracting ground water for construction purposes, from areas notified as critical or semi- critical from ground water potential prospective. Large area of Gujarat and Ahmedabad are notified as critical areas. Construction of new ground water structures is prohibited in the notified areas.

Ground Water quality Monitoring

Groundwater samples collected from bores for geotechnical investigations at 8 locations along metro during Nov/Dec 2013. They were analysed for pH, chloride and sulphates. Water sample had chloride (99 - 422 mg/l) and sulphates (2.7 – 56 mg/l). The pH value of soil is found between 7.1 to 9.76 which is therefore suitable as per IS-456 (2000). he water is alkaline and chloride and sulphates are within permissible limits for water usage for construction. These results tally with the earlier October 2012 analysis results reported in Table 14.18

Table 14.18: Chemical investigation of ground water collected from geotechnical locations

Sl. No.	Location	pH	Chloride (mg/l)	SO4 (mg/l)	SO3 (mg/l)
ST 01	Sabarmati River	7.28	421.87	17.25	14.37
ST 02	Kasturba Gandhi Road	7.10	229.93	13.25	11.04
ST 03	Gheekanta Road	7.13	249.92	12.75	10.62
ST 04	Near Arvind Mill	7.40	99.97	3.25	2.71
ST 05	New Cotton Mill	7.35	169.95	10.75	8.96
ST 06	Swastick Circle	7.76	215.93	10.00	8.33
ST 07	Rabari Colony	7.10	319.90	9.25	7.71
ST 08	Mahadev Nagar	9.76	409.87	56.00	46.67
	Limit as per IS-456 (2000) Table 1 Clause 5.40	Not less than 6	2000 mg/l for PCC 500 mg/l for RCC	481 mg/l	400 mg/l
Testing Protocol: IS 3025 P 11,P 32,P 24.					

The analysis results of the ground water samples collected indicate that the certain parameters like TDS, Chlorides and Total Hardness are exceeding the desirable limits of IS 10500 drinking water standards, but the rest of all Parameters are well within the permissible limits. In general it can be inferred that the quality of the ground water from the locations where the samples are collected is of reasonably good quality.

14.13. Soil Quality

Chemical tests were carried out on soil samples from 8 bores conducted along Metro phase I alignment. Soils are of medium permeability, sandy loam, alkaline and are fairly good quality agricultural soils bit with low moisture and water holding capacity, with N value > 100.

Table 14.19: Soil sampling locations

Sl. No.	Location	Ground Water Table depth below EGL (m)	In-situ Compactness of Soil
ST 01	Sabarmati River	10.8	Medium Dense to Very Dense
ST 02	Kasturba Gandhi Road	6.3	Medium to Very Dense
ST 03	Gheekanta Road	6.0	Medium to Dense
ST 04	Near Arvind Mill	9.6	Medium Dense to Very Dense

ST 05	New Cotton Mill	8.4	Medium Dense to Very Dense
ST 06	Swastick Circle	7.0	Loose to Dense
ST 07	Rabari Colony	3.3	Medium to Very Dense
ST 08	Mahadev Nagar	28.3	Medium Dense to Very Dense

Soil sample had chloride (59 - 199 mg/l) and sulphates (2.25 – 9 mg/l) which are within permissible limits. The pH value of soil is found between 7.58 to 9.76. The sampling locations are given in Table 14.20

Table 14.20: Chemical investigation of ground water collected from geotechnical locations

Sl. No.	**Location**	**pH**	Chloride (mg/l)	SO4 (mg/l)	SO3 (mg/l)
ST 01	Sabarmati River	8.54	139.96	6.00	5.00
ST 02	Kasturba Gandhi Road	7.58	149.95	6.75	5.62
ST 03	Gheekanta Road	8.45	49.98	3.00	2.50
ST 04	Near Arvind Mill	8.34	69.98	3.75	3.12
ST 05	New Cotton Mill	8.78	199.94	3.75	3.12
ST 06	Swastick Circle	9.35	59.98	2.25	1.87
ST 07	Rabari Colony	8.38	169.95	9.00	7.50
ST 08	Mahadev Nagar	9.76	159.95	6.00	5.00
Testing Protocol :IS:2720 P 26, P 27 & A text book of soil chemical analysis by P.R.Hesse					

14.14. IDENTIFICATION OF IMPACTS

The project is providing an alternative environment friendlier urban transport option, which is less energy intensive. Based on project particulars and existing environmental conditions, potential adverse / negative/positive impacts, have been identified and wherever possible these have been quantified. The impacts likely to result from the proposed development have been listed under the following headings:

a. Impacts due to Project Location,
b. Impacts due to Project Design,
c. Impacts due to Construction and
d. Impacts due to Project Operation.

For the potential impacts identified recommendations for mitigating measures have been stated in Environmental Management Plan (EMP).

14.15. IMPACTS DUE TO PROJECT LOCATION

The impacts are:

a. Land Acquisition,
b. Loss of trees/forest
c. Utility/Drainage Problems
d. Aesthetics
e. Climate change impacts

Land Acquisition

Development of proposed Metro Rail project involves acquisition of land. Land is mainly required for:

a. Metro Rail Structure (including Route Alignment), Station Building, Entry/Exit Structures, Traffic Integration Facilities, Parking etc.
b. Receiving/Traction Sub-stations.
c. Depots and Temporary Construction work sites.

Every effort has been made to keep land requirement to the barest minimum. Land requirement for the project is estimated at about 96 hectares most of which belongs to Government and Municipal organizations.

During construction period, huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored. Sufficient land is required for storage of these materials. Vacant sites will have to be identified along the corridor, which can be utilised for temporary storage of construction materials.

Loss of Trees/Forests/ flora and fauna

The project is in urban area; hence no forest land exists along the project alignment or its corridor. Most of the trees were planted along the roads. About 1600 trees exist on the proposed alignment, which are to be felled. With removal of these trees the process of CO_2 absorption, O_2 production and the income from Forest Products will get affected and the losses are reported below. Cost estimate for transplantation of 4000 trees is proposed to be included in DPR. This activity will primarily be carried out by social forestry department in coordination with AMC and MEGA. Project being within densely built up urban area, there are no protected or endangered flora and fauna species which would be affected by Metro Phase I. Gujarat people are culturally habituated to provide protection to birds, peacocks can be seen living within city limits. No specific measures are necessary for protection of fauna including birds since animal tolerance is embedded in city's cultural ethos.

Decrease in CO2 absorption and Oxygen production:

Total number of trees: 1600

Decrease in CO2 absorption : 34880 kg @21.8 Kg/year/tree for 1 year

Oxygen production@49Kg/year/tree for 1 year : 78400 kg

According to Clean Development Mechanism one tonne of CO_2 reduction will yield one Carbon credit and 6 Euros (1Euro = Rs.85) is earned by one carbon credit.

Therefore 34880 kg of decrease in CO_2 absorption is estimated as a loss of Rs. 17789 per year. Around 78,400 kg of Oxygen production will be reduced because of tree loss and this would lead to a loss of 43.55 lakhs (784000 (Kg of O_2) X 55.55 (Rs./Kg of O_2) per year.

Loss of forest products:

Total loss of trees (Nos.): 1600 Average cost of one tree: 1200

Total Loss: 19.20 lakhs

Therefore total loss with the removal of trees will be around 62.75 lakhs per year.

The average consumption of oxygen for a person is about 182 Kg/year. It means these trees would have met the requirement of about 431 people round the year.

As a compensation for felling trees, following Forest Department norms, for every tree felled 10 tall tree saplings are proposed for planting. Hence about 16000 tree saplings will need to be planted at various locations within and around Gandhinagar-Ahmedabad city region.

Utility/Drainage Problems

The alignment will cross river, drains / nalas, large number of sub-surface, surface and overhead 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. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance.

Aesthetics

Aesthetics can be defined as the characteristics of objects and of the human being perceiving them that make the object pleasing or displeasing to the senses. Visual impact assessment aims to predict and assess the significance and magnitude of visual impact from proposed developments.

The project creates visual intrusions in the existing landscape character. Some potential visual impacts are:

- Scale dominance to existing landscape.

- The interruption of lines-of-sight to a focal point by elevated corridor.
- Blocked view lines along visual corridors (such as roads/ streets).
- Severing of visual continuity of open-space.

Climate Change Impacts

The MEGA Phase 1 project area has moderate risk of earthquake, medium risk for flooding, and landslide triggered by precipitation. Although precipitation is moderate at 750 mm/year average, coupled with a flat terrain resulting in low risk of landslide and flooding, this risk should be addressed.

The following engineering designs have been incorporated in the project to address the risk of landslide and flooding:

• Seepage pump and pump rooms for each underground station

• Drainage pipes along the tunnel

• Structure underground station is essentially a concrete box about 30m wide, 15m high, 100m long and 1.2m thick RCC

• A diaphragm wall for underground station of 80 to 100cm thick to function as permanent side wall which is absolutely watertight

14.16. IMPACTS DUE TO PROJECT DESIGN

Selection of routing of the alignment, surface irregularities on the rail, irregular track geometry, rail wheel interaction are some of the aspects to be considered during design stage.

In the proposed project the alignment was selected that it causes minimum disturbances and impacts in land acquisition, archaeological /heritage structures etc. The land acquisition is kept to the barest minimum and mostly it is Government land.

Development of surface irregularities on the rail: Proper measures to be initiated in the design stage to prevent development of surface irregularities on the rail. Further, rail grinding at regular intervals by Rail grinding machine and also lubrication of rail by vehicle-mounted lubricator have been contemplated.

Irregular track geometry: The irregular track geometry generates noise and vibration. Suitable measures in the design stage are contemplated for continuous welding of the rail and laid to fine tolerance so that any noise/vibration on account of irregular track geometry could be reduced.

The vibration generated from rail-wheel interaction can be greatly absorbed by the elastic fastening system.

Apart from the above the following are some impacts due to project design. They are:

a. Stations, Platforms, Inlets and Outlets
b. Railway station refuse and
c. Risk due to earthquake

Stations, Platforms, Inlets and Outlets

The general rail level is approximately 9.8 m above ground level. The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the double 'U' shaped pre-stressed concrete girders is proposed. In order to keep the land acquisition to minimum, alignment is planned along central median of the road. Stations are located above central median. The stations are located keeping in view inter- modal transport link, upcoming and existing economic development, traffic generating nodes and high density area. Entry/exit structures to proposed stations have been planned in the open space available. Wherever necessary, roads are aligned to match the alignment of rail tracks of proposed metro to place viaduct on median of road.

Railway Station Refuse

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

a. Garbage,
b. Rubbish, and
c. Floor Sweepings.

Eatables are not allowed in paid areas, in metro stations. Generally no paper handling is anticipated through tickets. Hence the solid waste generation will be mainly from floor sweeping in the form of dust/ rubbish. There are no shop/ facilities for cooking at Metro stations hence there is no generation of garbage. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of MEGA project Authorities. The storage containers for this purpose need to be designed. However it is suggested that the capacity of these containers may not exceed 120 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.

Risk Due to Earthquake

The Seismic Zones of India are classified as Zone II, III, IV and V. As per the new Seismic Zoning Map, -Ahmedabad falls in Zone III where the earthquake risk has been modified from least active to 'moderate'. The India Meteorological Department (IMD) has considered seismic factor of 0.16 to be adequate for design purpose for Civil Engineering structures. This factor needs to be appropriately incorporated while finalising civil designs. Therefore suitable seismic coefficient may be adopted in the design of structure commensurate with the Indian Standard for seismic zoning of the country viz IS.1893-2002.

14.17. IMPACTS DUE TO PROJECT CONSTRUCTION

The impact in construction phase is temporary. These impacts are:

a. Air Pollution
b. Noise Pollution
c. Soil Erosion and Spoils Disposal,
d. Traffic Diversions,
e. Impact on Water Quality,
f. Loss of Historical and Cultural monuments.

Air Pollution

Construction activities generate dust and other forms of air pollution and if not managed properly, could lead to severe degradation of surrounding environment. Even though such impacts are temporary in nature, these begin with construction activity and decline during finishing stage, yet it is imperative to employ control measures.

At Construction Site dust will escape from the construction site if storage facilities for dust generating materials are not properly enclosed. Water sprinkling to be carried out during handling of excavation soil or debris or during demolition. Areas within the Site such as construction depots and batching plants, where there is a regular movement of vehicles must have hard surface that is kept clear of loose surface material. Haulage and delivery vehicles moving with high speed also create dust. Poorly maintained diesel gen-sets with inadequate stack height can also create air pollution at construction sites. During piling work on road median as also during drilling and blasting, dust will be generated and measures to contain the same are brought out in the management plan.

1.1..1 During Transport of Material

Quite often, particulate matter gets deposited upon public roadways during transport of material. Wheels of trucks and other moving vehicles deposit dust and mud on public road if not washed clean. Often, materials having the potential to create dust are loaded to a level higher than the side and tail boards. Vehicles with an open load carrying area used for moving potentially dust-producing materials shall have properly fitting side and tailboards, and material shall be carried in vehicles fitted with covers.

Noise Pollution

Construction of facilities and structures would require the use of equipment, which may generate high noise levels and adversely affect noise sensitive receivers. Pneumatic impact tools and equipment used at the construction site without exhaust mufflers also create noise.

Impact devices, such as jackhammers, and pavement breakers and diesel generators create noise when used without acoustically attenuating shields. Diesel-powered equipment and pneumatic impact tools create more noise than electric instead and hydraulic tools.

Other sources of noise include movement of trucks and heavy material, idling, assembly on-site and inadequate physical separation between noise generators and noise receptors. Measures to control noise during construction are discussed in the management plan.

Health

Health risks during construction activity include disease hazards to workers due to lack of sanitary facilities like safe disposal of human waste and garbage clearance and disposal facility. In order to avoid such a situation, proper mitigation measures should be incorporated, which should include proper water supply, sanitation, drainage, healthcare and human waste disposal facilities in labour camps.

Soil Erosion and Spoils Disposal

Though the project may not have significant impact on soil erosion, minor impact on soil erosion due to runoff from unprotected excavated areas may result, especially when erosion tendency of soil is high. Problems could arise from dumping of construction spoils (concrete, bricks), waste materials (from contractor's camp) etc. causing surface and ground water pollution. Hence, it is proposed to have ready mix concrete directly from batching plant for use at site. Pre-fabricated structure will be a better option wherever feasible/possible.

Spoils management

Approximately 16,03,000 cubic meters of excavated soils will be generated from the construction of the 3 underground stations (Shahpur, Relief Road and Kalupur Railway Station) and due to underground tunnelling for 15km length. Out of this about 10 % will be used for back filling. Rest will be disposed in designated dumping yards of Ahmedabad Municipal Corporation (which are yet to be determined and are subject to AMC approval). Dumping will be done at sites currently being used for dumping construction waste materials.

A good option being explored is to provide the excavated soil to Ahmedabad Riverfront Improvement Project which needs huge quantity of soil to extend the length of riverfront improvement. MEGA and Riverfront project authorities need to explore this good option.

A spoil management plan will be implemented that details the location of spoil disposal sites, transport of spoil, and disposing of spoil. The Contractor will perform the following tasks:

- Dispose spoils on permitted sites as instructed by MEGA or AMC

• Ensure the adequacy of the disposal site to handle the volume of spoils that will be generated

• Prepare, submit and seek approval from MEGA for spoil dump plan that provides the: i) dump size, layout, and form, ii) means of controlling water and wind erosion, iii) measures to prevent spoil dump contamination, vehicular, and public access.

• Explore the possibility of using spoil materials to rehabilitate borrow pits

• All haul vehicles should be covered or soil sprayed with water before leaving the site specially during windy condition

• Spoil dumps shall have slopes no steeper that 1V:2.5H

• Final shaping, top soiling, and immediate re-vegetation

Traffic Diversions and Risks to Existing Buildings

During construction, traffic diversions on roads will be essentially required. As most of the construction activities will be confined to centre of the road, one-way traffic with diversion of traffic to nearby roads will become compulsory and local people may be put to certain inconvenience and hardship. Advance information on communication systems in coordination with the Police Authorities has to be organised. As elevated portion is to be located in the middle of the road with deck width being much less than the existing road width, hence risk to the existing buildings all along the route will be practically negligible.

Impact on Water Quality

Construction activities may have impact on water bodies due to improper disposal of waste. The waste could be due to the spillage of construction materials, dumping of used water, oils and greases, and labour camp. But the quantities of such spills are very negligible. Care, however, needs to be taken to provide adequate sanitary facilities and drainage at the construction sites and in the temporary colonies of the construction workers. Provision of adequate washing and toilet facilities with septic tanks and appropriate refuse collection and disposal system should be made obligatory.

Contamination of ground water can take place, if the dump containing above substances gets leaked and percolate into the ground water table. This is not the case with the present project, as the activity does not involve usage of any harmful ingredients. Moreover, activities are of short duration and adequate measures for proper disposal of solid and liquid waste have been recommended in the Environmental Management Plan to be followed during construction. Hence, in overall, the impact on ground water or surface water quality is anticipated to be minimum due to the proposed project.

The three city lakes of Kankaria, Chandola and Vastrapur are not affected. Chandola and Vastrapur are a few kiliometers from the nearest point of the metro alignment.

at one point between Kalupur metro station and Apparel Park metro station, one edge of Kankaria lake is less than a kilometer distance. However this part of metro is the 15km underground stretch hence no impact is likely on Kankaria lake. The underground rail alignment is on the east side of Ahmedabad railway station and Kankaria lake is on west side; the whole area in between is densely built up, ensuring there is a physical barrier.

Loss of Historical and Cultural Monuments

No historical/cultural monuments will be lost or affected as a result of the proposed development. Metro is passing near 10 ASI monuments which are ASI protected monuments as per record. Presently road traffic is passing alongside these monuments. By planning a Metro System, the areas shall be decongested and number of vehicle passing will be reduced. Thus the life of these structures can be increased. Necessary protection of these Monuments will be ensured during construction with the availability of advanced technologies. It would be best to consult and clarify the legal and regulatory permissions requirements with Gujarat State Archaeology department and Archaeological Survey of India. If need be realignment of some stretches could be necessary to keep the mandatory 100m margin from ASI monuments.

Potential Impact of Metro Phase 1 on Cultural Monuments

From a review of the metro rail construction and operation activities in Delhi, Bangalore and Jaipur project activates that are like to pose adverse impacts on cultural monuments are identified. Discussions with design consultants on tunnelling, metro rail operation, and heritage authorities allowed the construction of the following activity-impact receptor matrix shown in Table 14.21 below.

Table 14.21: MEGA Phase 1 activities likely to affect Cultural Monuments

Project Activity	Description of impacts	Likely Cultural Monuments to be Affected

Construction		
Tunnel boring under Shahpur to Apparel Park (E-W corridor)	Noise and Vibration may cause structural or cosmetic damage Disturbance or annoyance to people in the vicinity Destruction of buried artefacts which may be discovered by chance Ground settlement	Delhi Darwaza, Qutubaddin Shah's Mosque, Kazi Mohammad Cristi's mosque, Rani Rupvati's Mosque, Kalupur Darwaza and Brick Minar
Cut and cover method in constructing underground stations	Elevated dust, noise, and vibration Disturbance or annoyance to people in the vicinity	Delhi Darwaza, Qutubaddin Shah's Mosque, Kazi Mohammad Cristi's mosque, Rani Rupvati's Mosque
Operation of heavy excavating equipment	Elevated dust, noise, and vibration	All 9 Cultural Monuments
Hauling of excavated materials across the old and congested city areas	Noise, vibration, and dust	All 9 Cultural Monuments
Work camps	Risk of theft	Buried artefacts
Operation		
Metro rail operation	Noise and vibration	All 9 Cultural Monuments

14.18. IMPACTS DUE TO PROJECT OPERATION

The project operation will bring both positive and negative impacts. Operation of metro will decongest roads, reduce air and noise pollution and have some impact on environment. The Metro will yield non-tangible benefits such as savings in vehicle operating costs, less travel time, better accessibility, integration of different modes of transport. Some social impacts have been listed:

Benefits to Economy due to:

a. Employment Opportunities
b. Reduction in number of vehicle trips
c. Cost savings due to reduction in number of vehicle trips
d. Reduction in Air pollution

Reduction in number of vehicle trips

Based on the Traffic Demand studies conducted for the MEGA project and as per the data available in the DPR the number of passenger trips in the horizon years 2018, 2021, 2031 and 2041 are projected in Table 14.22 for 4 scenarios.

Table 14.22: Summary of Transport Demand (Daily Passengers, one side in lakhs)

Scenario	**2018** **Phase I**	**2021** **Phase I**	**2031** **Phase I + II**	**2043** **Phase I + II**
Business As Usual (BAU)	293172	422749	672336	1442392

Gradual	339136	454719	731214	1442392
Moderate	397929	537792	837383	1442392
Rapid	457664	661606	930294	1442392

Source: CoE in Transport, CEPT University

Table 14.23 presents four scenarios of the percent reduction in number of vehicle-kilometres achieved by implementing Metro Phase-1.

Table 14.23: Percentage Reduction in Number of Vehicle-Kilometres with Metro

Scenario	Year	% Savings in veh-kms		
		Two Wheelers	Cars	3 Wheelers
Business as usual	2018	4%	7%	4%
	2021	14%	14%	16%
	2031	28%	28%	29%
	2043	46%	46%	48%
Moderate speed of modal shift to Metro	2018	9%	12%	9%
	2021	18%	19%	20%
	2031	32%	31%	34%
	2043	47%	47%	49%
Rapid speed of modal shift to Metro	2018	13%	16%	14%
	2021	22%	23%	24%
	2031	35%	35%	38%
	2043	47%	48%	51%

Source: CoE in Transport, CEPT University

The net reduction (air emissions from road vehicles - air emissions from metro) in air emissions would be substantial, increasing from 15% to 51% over the project horizon.

Reduction in Air pollution emissions

Compared to other modes of transport, the metro is least polluting and can be classified as an environment friendly technology since no air emissions are involved in running and operating the metro trains.

Reduction in number of vehicle trips will result in reduction of air pollution emissions. To estimate the carbon emission reduction from the decrease in trips, emission factors developed by the Automotive Research Association of India, Pune (study sponsored by CBCP/MOEF, 2008) were used and are reproduced in Table 14.24.

Table 1 Error! No text of specified style in document.**-24: Emission factors to estimate carbon emissions (in g/km) due to reduction in number of vehicles**

Emission Source	Emisson Factor													
	CO (g/km)			HC (g/km)			PM (g/km)			CO2 (g/km)			CH4 (g/km)	N2O (g/km)
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	Avg
2 Wheeler	0.16	11.41	3.10	0 .15	7 .70	1 .95	0 .01	0 .07	0 .04	0 .01	45.60	27.39	0.18	0.004
Car	0.04	6 .78	1 .94	0 .08	0 .85	0 .04	0 .00	0 .19	0 .04	95.65	172.95	138.33	0.17	0.017
3 Wheeler	0 .41	23.16	3.61	0 .14	6 .04	1 .72	0 .02	1 .20	0 .24	54.50	-	84.89	0.18	0.052

Source; Draft Report on Emission Factor Development for Indian Vehicles. The Automotive Research Association of India, Pune.

Using the emission factors in Table 14.24 and average emission values, estimated reduction in emissions and are shown in Table 14.25. The combined emission reductions per day from 2 & 3 wheelers and 4 wheelers is shown.

Table1 4-25: Total Emission Reductions, Metric Tons / day

Scenario	Year	CO	HC	PM	CO2	CH4	N2O
Business as usual	2018	-2.83	-1.43	-0.08	-58.87	-0.17	-0.02
	2021	-10.07	-5.58	-0.22	-165.33	-0.60	-0.04
	2031	-30.76	-16.98	-0.68	-509.71	-1.82	-0.12
	2043	-69.57	-38.24	-1.56	-1169.86	-4.13	-0.29
Moderate	2018	-5.88	-3.10	-0.15	-111.84	-0.35	-0.03
	2021	-13.46	-7.40	-0.30	-226.36	-0.80	-0.06
	2031	-35.27	-19.54	-0.77	-578.15	-2.09	-0.14
	2043	-70.48	-38.72	-1.59	-1187.58	-4.18	-0.29
Rapid	2018	-8.60	-4.65	-0.20	-152.52	-0.51	-0.04
	2021	-16.20	-8.91	-0.36	-271.97	-0.96	-0.07
	2031	-39.05	-21.64	-0.86	-639.76	-2.31	-0.16
	2043	-71.25	-39.16	-1.60	-1199.14	-4.23	-0.29

Where the metro does not reach, there would be increase of passengers travelling by bus. Hence it is presumed that there would be no net reduction in emission from buses, assuming increased number of buses using less polluting engines, keeping net emission same. It is estimated that 69.57 tons per day of Carbon Monoxide, 1170 tons per day of Carbon Dioxide and 38 tons per day of Hydrocarbons will be reduced by the operation of Metro Phase 1 during the year 2043 under the Business as Usual scenario.

Noise Pollution

The roughness of the contact surfaces of rail and wheel and train speed is the factor, which influence the magnitude of rail - wheel noise.

Wherever vehicular parking is being proposed at stations, there noise levels are expected to increase substantially during the morning and evening hours due to starting, idling and racing of vehicles. However, the predominant noise on the route alignment is due to the traffic and noise levels from the metro operations are much less than the ambient noise levels. However, because of the metro wherever there is reduction of vehicular traffic, the road traffic noise will come down. Given the high ambient noise levels, it is imperative that the government enforces noise control measures (silence zone, no horns, traffic discipline etc.)

Vibration:

Low vibration level is achieved in the engineering design adopted from the Delhi Metro Rail. The design includes vibration control mechanisms to attenuate noises from rail wheel interaction. Vibration can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

Water Requirement

Detail investigations were carried out by MEGA for deciding suitable source of water to get required quantity and quality of water. For many years now, Narmada river water is released into Sabarmati River and due to water top up to full level in the Sabarmati River throughout the year, water aquifers are being charged. As a result ground water tables in the area on both the sides of the river have considerably come up and quality of water has also improved considerably in shallow aquifers.

In view of this it was proposed that the water requirement will be met through shallow tube wells. Water samples collected from various tube wells in Ahmedabad and analysed by a laboratory revealed that the water quality is suitable for domestic use and no treatment except Chlorination may be required.

The water requirement estimated for the MEGA Metro Rail Project is given in Table 14.26.

Table1 Error! No text of specified style in document.**-26: Water requirement for the project**

A	Water requirement for construction considering 900 working days for construction activity **0.330 mld**	
B	Water requirement for curing considering 900 working days for construction activity **0.164 mld**	
C	Water Requirement for workers **0.080 mld**	
	Total Water Requirement for Entire Construction Activity	**0.574 mld**

14.19. IMPACTS DUE TO DEPOTS

Two full-fledged Depots cum Workshop have been planned at APMC and Apparel Park. Two other Stabling cum Inspection Depots to facilitate operational ease, minimum headway and avoid idle running of rakes are being planned for which the locations will be finalized at later date depending on the availability of land and requirement.

The impacts anticipated at depot are:

a. Water supply
b. Wastewater
c. Noise Pollution
d. Soil Contamination

Water Supply

Water is required in the depots for various purposes such as domestic use, metro car washing, horticulture, fire fighting, solar panel cleaning etc. The source of water supply for the Depots is ground water and it is proposed to drill shallow tube wells for meeting the water requirements of the depots. Since, the water level in Sabarmati River is full throughout the year the water aquifers in Ahmedabad region are being fully charged and ground water is sufficiently available. Hence, there is no impact due to water supply for the depots.

For drinking water facility, it is proposed to use Aqua Guard or RO water purifier which will be located conveniently in the depot building.

Wastewater

Domestic Sewage

The domestic waste / sewage generated at the Depot will be collected at one suitable point inside the depot. From there it will be discharged to the nearest manhole of existing sewerage system of the corporation if level permits or pumped to the manhole or treated onsite by DEWATS and treated water reused.

It is estimated (that the quantity of the sewage generated will be only about 0.09mld. The sewerage system of the AMC can easily accept this flow. Hence the impact is negligible.

Effluent from washing of metro cars

Wastewater generated due to washing of cars will mainly contain oil and grease. Wastewater generated from heavy washing plant will contain some impurities like detergents also. For removal of oil & grease skimming tanks are proposed outside washing plants. For removal of detergents and any such impurities Effluent Treatment Plant (ETP) is proposed. It is proposed to reuse treated effluent from ETP for washing of cars in auto wash plant. Treated effluent from ETP will be suitable to reuse for horticulture purpose also.

As the sewage quantity likely to be generated will only be about 0.09 mld, and the quantity of wash water will be less than that of horticulture requirement, there will be no surplus of wastewater from washing of cars. However necessary permissions / approvals from the AMC are required for the discharge of wastewater into the manhole of the existing AMC sewerage system. There will be minimal impact due to wastewater from the Depot.

Noise Pollution

The main sources of noise from depot are the operation of workshop. Trains will be coming to depot for washing and maintenance. The roughness of the contact surfaces of rail and wheel and train speed is the factor, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. The noise generation and its impacts are confined to within Depot premises. Implementation of noise control measures suggested in the Management Plan in Chapter 6 will mitigate the noise pollution in the Depot. The noise levels due to Depot operations will have negligible impact on the ambient noise levels in the surrounding environment.

Soil Contamination

The primary source of soil contamination at the Depots would be the waste oil/ grease and other chemical spillages. Handling and disposal of such waste may cause environmental degradation and nuisance. To prevent it, such waste has to be handled and disposed properly. As such, transportation and disposal of all such waste shall be strictly managed. Since the depot surface would be paved, chances of soil contamination are minimal to that extent. Still, use of best management practices to handle, store and dispose of such waste as may lead to soil contamination, will further reduce the chances of the same. Effluent treatment plant will be set up on the depot site to take care of effluents emanating from the depot during its operation. It is only after the treatment wastewater will be discharged resulting in no contamination of soil.

14.20. EVALUATION OF IMPACTS

As different parameters have different impacts either beneficial or adverse and of different magnitude, substantial subjectivity is involved in judging and assigning their relative importance. There are numerous methods for carrying out impact assessment, which can be grouped into the following categories:

a. Ad-hoc
b. Checklist
c. Matrix
d. Network
e. Overlays
f. Environmental Index

Of the methods listed above, Matrix Method has been used and is presented below.

Matrix Method of Evaluation

The matrix method used for evaluation of impacts consists of project activities on the x-axis and the environmental attributes likely to be affected by these activities on the y-axis. Each cell of the matrix represents a subjective evaluation of the impacts of a particular activity on a particular attribute in terms of magnitude and importance. A blank cell indicates no impact of the activity on the component. The magnitude (M) is represented by a number from 1 to 4 where

1 = minimal 2 = appreciable 3 = significant 4 = severe

Positive sign (or no sign) indicates beneficial impact and negative sign indicates adverse impact. The importance (I) of the impact is given on a scale of 1 to 4 in each cell. This number indicates relative importance of the impact of the activity on the concerned attribute for this project. The magnitude and importance are multiplied to get a score of each cell. The score of individual cells in each row are added to determine the total impact of the project activities on each attribute. Similarly, the score in individual cells in each column are added to determine the total impact of each activity on all the environmental attributes likely to be affected. The grand total of all cells indicates the total project impact.

Since both 'M' and 'I' vary from 1 to 4, the total score in each cell can theoretically vary between –16 to +16. Therefore the total project impact can vary between (-16 x total number of cells in the matrix) and (16 x total number of cells in the matrix). To compare score from matrices containing different number of cells, the total project scores can be normalized to a scale of 100 as follows

Total project impact $_{\text{scale of 100}}$ = ((Total project impact $_{\text{computed by matrix}}$) / (16 x total number of cells in the matrix)) X100. On this scale, the overall impact can be classified as follows, Table 14.27.

Table 1 Error! No text of specified style in document.**-27: Environmental Impact Classification Scale**

Total project impact (Scale of 100)	**Magnitude of impact**
-100 to -75	Severely adverse
-75 to -50	Significantly adverse
-50 to -25	Appreciably adverse
-25 to 0	Adverse
0 to 25	Beneficial
25 to 50	Appreciably beneficial
50 to 75	Significantly beneficial
75 to 100	Extremely beneficial

Two scenarios are considered for evaluation. The first scenario is evaluation "Without EMP". This scenario will be based upon the assumption that the proposed project/development would go ahead without any environmental management plans being implemented. The total project impact for this scenario will be worked out and it has to be converted to a scale of (+/-) 100. Generally the total project impact for this scenario will be in the negative side indicting that if the project goes ahead without an EMP, the adverse impact on the existing environment would be several times that of the impact without the project.

Thus, the EMP will have to be implemented to minimise the potential negative impact due to the proposed activity.

The second scenario is evaluation "With EMP" This scenario will be based upon the assumption that the proposed project/development would go ahead with environmental management plans being implemented. If the environmental management strategies are fully implemented, the adverse impact of the project would be reduced, and there will be an overall improvement in physical, chemical, biological and socio-economic environment of the region. The total project impact score on a scale of (+/-) 100 for this scenario will generally be on the +ve side i.e., on the beneficial side indicating that the proposed activity will be beneficial for the environment of the area, provided the EMP is in place.

The Impact Assessment of the project Without EMP and With EMP is presented in Tables 14.28

Table 1 Error! No text of specified style in document.**-28: Impact Assessment without EMP**

Environmental components likely to be affected		Project activities likely to affect environmental components							
		Project Location	Pre-Construction	Construction activities	Excavation	Transportation	Operation	Depot	Total impact on component
Air quality	**M**	-2	-2	-3	-3	-3	2	-2	**-43**
	I	3	3	4	3	4	3	2	
Noise levels	**M**	-2	-3	-3	-3	-3	-3	-3	**-55**
	I	2	3	3	4	3	2	2	
Surface water quality	**M**		-1	-2	-2		-2	-1	**-16**
	I		2	2	2		2	2	
Ground water quality	**M**		-2	-2	-3		-2	-3	**-31**
	I		3	3	4		2	1	
Soil quality	**M**	-2	-3	-2	-3	-2		-3	**-38**
	I	2	2	3	3	2		3	
Land use pattern	**M**	-2	-2	-3	-3	-2	-2	-2	**-48**
	I	3	3	3	3	3	3	3	
Flora and Fauna	**M**	-2	-3	-3	-2			-2	**-32**
	I	3	3	3	2			2	
Aesthetics	**M**	-2	-2	-3	-2	-2	-2	-2	**-41**
	I	3	3	3	3	3	2	2	
Human health	**M**		-2	-3	-2	-3	-2	-2	**-38**
	I		2	3	3	3	2	3	
Socio-economic status	**M**	-1	1	2	1	1	2	1	**20**
	I	2	2	3	2	3	3	3	
Economy, trade and commerce	**M**	-1	1	2	2	2	2	2	**30**
	I	2	2	3	2	3	4	3	
Total impact		-34	-52	-66	-60	-34	-16	-51	**-292**

I = Importance, M = Magnitude Impact scale: 1 = Minimal, 2 = Appreciable, 3 = Significant, 4 = Severe. Positive sign (or no sign) indicates beneficial impact, Negative sign indicates adverse impact, Blank indicates no impact

Table 1 Error! No text of specified style in document.**-29: Impact Assessment with EMP**

Environmental components likely to be affected		Project activities likely to affect environmental components							
		Project Location	Pre-Construction	Construction activities	Excavation	Transportation	Operation	Depot	Total impact on component
Air quality	**M**	2	-1	-1	-1	-1	3	2	**3**
	I	2	3	4	3	4	3	2	
Noise levels	**M**	-1	-1	-1	-1	-1	2	-1	**-12**
	I	2	3	4	4	3	4	4	
Surface water quality	**M**		1	-1	-1		1	1	**2**
	I		2	3	2		2	3	
Ground water quality	**M**		1	1	-1		1	1	**9**
	I		3	3	3		3	3	
Soil quality	**M**	-1	-1	-1	-1	-1		1	**-9**
	I		2	2	3	3	2		
Land use pattern	**M**	2	-1	-2	-1	-1	1	2	**0**
	I	3	3	3	3	3	3	3	
Flora and Fauna	**M**	2	-1	-1	-1		2	2	**7**
	I	3	2	3	2		2	2	
Aesthetics	**M**	2	-1	-1	-1	-1	2	-1	**-4**
	I	3	3	3	3	3	2	2	
Human health	**M**		-1	-1	-1	-1	3	-1	**-4**
	I		2	3	2	3	3	3	
Socioeconomic status	**M**	3	2	3	2	2	4	3	**60**
	I	4	2	3	2	3	4	3	
Economy, trade & com-	**M**	4	2	3	2	3	4	4	**70**
	I	4	2	3	2	3	4	3	
Total impact		**46**	**-5**	**-8**	**-17**	**-3**	**81**	**35**	**122**

I = Importance, M = Magnitude Impact scale: 1 = Minimal, 2 = Appreciable, 3 = Significant, 4 = Severe. Positive sign (or no sign) indicates beneficial impact, Negative sign indicates adverse impact, Blank indicates no impact

Evaluation of alternative scenarios

Without EMP

This scenario is based upon the assumption that the proposed development would go ahead without any environmental management options being implemented. The total project impact for the scenario, as can be seen in table 1, was found to be –292 on a scale of (+/-) 1232. The score on a scale of (+/-) 100 for this scenario was found to be – 23.7, which is on the adverse side (almost bordering appreciably adverse). This shows that if the project goes ahead without an EMP, there will be adverse impact on the existing environment. Thus, the EMP will have to be implemented to minimise the potential negative impact due to the proposed project.

With EMP

If the environmental management strategies discussed in Chapter 5 is fully implemented, the adverse impact of the project would be reduced, and there will be an overall improvement in environment of the region. This is reflected in the total project impact score of + 122 on scale of (+/-) 1232. The score on a scale of (+/-) 100 for with EMP scenario is 9.90, which is on the beneficial side. Therefore, the proposed project **will be beneficial** for the environment of the area, provided the EMP is implemented.

14.21. MANAGEMENT PLANS

As MEGA undertakes to build this Phase I of the Metro system, it envisages enforcing adequate environmental standards to provide for the protection of the people and the environment. The environmental issues likely to develop during project construction and operation phases could be minimized by making necessary provision in the project design and adopting an Environmental Management Plan (EMP).

The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components.

The mitigation measures are essential and shall be undertaken in various phase of project cycle viz. pre-construction, construction and operation stage of the project.

MEASURES DURING PRE-CONSTRUCTION STAGE

The pre construction stage activities involves Land acquisition, site clearance including tree felling and transplanting , demolition or slicing of existing buildings and other structures as necessary for the permanent and temporary works and , disposal of building and tunnelling debris. The measures for the pre-construction stage activities are described in the following paragraphs

Land acquisition

In the Phase I, the alignment is elevated and is planned on the median of the road except the Shahpur to Apparel Park section which would be underground. Hence the land acquisition is reduced to the barest minimum. However land is required for parking, entry, exits & traffic integration purpose at the stations. The land required will be acquired and compensation will be paid. The land compensation is included in the project cost.

Tree felling and compensation for loss of trees:

During the construction of the Phase I part of the Metro there are trees along the viaduct alignment. About 1600 trees are likely to be felled. Priority should be given for pruning the branches of the trees rather than completely felling the tree. However, if the tree is causing obstruction to the works at site, it should be recommended for felling. The following norms for tree cutting and stacking the tree cuttings are to be ensured:

Norms for Tree Cutting & Stacking:

The tree has to be classified before cutting and it has to be listed whether it falls under Fire Wood tree, Timber/Secondary Timber or a Waste tree.

For the loss of trees as compensation and development of Green Belt under the project, following the general norms of Department of Forests, plantation of tall tree saplings at a ratio of 10:1 i.e. planting 10 saplings for every tree felled is to be implemented. Hence 16,000 saplings are required to be planted. The planting of tree saplings can be taken up in and around the city, in the open areas, government lands, educational institutions, upcoming residential layouts etc. The total area required for planting the 16,000 trees is about 11 Ha (@7 sq m /tree space). It is presumed that for planting the tree saplings no land cost will be involved. Cost of undertaking compensatory planting in 11 Ha of area will be Rs. 22.0 Lakhs (@about Rs. 200,000 per hectare). Tree guards to be provided wherever necessary to safeguard the trees from grazing animals. The cost towards providing tree guards is estimated as Rs. 112.0 Lakhs (@Rs 700 per tree guard X 16,000 saplings). Thus the total cost for compensatory planting for the loss of trees works out to Rs. 134.0 Lakhs.

Demolition and slicing of existing buildings and other structures and disposal of building debris:

In the pre-construction stage certain existing buildings, and other structures will have to be considered for either demolition or partially slicing. A separate survey is undertaken to identify the requirement of demolition of buildings and other structures in the metro alignment However, the building debris have to be disposed of suitable without causing and impact on the environment. The building debris will have to be transported and dumped into pre-designated area approved by the Ahmedabad Municipal Corporation. The building debris will have potential to create dust. The vehicles/trucks transporting the debris shall ensure that the materials are not to be loaded to a level higher than the side and tail boards and may be carried in vehicles fitted with covers.

14.22. MEASURES DURING CONSTRUCTION STAGE

The mitigation measures during the Construction stage are suggested for the application of the environmental controls during the construction of project and are intended to translate into practice the following three important aspects

The construction activities should not:

a. Cause inconvenience or endanger public
b. Create a permanent visual eyesore
c. Result in unmitigated ecological or environmental degradation

Noise Pollution Control

There may be an increase in noise level in ambient air due to construction activities. The increase in levels is marginal; hence local population will not be adversely affected. However the exposure of workers to high noise levels needs to be minimized. This can be achieved by job rotation, automation, protective devices, noise barriers, and soundproof compartments and control rooms etc,

Soil Disposal

During the construction soil excavated and from tunnel is generated. The excavated soil shall have to be disposed of in environmental friendly manner. Adequate measures need to be adopted for collection, transfer and disposal of excavated soil. Soil collection, transportation, disposal and its treatment need to be carried out in a systematic manner.

Utility Restoration

During the project the utilities likely to be affected are sub-surface, surface and overhead. These are mainly water supply, sewer pipe, storm water drains, telephone cables, overhead transmission lines, electric poles, traffic signals etc. These utilities are essential and have to be maintained in working conditions during different stage of construction, by temporary / permanent diversions or by supporting in position. Since these may affect project schedules and costs hence advance actions will be required.

1.1..2 Hazardous Waste

Classification of waste as Hazardous shall be in accordance with Hazards Waste (Management & Handing) Rules 1989, and 2003 or its latest amendment.

Hazardous waste would mainly arise from the maintenance of equipment. These may include, but not be limited to, the following:

a. Used engine oils, hydraulic fluids and waste fuel.
b. Spent mineral oils/cleaning fluids from mechanical machinery.
c. Scrap batteries or spent acid/alkali.
d. Spent solvents/solutions, some of which may be derived, from equipment cleaning activities.

The hazardous waste to be disposed only through an authorised agencies dealing with the same and approved by either MoEF or Gujarat State Pollution Control Board The hazardous waste shall be stored on an impermeable surface with containment bund to retain leaks, spills and ruptures.

All waste collection containers shall be of appropriate size with a closed lid. Each container will be clearly labelled both with a colour code system and indicating the contents or type of waste in local language and English.

14.23. MITIGATION MEASURES DURING OPERATION STAGE

Air Pollution Control

The Delhi Metro operation has shown that because of modal shift from other modes of transport to Metro, significant reduction in air pollution is achieved. Similarly anticipating the same result, the air quality of Ahmedabad will improve because of the Metro. It is recommended to monitor air quality for three years after the operation of the corridors to record changes in the air quality.

Noise Pollution Control

The ambient noise levels at most places along the alignment is high due to heavy vehicular movement and at most locations the noise levels exceed the National noise standards. Experience in Delhi Metro has shown that at some locations, the noise levels have gone down because of the Metro. However, the impact of metro operation noise will depend on the type of corridor, proximity to the tracks, ambient noise levels and vehicular density. Keeping in view of MEGA's ambition of maintaining world class metro operation standards the target should be kept towards low noise in the long run. To achieve this goal certain measures are recommended.

a. The practical measures include the use of barriers, concrete slab deck, resilient fasteners, rail isolation for the control of elevated structure noise and ground vibration, rail welding, wheel condition monitoring, wheel truing and rail grinding, resilient wheels, damped wheels and station acoustic treatment.
b. Wherever the ambient noise levels increase because of the metro, the erection of a noise barrier on elevated tracks will ensure that the metro trains may not introduce appreciable cumulative

increase in the ambient noise level in the vicinity or along the elevated corridor facing the sensitive areas..

c. A detailed study may be undertaken to identifying the actual stretches of the sensitive receptors such as residential buildings, educational institutions such as schools, colleges etc., Hospitals, health care units, important worship places such as temples, churches, mosques etc. falling within a distance of 50 m (this distance is considered since the impact of noise is likely to be felt more here) on either side of the centre of the alignment. Actual noise measurements may be undertaken at the identified sensitive locations once the train starts using the traction to determine the need for considering implementation of noise control / mitigation measures.
d. In sensitive areas, track on floating slab can be provided so as to avoid propagation of noise/vibration to adjacent structures. Additional screening of noise/vibration can be arranged by providing parabolic noise/vibration reflecting walls on each sides of the track, as being provided by DMRC in ongoing rail corridor.
e. Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

A provision of **Rs 500 Lakhs** has been proposed for adopting noise control measures that may be required to be implemented during operation stage.

14.24. MANAGEMENT PLANS FOR DEPOT

Provision of Rain Water Harvesting

Rainwater harvesting is the process of augmenting the natural filtration of rainwater into the underground formation by some artificial methods. "Conscious collection and storage of rainwater to cater to demands of water, for drinking, domestic purpose & irrigation is termed as Rainwater Harvesting. Broadly there are two ways of harvesting rainwater:

a. Surface Runoff Harvesting
b. Roof top Rainwater Harvesting

It has been proposed to construct roof top rainwater harvesting structure in the Depot sites. This approach requires connecting the outlet pipe from rooftop to divert the water to specially designed percolation wells. The workshop complex, Inspection bay, stabling shed, administrative blocks etc. buildings have a large roof area and can be utilized for harvesting roof top rainwater to recharge aquifer.

'Rain Water Harvesting' structure is recommended to be installed at the two Depot sites. It is proposed to collect the rain water from the roofs and charge the ground water through percolation wells. It is recommended to design to implement RWH for atleast 25%-30% of the total Depot surface area. This water is relatively pure and fit for recharging the groundwater. Rainfall over balance of the Depot area would be directed to the water bodies for depot use after treatment. The rain water shall be used after treatment for all purposes inside Depots.

For protecting the depot from inundation due to very heavy rains, one discharge pipe shall be laid in the water bodies to discharge excess water in such remote eventuality. By this the rain water would be fully utilised.

A provision of **Rs. 150 Lakhs** has been estimated for the percolation wells (15 Nos. in each Depot).

Training

The training and extension programmes need to be conducted for Metro Rail Officers on environmental issues relating to the Metro project. Apart from training, should also include programmes on guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection etc.

The overall Environmental Management Plan in the tabular format is presented in Table below:

Table 14.30: ENVIRONMENT MANAGEMENT PLAN

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
			PRE-CONSTRUCTION		
PC1	Contractor Preparatory Works		The Contractor will within 30 days of contract signing; 1) Submit resume of the environmental focal person 2) Prepare monthly monitoring formats and deadlines for submission. 3) Will submit for approval an action plan to secure all permits and approvals needed during construction stage which include but not limited to: i) operation of crushers and hot mix plants, ii) transport and storage of hazardous materials (e.g. fuel, lubricants, explosives), iii) waste disposal sites and disposal management plan, iv) temporary storage location, iv) water use.	Contractor and Consultant	Part of contractors cost
PC2	Coordinate with MEGA Traffic Management Plan	Nuisance from traffic congestion	The Contractor will discuss and coordinate implementation of the traffic re- routing scheme. At the minimum, the traffic management plan will have the following components: construction traffic, ensuring access to properties, parking, access by construction vehicles, traffic diversion due to temporary road	Contractor and Consultant	Part of contractors cost
PC3	Community liaison	Complaints	To ensure that ongoing feedback is provided on the project progress Contractor will provide a minimum of two (2) weeks notification to directly affected residents, businesses and other relevant groups of the intended construction commencement date.	Contractor and MEGA	Part of contractors cost
PC4	Ground staking	Chance finding of	At least 30 days before the start of tunnelling, the Contactor with	Contractor and Archaeology	Part of construction

		artefacts	supervision from the Archaeology Department will employ a ground penetrating radar, detect the presence of buried artefacts along the tunnel alignment. The Contractor, on behalf of MEGA, will coordinate with the Archaeology Department to designate an on-site representative during the entire duration of the project.	Department	cost
PC5	Briefing on working near heritage resource.	Damage to heritage resource. Cultural conflicts	All workers will undergo a briefing with the Archeology Department to ensure safeguarding of heritage resource and cultural/religious practices.	Contractor and Archaeology Department	Part of construction cost
			CONSTRUCTION		
C1	Tunnel boring and cut and fill	Damage to heritage resources	No heritage resources are inadvertantly damaged during construction.	Contractor	Part of contractors cost
C2	Surface noise from excavating equipment	Noise pollution	The contractor will ensure that noise from construction activities does not result exceed relevant limits. Mitigation measures to be implemented by the Contractors are: 1) liaise with local residents 2) local residents and shop owners to be informed of the nature and duration of intended activities prior to commencement 3) equipment compounds will be located off-site 4) noise barriers will be installed at critical work areas 5) enclose noisy activities if above the noise limits 6) employ transportable noise screens between noise sources and identified noise sensitive areas 7) maximize the possibility of scheduling noisy activities at the same time to minimize the duration of exposure	Contractor	Part of construction cost
C3	Spoils disposal	Sediment runoff from the work site during monsoon. Contamination of disposal sites. Community hazard due to improperly disposed materials.	A spoil management plan will be implemented that details the location of spoil disposal sites, transporting soil, and disposal. The Contractor will perform the following: 1) dispose spoils on AMC permitted sites 2) seek approval from MEGA to a spoil dump plan that provides the: i) dump size, layout, and form, ii) means of controlling water & wind erosion, iii) measures to	Contractor	Part of construction cost

			prevent spoil dump contamination 3) Explore the possibility of using spoil materials to rehabilitate borrow pits		
C4	Groundwater extraction	Depletion of groundwater , Compete with existing groundwater users	The Contractor shall secure permission for groundwater extraction from pertinent groundwater authorities before establishing tube wells.	Contractor and Consultant	Part of construction cost
C5	Disruption of essential services	Temporary damage or shifting of utilities particularly water & sewer pipes, cables and electrical lines	The Contractor will ensure that the public will be minimally affected when constructing in close proximity to essential services by: 1) coordinate and secure necessary permits for utility shifting prior to construction 2) inform residents 3) all planned interruptions schedules will be shared with MEGA 4) in the event of unforeseen disruptions, contractor will take all reasonable actions to have the service promptly restored 5) relevant utility agencies will be informed of proximity to essential service line and be kept on standby.	Contractor and Consultant	Part of construction cost
C6	Construction camp, Batching plant and casting yard operations, and occupational safety	Solid and liquid waste generation. Communicable diseases. Hazardous materials. Emergency preparedness. Personal protective equipment	Contractor shall comply with all labour, safety, health and other applicable laws, specifications and best professional practices	Contractor and Consultant	Part of construction cost
C7	Cleanup Operations, Restoration and Rehabilitation	Public health and aesthetics	Contractor shall prepare site restoration plans, subject to review and approval by MEGA. The cleanup and restoration are to be implemented by the Contractor prior to demobilization. All spaces excavated and not occupied by permanent works shall be refilled with earth up to surface of surrounding ground.	Contractor and Consultant	Part of construction cost
OPERATION					
O1	Noise and Vibration	Vibration from train operation may cause structural or cosmetic damage	MEGA will continue and maintain the monitoring sites established by the contractor for noise and vibration and will observe the same trigger values.	MEGA	Operating cost

02	Waste water from Depot	Contamination of groundwater by petroleum laden waste	MEGA will operate wastewater treatment facilities capable for removing petroleum contaminants and will meet national standards.	MEGA	Operating cost
03	Depletion of groundwater	Water requirement for train and facility cleaning, and water for commuters	Each station will require 18,000 litres per day, platform washing is 5 litres/square meter, 70,000 litre per day for car washing, and plus passenger water requirement. Rain water harvesting facilities will be installed at both the depots. Only recycled water will be used for facility cleaning and landscape irrigation. All toilets will be equipped with low-flow fixtures.	MEGA	Operating cost

14.25. Environmental Monitoring

The environmental monitoring will be required for the construction and operational phases. The main objectives of environmental monitoring are:

a. to assess the changes in environmental conditions,
b. to monitor the effective implementation of mitigation measures,
c. to warn significant deteriorations in environmental quality for further prevention action.

In order to meet the above objectives the following parameters need to be monitored:

a. Compensatory plantation
b. Water quality
c. Air and noise quality
d. Heritage resources impact monitoring

Compensatory Planting

Compensatory Planting should commence with the start of project cycle. The State Forest Department may be approached for assistance in undertaking compensatory planting. As an alternate the MEGA Authorities may request the State Forest Department to undertake the compensatory planting and may transfer the cost to the Forest Department. However, it has to be ensured that the required number of tree saplings following the Government norms i.e., planting 10 tree saplings for every tree felled need to be planted before the construction is over.

Water Quality

Water quality shall be monitored for one year before and for at least two years after the completion of the project thus for total 6 years. Monitoring should be carried out at least four times a year to cover seasonal variations by any recognized private or Government agency. Water quality shall be analyzed by applying the standard technique. The parameters for monitoring would be pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand

(COD), Total Dissolved Solids (TDS), Chlorides, Nitrates, Sulphates, Total nitrogen, Total Phosphate and Oil & Grease.

The monitoring points could be river, ground and surface waters. The ground water sampling could be in Metro corridor. Surface and ground water need to be monitored near soil disposal sites. River water quality needs to be monitored seasonally. The cost of water sampling is expected to be Rs. **7.2 Lakhs** (for 13 water parameters at 6 locations at quarterly interval for 6 years at Rs. 5000 per location).

A detailed epidemiological study related to water borne diseases should be carried out and the data should be compiled for every year in the project area. This shall be monitored for labour camps. The cost will be about Rs. 1.0 Lakh per year with 10% increase for five years. The total cost will be **2.15 Lakhs**.

Air & Noise Quality

Ambient air quality and Noise levels should be monitored during the pre-construction phase, construction phase and for four years and two years after the completion of the project (total 6 years). It is proposed to have the monitoring programme at twenty locations for air quality and twenty locations for noise quality monitoring. The parameters recommended for ambient air quality monitoring are Particulate Matter PM_{10}& $PM_{2.5}$, Suphur-di-oxide, Nitrogen Oxides and Carbon monoxides and for ambient noise level Leq(day) and Leq (Night) Noise Levels in dB(A) are recommended.

The cost for ambient air quality and Noise levels monitoring works out to be **Rs. 50 Lakhs** as per the break up given in flowing tables 6.1 and 6.2.

Table 14-31: Proposed Monitoring Programme for Air and Noise Quality a) During Pre-construction and Construction Phases

Monitoring	**Number of Proposed Site**	**Frequency**	**Cost (Rs. In Lakhs)**
Ambient Air Quality	10	Once a month for 4 years	4*12*10*6000 = 27.36 lakhs
Noise Levels	10	Once a month for 4 years	4*12*10*2200 = 10.56 lakhs
Total Cost			**37.92 say 38 lakhs**

Table Error! No text of specified style in document.**-2: Proposed Monitoring Programme for Air and Noise Quality b) During Operation Phases**

Monitoring	**Number of Proposed Site**	**Frequency**	**Cost (Rs. In Lakhs)**
Ambient Air Quality	5	Once a month for 2 years	2*12*5*7500 = 9.0 Lakhs
Noise Levels	5	Once a month for 2	2*12*5*2500 = 3.0

		years	Lakhs
Total Cost			**12 lakhs**

Heritage Resources Monitoring

Heritage resource impact monitoring needs to be done during project construction and operation. Being a specialized field, MEGA is advised to involve heritage experts in devising a suitable impact monitoring system. The level of monitoring would also depend on the shortest distance of metro alignment to any of the notified heritage resources.

Establishment of an Environment Division

It is recommended that MEGA Project Authority establishes an Environment Division/Cell at the initial stage of the project itself. The task of the division would be to supervise and coordinate studies, monitoring and implementation of environmental mitigation measures.

14.26. COST ESTIMATES

The cost of land, building, water supply, drainage, sanitation and utility restoration has been incorporated in Detailed Project Report cost estimates. This section details only those cost on environment not included in DPR. All costs involved in Environmental mitigation and monitoring are summarized and the Environmental Cost estimated is presented in Table below:

Table14.32: Environmental Costs

Sl. No.	Particulars	RS. (in Lakhs)
1.	Compensatory Planting	134.00
2.	Monitoring of air/noise (pre, construction and operation phases)	50.00
3.	Monitoring of Water (pre, construction and operation phases)	7.20
4.	Epidemiological studies	2.15
5.	Soil Conservation	2.00
6.	Cost towards implementation of measures to control noise	500.00
8.	Construction of Sewerage system at Depots	40.00
9.	Construction of Effluent Treatment Plant at Depots	45.00
10.	Provision for Green belt Development in Depot area	60.00
11.	Provision of Rain Water Harvesting	150.00
12.	Health and Safety Measures	5.00
13	Cost of Training Programme	12.00
14	Establishment of Environment Division	2.50
15	Monitoring compliance of heritage resources impact	100.00
	Sub Total	**1109.85**
	Miscellaneous items @10% of sub total	**110.99**
	TOTAL	**1220.84**

	Say	**1221 Lakhs**

Appendix 1

Wastewater and Water Indian National Standards

Table A-1: Wastewater (Inland Surface water) discharge standards

Sl. No.	List of Parameters	Units	Standard
1	Colour & Odour		All efforts should be made to re-move colour and unpleasant odour as far as practicable.
2.	Suspended Solids	mg/L	100.0
3.	Particle size of Suspended Solids	--	Shall pass 850 micron IS Sieve
4.	pH value	--	5.5 to 9.0
5.	Temperature	-	Shall not exceed 5C above the receiving water body temperature
6.	Oil and grease, max.	mg/L	10.0
7.	Total residual chlorine, Max.	mg/L	1.0
8.	Ammonical Nitrogen (as N), Max.	mg/L	50.0
9.	Total Kjeldahl nitrogen (as N), Max.	mg/L	100.0
10.	Free ammonia (as NH_3), Max.	mg/L	5.0
11.	Biochemical Oxygen Demand (3 days at 27C), Max	mg/L	30.0
12.	Chemical Oxygen Demand Max.	mg/L	250.0
13.	Arsenic (as As), Max.	mg/L	0.2
14.	Mercury (as Hg), Max.	mg/L	0.01
15.	Lead (as Pb), Max.	mg/L	0.1
16.	Cadmium (as Cd), Max.	mg/L	2.0
17.	Hexavalent chromium (as Cr^{+6}), Max.	mg/L	0.1
18.	Total Chromium (as Cr.) Max.	mg/L	2.0
19.	Copper (as Cu), Max.	mg/L	3.0
20.	Zinc (as Zn), Max.	mg/L	5.0
21.	Selenium (as Se), Max.	mg/L	0.05
22.	Nickel (as Ni), Max.	mg/L	3.0
23.	Cyanide (as CN), Max.	mg/L	0.2
24.	Fluorides as F	mg/L	2.0
25.	Dissolved phosphates (as P), Max.	mg/L	5.0
26.	Sulphides (as S), Max.	mg/L	2.0
27.	Phenolic compounds (as C_2H_5OH), Max.	mg/L	1.0
28.	Radioactive Materials a) Alpha Emitters, Max. b) Beta Emitters, Max.	C/mL; C/mL	10^{-7} 10^{-6}

Table A-2: Tolerance Limits for Surface Water Quality

Sl. No	Characteristics	Designated Use Class of Indian Waters				
		A	B	C	D	E
1	pH value	6.5 - 8.5	6.5 -8.5	6.5 - 8.5	6.5 -8.5	6.0 - 8.5
2	Dissolved Oxygen, mg/l, min	6	5	4	4	-
3	Biochemical Oxygen Demand (5 days at 20$_0$C), mg/l	2	3	3	-	-
4	Total Coliform organisms, MPN/100 ml. Max	50*	500*	5000*	-	-
5	Colour, Hazen units	10	300	300	-	-
6	Chlorides (as Cl), mg/l max	250	-	600	-	600
7	Sodium Adsorption ratio max	-	-	-	-	26
8	Boron (as B), mg/l. Max	-	-	-	-	2
9	Sulphates (as SO_4), mg/ l	400	-	400	-	1000
10	Nitrates (as NO), mg/l max	20	-	50	-	-
11	Free Ammonia (as NH_3), mg/l	-	-	-	1.2	-
12	Conductivity at 25$_0$ C micro Ohm / Cm max.	-	-	-	1000	2250
13	Arsenic (as As), mg/l. Max.	0.05	0.2	0.2	-	-
14	Iron (as Fe), mg/l	0.3	-	50	-	-
15	Flourides (as F), mg/l	1.5	1.5	1.5	-	-
16	Lead (as Pb), mg/l. max.	0.1	-	0.1	-	-
17	Copper (as Cu), mg/l	1.5	-	1.5	-	-
18	Zinc (as Zn) mg/l/ max.	1.5	-	1.5	-	-
19	Manganese (as Mn), mg/l	0.5	-	-	-	-
20	Total Dissolved Solids, mg/l	500	-	1500	-	2100
21	Total Hardness (as CaCO3), mg/l	300	-	-	-	-
21	Magnesium (as Mg), mg/l	100	-	-	-	-
23	Chlorides (as Cl), mg/l	250	600	-	-	600
24	Cyanides (as CN), mg/l	0.05	0.05	0.05	-	-

Notes:

A: Drinking Water Source without conventional treatment but after disinfection;
B: Outdoor bathing organized;
C: drinking water source with conventional treatment followed by disinfection;
D: propagation of wildlife and fisheries;
E: irrigation, industrial cooling, controlled waste disposal.

Indian and WHO Standards for Drinking Water

Table A-3: Indian and WHO Standards for Drinking Water

Sl. No.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organization Guidelines
		Desirable Limit	Permissible Limit	Maximum allowable concentration
1	Colour	5 Hazen units	25 Hazen units	15 True Colour Units
2	Turbidity	5.0 NTU	10 NTU	5.0 NTU
3	PH	6.5-8.5	No relaxation	6.5-8.5
4	Total Hardness (as $CaCO_3$)	300 mg/L	600 mg/L	500 mg/L
5	Chlorides (as Cl)	250 mg/L	1000 mg/L	250 mg/L
6	Residual Free Chlorine	0.2 mg/L	-	-
7	Dissolved Solids	500 mg/L	2000 mg/L	1000 mg/L
8	Calcium (as Ca)	75 mg/L	200 mg/L	-
9	Sulphate (as SO_4^{2-})	200 mg/L	400 mg/L	400 mg/L
10	Nitrate (as NO_3^-)	45 mg/L	100 mg/L	10 mg/L
11	Fluoride (as F^-)	1.0 mg/L	1.5 mg/L	1.5 mg/L
12	Phenolic Compounds (as C_6H_5OH)	0.001mg/L	0.002 mg/L	-
13	Anionic Detergent (as MBAS)	0.2 mg/L	1.0 mg/L	-
14	Mineral Oil	0. 01 mg/L	0.03 mg/L	-
15	Alkalinity	200 mg/L	600 mg/L	-
16	Boron	1.0 mg/L	5.0 mg/L	-
17	Zinc (as Zn)	5.0 mg/L	15 mg/L	5.0 mg/L
18	Iron (as Fe)	0.3 mg/L	1.0 mg/L	0.3 mg/L
19	Manganese (as Mn)	0.1 mg/L	0.3 mg/L	0.1 mg/L
20	Copper (as Cu)	0.05 mg/L	1.5 mg/L	1.0 mg/L
21	Arsenic	0.05 mg/L	NR	0.05 mg/L
22	Cyanide (as CN)	0.05 mg/L	NR	0.1 mg/L
23	Lead (as Pb)	0.05 mg/L	NR	0.05 mg/L
24	Chromium (as Cr^{6+})	0.05 mg/L	NR	0.05 mg/L
25	Aluminium (as Al)	0.03 mg/L	0.2 mg/L	0.2 mg/L
26	Cadmium (as Cd)	0.01 mg/L	NR	0.005 mg/L
27	Selenium (as Se)	0.01 mg/L	NR	0.01 mg/L
28	Mercury (as Hg)	0.001 mg/L	NR	0.001 mg/L
29	Total Pesticides	Absent	0.001 mg/L	--

NR – No Relaxation

Chapter - 15

Security Measures for a Metro System

Chapter -15

SECURITY MEASURES FOR A METRO SYSTEM

15.1 INTRODUCTION

Metro is emerging as the most favoured mode of urban transportation system. 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 the high cost of infrastructure, its economic impotence, being the life line of city high news value, fear & panic and man casual ties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

15.2 NECESSSITY OF SECURITY

It is well known that public transportation is increasingly important for urban areas to prosper in the face of challenges such as reducing congestion and pollution. Therefore, security places an important role in helping public transport system to become the mode of choice. Therefore, excellence in security is a prerequisite for Metro system for increasing its market share. Metro railway administration must ensure that security model must keep pace rapid expansion of the metro and changing security scenario.

15.3 THREE PILLARS OF SECURITY

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

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

Staff engaging with the passengers creates a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective staff has to be qualified, trained, well equipped and motivated. They should be trained, drilled and tested. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed communicated and drilled in advance.

There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems are to differ i.e., making planning or execution of on attack too difficult, detect the planned evidence before it occurs deny the access after in plan of attack has been made and to mitigate i.e. lessen the impact severity as the attack by appropriate digits.

15.4 PHASES OF SECURITY

There are three phases of security as under:

(i) Prevention

These are the measures which can prevent a security incidence from taking place. These can be identified by conducting a risk assessment and gathering intelligence. Prevention begins with the daily operational security -problems. Uncared for dirty, damaged property is a breeding ground for more serious crime.

(ii) Preparedness

Plans must be prepared to respond to incidents, mitigate the impact. Train staff accordingly and carry out exercises. The results of the risk assessment give a basis for such plans.

(iii) Recovery

Transport system must have laid down procedures/instructions for the quick recovery of normal service after an incident. Recovery is important for the financial health of the operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should ^also include an evaluation process for the lessons learnt.

15.5 RESPONSIBILITIES AND PARTNERSHIPS

Security is a sovereign function and hence is the responsibility of the state. Security in public requires clear governance. Responsibility should be clearly defined. In Gujarat State, security would be the responsibility of the state govt.

Appropriate security agency would be nominated by MEGA before actual operations to take care of safety & security system for the entire networks in terms of human safety and protection of assets to avoid sabotage.

15.6 PROPOSED PROVISIONS FOR SECURITY SYSTEM

1. CCTV coverage of all metro stations. With a provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations. Cost of this is included in Telecom estimate.
2. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required. Cost is Rs.1.65 Lacs approximately, 0n 2014 prices.
3. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations. Cost of one Multi-zone DFMD is Rs 2.15 Lacs approximately.
4. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station. Cost of one HHMD is Rs 7500/- approximately at 2014 prices.
5. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of MEGA. Cost is Rs. 1.25 crores including vehicle.
6. Bomb Blanket at least one per station and Depots. Cost is Rs. 50,000/- per bomb blanket.
7. Wireless Sets (Static and Hand Held) as per requirement of security agency.
8. Dragon light at least one per station and vital installation.
9. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
10. Dog Squads (Sniffer Dog), at least one dog for 4 metro stations which is at par with current arrangement of Ahmedabad Metro. Cost of one trained sniffer dog is Rs. 1.25 Lacs approximately. 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.
11. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration metro station.
12. Bullet proof jackets and helmets for QRTs and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 metro stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.

13. Furniture to security agency for each security room, and checking point at every entry point at stations. Scale is one office table with three chairs for security room and office of GO and one steel top table with two chairs for checking point.

14. | | | |
    |---|---|---|
    | Ladies frisking booth | - | 1 per security check point (AFC Arrey) |
    | Wooden Ramp | - | 1 per DFMD for security check points. |

15. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.

16. Physical barriers for anti scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.

Chapter - 16

Disaster Management Measures

Chapter - 16

DISASTER MANAGEMENT MEASURES

16.1 INTRODUCTION

“Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation.” Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 *"disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area”.* As per world health organisation (who):
“Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area.”

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

16.2 NEED FOR DISASTER MANAGEMENT MEASURES

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

16.3 OBJECTIVES:

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

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

16.4 LIST OF SERIOUS INCIDENTS REQUIRING USE OF PROVISIONS OF THE DISASTER MANAGEMENT MEASURES

Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

a. Man Made Disaster

1. Terrorist attack
2. Bomb threat/ Bomb blast
3. Hostage
4. Release of Chemical or biological gas in trains, stations or tunnels
5. Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
6. Train accident and train collision/derailment of a passenger carrying train
7. Sabotage
8. Stampede

b. Natural Disaster

1. Earthquakes
2. Floods

16.5 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

A. The National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:-

(1) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act *(The Disaster Management Act, 2005),* an authority to be known as the National Disaster Management Authority.

(2) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:-

(a) The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;

(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disaster Management Authority:

Establishment of State Disaster Management Authority:-

(1) Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(2) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:-

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;

(b) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;

(c) The Chairperson of the State Executive Committee, ex officio.

(3) The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the State Authority.

(4) MEGA would abide by the constitutional delegation stated under para 3 as above.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary

(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.

(3) State Level Committee under the chairmanship of Chief Secretary.

(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;

(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(iii) The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

16.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

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

(A) Fire Detection and Suppression System

(B) Smoke Management

(C) Environmental Control System (ECS)

(D) Tunnel Ventilation System

(E) Track-Way Exhaust System (TES)

(F) Station Power Supply System

(G) Dg Sets & Ups

(H) Lighting System

(I) Station Area Lights

(J) Tunnel Lighting

(K) Tunnel Lighting Control From Bms

(L) Seepage System

(M) Water Supply And Drainage System

(N) Sewage System

(O) Any Other System Deemed Necessary

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

16.7 PREPAREDNESS FOR DISASTER MANAGEMENT

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their well being seeking their cooperation.

Since learning can only be perfected by ‘doing’ the following Mock Drills are considered essential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train
f. Hot line telephone communication with state disaster management authority.

Chapter - 17

Multi Modal Transport Integration

Chapter – 17

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

17.1 BACKGROUND

The proposed metro in Ahmedabad has two corridors totaling 35.956 km and 32 stations, including terminal stations. It traverses across the city in the north-south and east-west direction and along its path covers many important origins and destinations. However, its reach will not be enough to reach all origins and destinations. Fortunately, Ahmedabad has planned for a multi-modal system, where the proposed metro complements the existing BRTS and AMTS services. The need is now to ensure that people have safe, comfortable and secure access to the above modes as well as seamless integration facilities.

Ahmedabad has already planned for a network of 116 km of BRTS across the city. This is expected to carry over 5 lakh passengers daily. At present, 67 km is operational with a ridership of 1.4 lakh. The remaining 49 km is under construction and is expected to be completed in stages by 2015.

The AMTS, which is a much older service, has a fleet of close to 800 buses and operates over 150 routes. It has a daily ridership of close to 7 lakh. As the BRTS expands, the AMTS routes are being rationalized to avoid major overlaps and expand into new, upcoming suburbs of Ahmedabad. They are also expected to act as feeders to the BRTS. A new proposal by the AMTS calls for moving away from the traditional destination oriented services to direction based services. Accordingly, new routes have been proposed, consisting of 16 radial and 3 ring routes, running at high frequency. This new system is expected to be operational in phases beginning from May 2014.

The Centre of Excellence in Urban Transport, CEPT University has been commissioned by MEGA to undertake a study on last mile connectivity for proposed metro corridor. The Last Mile Connectivity refers to the provision of travel service from home or workplace to the nearest public transportation mode. A trip is considerd as the entire journey between origin and destination. Commuters may utilize and combine different mdes of transport for the entire trip. Metro or BRTS may cater to a majority of this kind of trip, but commuters always need to complete the access and egress part on their own.

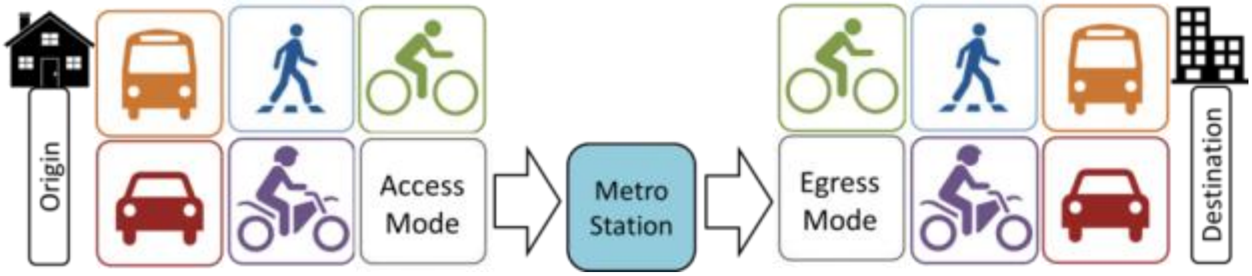
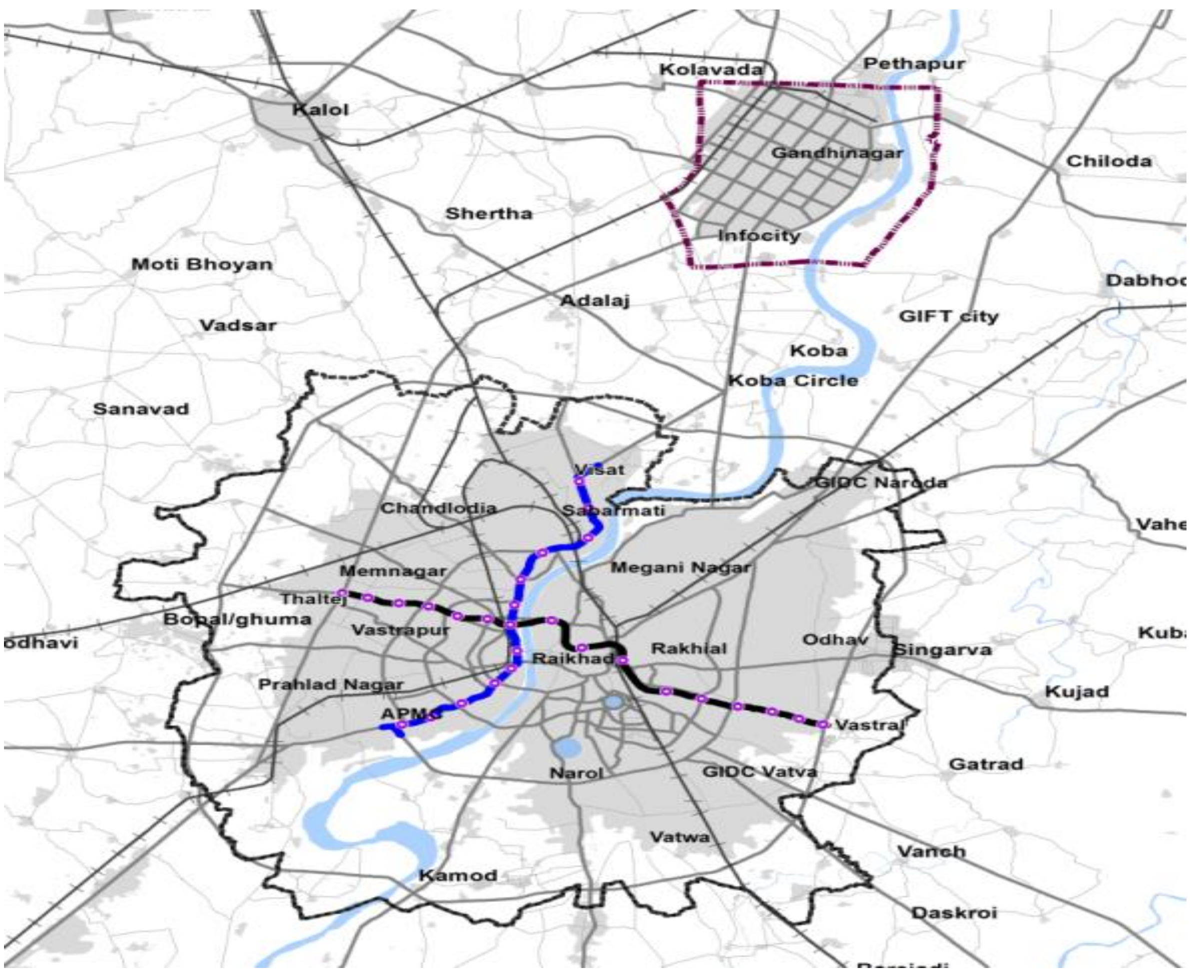


Figure 17.1 Components of trip



Map 17.1 Proposed Metro corridor

The map above shows the metro corridors proposed in phase 1. Along with the BRTS and AMTS, it is expected that the mode share of public transit in Ahmedabad will increase from the present 15% to 40% by 2020. However, there is a need to ensure that these three systems are integrated in such a manner that the commuter gets benefit of single trip through fare integration as well enjoys a seamless physical transition from one mode to another. Along with this, there is a need to ensure that last mile connectivity through pedestrian and bicycle facilities are enhanced.

This chapter will look at concepts of last mile connectivity along with multi-modal integration, and identify key interchange locations that need to be identified in Ahmedabad keeping in mind present and future demand and potential.

The cost requirement for such facilities would also be estimated at block costs level to get an idea of the funds required.

17.2 AIM AND OBJECTIVES

The aim of this study is to suggest measures to increase last mile connectivity for metro users and to integrate metro with other modes of transit. The specific objectives are:

- To suggest measures that provide local destinations with safe, comfortable and convenient accessibility to Metro stations
- To propose design guidelines for local street environment
- To propose conceptual designs that will maximize benefits and efficiency of interchanges

17.3 CURRENT ISSUES

Last mile connectivity actually impacts on overall ridership and usage of any mass transit system. It is essential to provide or improve last mile connectivity and link them for ease of access for users. Even if street infrastructure that comprises of last mile connectivity falls outside Metro or BRT's jurisdiction and control, they remain critical components of an effective public transportation. The easier it is to access the Metro or BRT, the more likely people are to use it. Data from the BRTS shows that 65% of its commuters walk to and fro from its stations. It also means that access beyond the initial 400-500m is not comfortable enough to attract people onto the BRTS. The unavailability of this type of service is one of the main restraints to the use of public transport in urban areas.

17.4 METHODOLOGY

Currently, the default solutions to the LMC are walking, taking an auto, driving a private vehicle or taking a ride. This can be integrated with other mode of travel as well as feeder services. This perception put last mile connectivity at different levels. These levels can be identified in three different stratums.

1. The access to the station can be improved drastically by creating better pedestrian and NMT infrastructure around the station area. The planning of such street infrastructure can be done through **Local Area Access Plan. (LAAP)**
2. The connectivity for mass transit system can be expanded by providing dedicated integrated feeder systems to the surrounding areas. Providing integrated feeder services to the stations as well as integrating with the existing public transport network will expand the catchment and accessibility of the stations
3. Integration of NMT, para transit, feeder services and other public transport modes with metro stations is possible by planning and designing seamless interchange stations which facilitates physical integration of different access or egress modes.

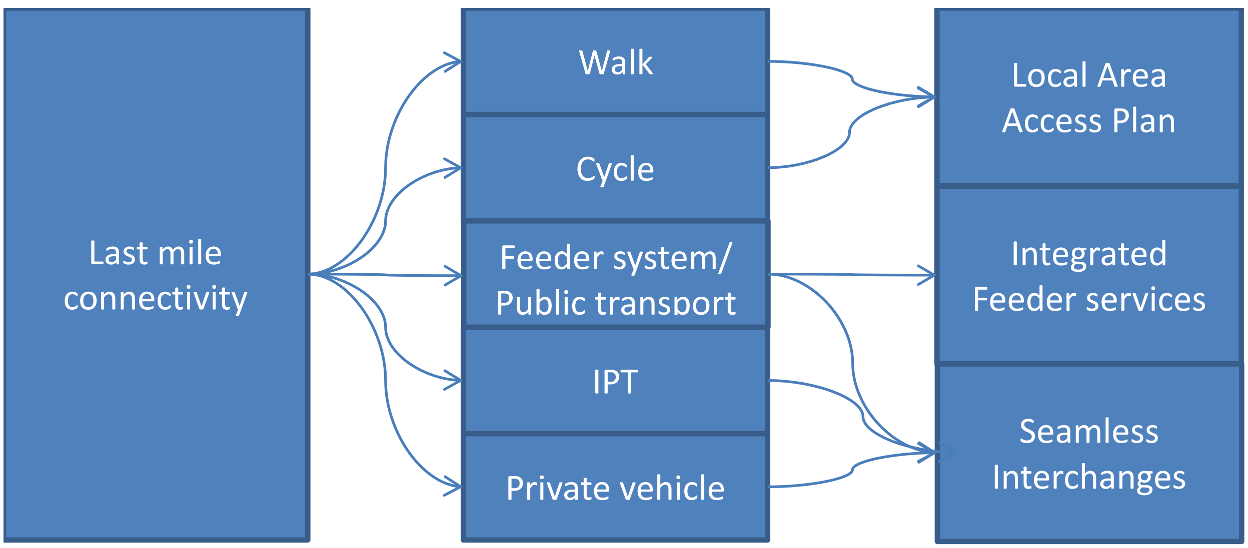


Figure 17.2 Different aspects of Last Mile Connectivity

The study will look at each metro station and the surrounding area in detail. The land use for a distance of 500m from the corridor has been surveyed to understand nature of existing development. All prominent activities such as schools, colleges, hospitals, malls etc. will be mapped to ensure that the LAAP caters to all of them. At the same time, for each station, feeder services in the form of BRTS and AMTS will be identified. Each metro station will be classified in terms of level of the interchange, which will be finalized based on the number of modes and frequency of services.

17.5 LOCAL AREA ACCESS PLAN

The basic level of connectivity for any mass transit system would be linking local areas to the nearest mass transit station. The concept of "Ahmedabad Local Area Access Plan (ALAAP)" has already been proposed as part of developing Bus Rapid Transit System for the city of Ahmedabad which also can be applied for last mile connectivity for Metro corridor.

LAAP identifies the road network along the Metro corridor that should be taken up for pedestrian and NMT improvement.

17.5.1 Introduction to LAAP

LAAP is a plan that links local areas around transit stations with nearest mass transit facility through attractive and well-designed NMT Infrastructure. LAAP is a context sensitive planning project that is tailored to meet the following needs of the pedestrians and bicycle users in the context of Ahmedabad. It will have the following objectives:

- To connect NMT users to mass transit stations and from mass transit stations to final destinations
- To ensure the safety of pedestrians and bicycle users
- To enhance the connectivity between various origins and key destinations through safe and well-connected street networks for NMT users

17.5.2 Benefits of LAAP

LAAP provides a safe, direct and convenient pedestrian connectivity to public transit, to various amenities like schools, collages, hospitals, recreational places and local market areas and major landmarks. The direct benefits are listed below:

- Improved pedestrian and bicycle accessibility to public transport system (Ahmedabad Metro)
- Improved pedestrian and bicycle access to important destinations like, jobs, schools, collages, recreational areas, local markets, hospitals, religious places and commercial activities
- Improved existing pedestrian and bicycle infrastructure through context sensitive street design solutions, appropriate implementation and enforcement plan
- Facilitating pedestrians and bicycle users at interchanges by providing excellent and seamless physical connection
- Special focus on improving pedestrian and bicycle connectivity and accessibility to parks, water fronts and other recreational places around the Ahmedabad city
- Increasing pedestrian and bicycle safety at intersections through appropriate traffic calming measures and traffic management system
- Direct, safe and convenient pedestrian access to on street economic activities
- Managing the local pedestrian and bicycle access to local on street markets by efficient and pragmatic street design

The indirect benefits are listed below:

- Walking and bicycling are non-polluting travel modes and costs nothing to the user. More walking and cycling improves the overall quality of life.
- Reduced dependence on private vehicles for short and local trips by enhancing high quality and marvelous walking and bicycling environment
- Ahmedabad city will be livable and walkable through LAAP

- Ahmedabad Local Area Access Plan will serve as the feeder links as it incorporates easily available modes for travel, time and cost incurred for last mile connectivity and ease of walking to and from public Transit stations and other Interchanges
- Ahmedabad Local Area Access plan is an opportunity to improve pedestrian and bicycle access and connection to public transit service and to other key destination. This clearly indicates that, in future, LAAP has potential to maximize the public transit ridership as well as to increase the overall mode share of pedestrians and bicycle users.

17.5.3 Identifying streets in LAAP

The methodology of the network selection is completely based on the spatial distribution of amenities, public transit network, and transit infrastructure and land use characteristics. The following steps are taken to finalize the LAAP network.

Define the area for LAAP

- Define boundary as per local context
- Collect and analyze characteristics of streets, transport, activity pattern and land use

Map activities

- Map important amenities, key destinations of trip generators and land use characteristics
- Overlap existing and proposed public transit facilities (Bus Rapid Transit corridors, Bus stations, local feeder bus service network, Metro, Light Rail Transport or other if any)

Connect with nearest transit facility

- Identify streets that directly connects the important amenities or key destinations with the nearest public transit facility (BRT corridor or BRT Bus Station, Local feeder bus service routes, Metro, etc.)

Connect amenities

- Identify local street network to provide direct and shortest distance travel routes to interconnect the amenities along with connection to the public transit facility

Complete the network

- Highlight the missing links and complete the street network to enhance the connectivity, consistency and accessibility within the neighbourhood through Local Area Access Plan

Identify special cases

- Identify the special scenarios where different and innovative solution can be applicable

17.5.4 LAAP for Metro Stations.

LAAP for each metro station is proposed by adopting the methodology developed for preparing LAAP. Area defined for preparing the LAAP is taken between 500-750 m from the metro station. The LAAP network also takes in to consideration nearby BRT station to be connected. Along with assessment of activities, landuse assessment is also carried out before preparing LAAP. Detailed description of landuse and LAAP is described below.

- East West Corridor: Thaltej Gam to Vastral Gam (20.53 km Elevated and 6.335km Underground)
- North South Corridor: Motera Stadium to APMC (15.42 km)

17.5.4.1 East West Corridor: Thaltej Gam to Vastral Gam

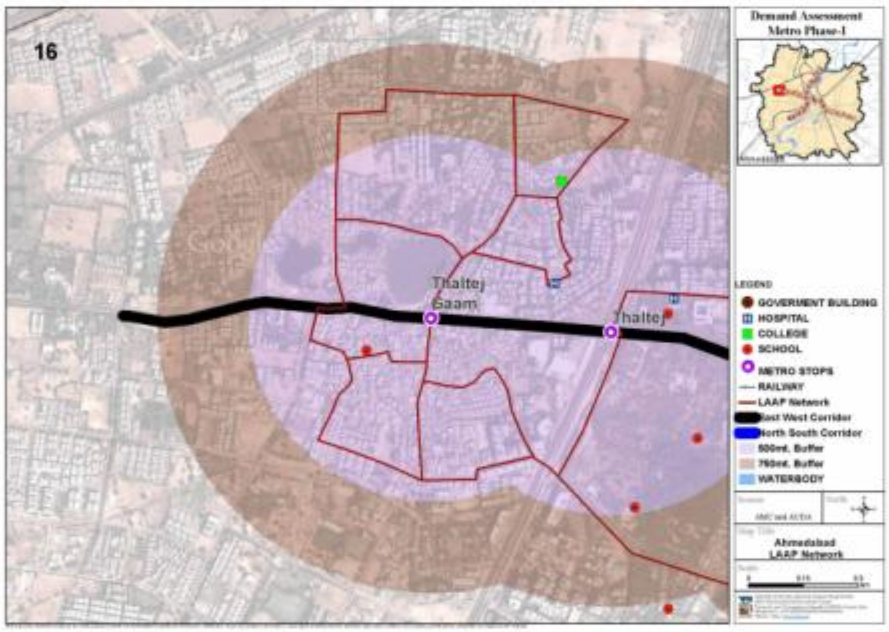
Thaltej to Drive in Cinema

Thaltej Junction is terminal for western part of East West corridor. Length between Thaltej junction to Drive in cinema is 0.85 km with 30m right of way. The major land use along the corridor is institutional and health care buildings in south with Udgam School, Sardar Patel Institute of Economic Research, Trinity health care, SAAL hospital on corridor edge. Centre for Environment Education, Doordarshan Kendra, Goyal intercity residential colony, Acropolis mall, dense residential area in north and Drive in Cinema being many of other important destinations are located in the walkable peripheral range of the corridor. Buildings along the corridor are moderately high with three to four floors except SAAL Hospital which is ten floor high and Goyal residency with six floors.

The Thaltej terminal intersects at S.G. Highway which connects to Gandhinagar in north and and Sarkhej in south direction. This road being one of the major commercial centres, it is expected to attract many passengers from this area. This part of the corridor also intersects at major arterial road leading to Sattadhar cross road in the north and Prahlad nagar area in the south.

Map 17.2 Landuse from Thaltej to Drive-in cinema

The map below shows how LAAP will connect important origins and destinations in this area.



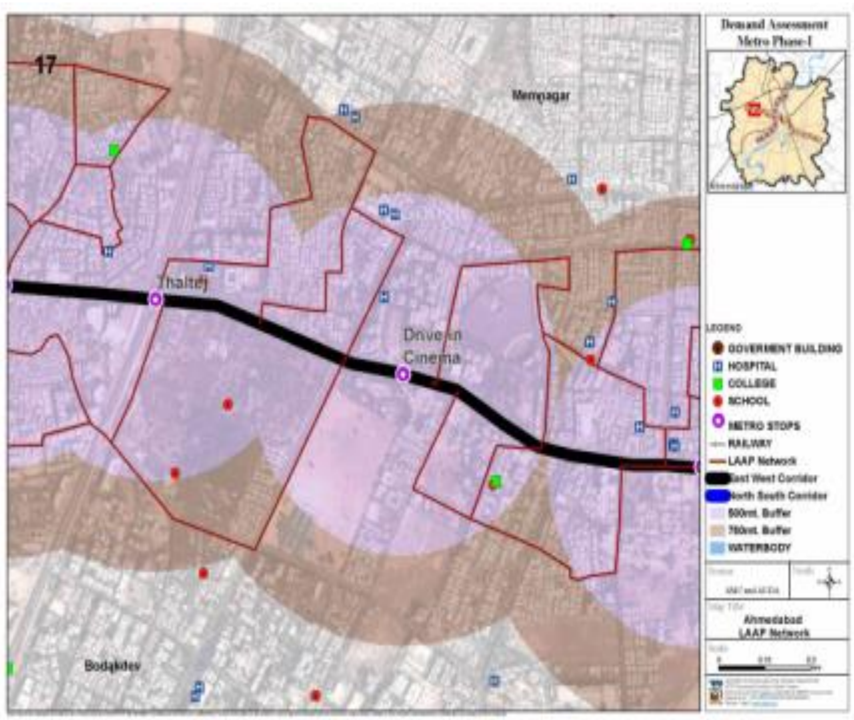
Map 17.3 LAAP network around Thaltej metro station

Drive in cinema to Gurukul Road

The length of this stretch from Drive in Cinema to Gurukul road is 0.95km having 30m right of way. This area serves as major commercial centre of the city with Himalaya mall, Ginger hotel and Maruti complex. Along with commercial activities, institutes like Swaminarayan Gurukul and Asia high school are also located on the road edge. SKUM School and Maharaja Agrasen Vidyalaya are also located in 500m peripheral range of the corridor. A high rise residential colony called Indraprastha towers is also located along the corridor. Behind the road edge on north side of the corridor, dense residential area exists. There are government buildings like Gujarat Bahumali Bhavan and government staff quarters also located along the corridor. One of the leading Sterling hospital is also located in the peripheral range of the corridor along with many other clinics and hospitals. Buildings along the corridor are having more than five floors, where Indraprastha being the tallest with ten floors. An arterial road intersects the corridor at Gurukul junction, which leads to Bhuyangdev char rasta.

Map 17.4 Land use from Drive in cinema to Gurukul Road

The map below shows the LAAP for this stretch.



Map 17.5 LAAP network around Drive in Cinema metro station

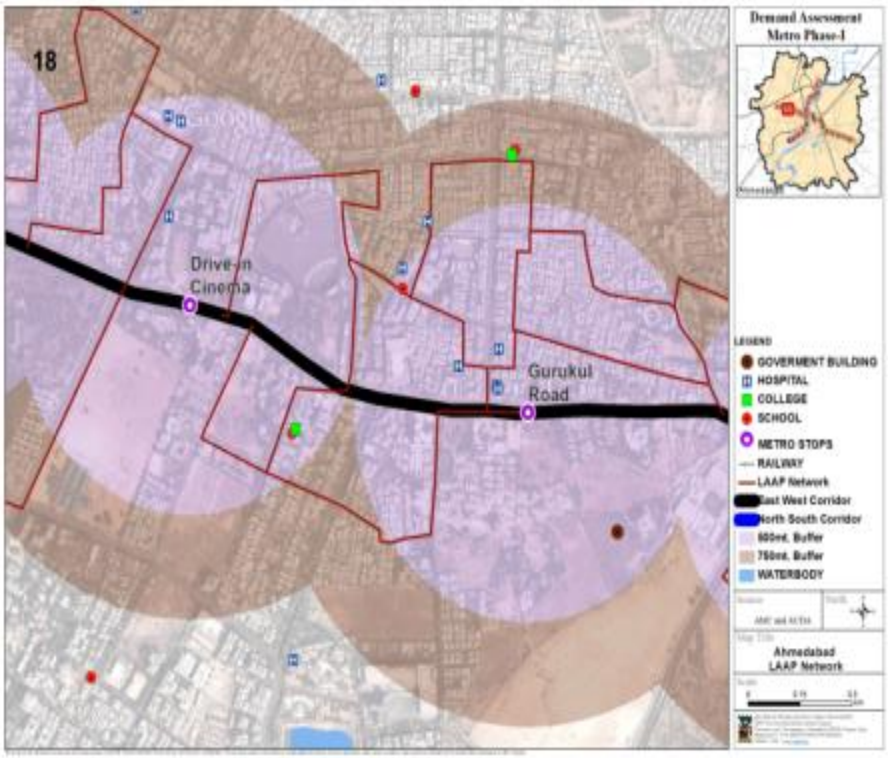
Gurukul Road to Helmet Cross road

The corridor from Gurukul road to Helmet cross road is having 0.9km length with 30m existing right of way. The corridor serves majority of Gujarat University land area along and Memnagar gamtal on north direction in the peripheral area. Public amenities like Gujarat convention centre, Mahatma Gandhi Labour Institute, Apang Manav Mandal and temporary exhibition space in University ground creates the location as prime space. Number of commercial activity in form of small shops and even in the form of commercial buildings like R3 mall exists along the corridor and within peripheral area. During festival season Navratri also organized by Government of Gujarat in Gujarat University ground. The health care facilities are also located near Helmet junction. Buildings along the corridors are four to five floors high.

This part of the corridor intersects with 132' ring road which is also the BRTS corridor. Helmet cross roads will be the interchange location for public transportation and thus will be serving as important destination along metro corridor.

Map 17.6 Landuse from Gurukul Road to Helmet Cross road

The map below shows the proposed LAAP for this stretch.



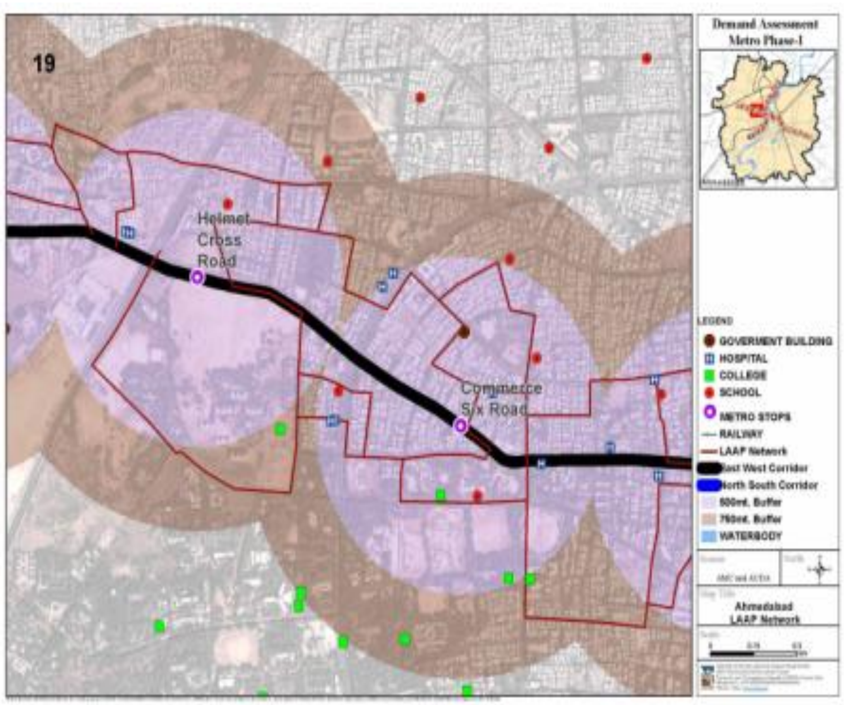
Map 17.7 LAAP network around Gurukul road metro station

Helmet Cross road to Commerce six roads

The stretch between Helmet Cross roads to Commerce six roads is 1 km in length with 26 to 30 m existing right of way. This stretch is the nearest destination to the Gujarat University and other colleges and is thus a very important destination along metro corridor. Prime institutions like CEPT University, B.K. School of management, L.M. School of Pharmacy and L.D. Engineering College are located within walkable range of the corridor. It is surrounded by commercial activity along the corridor and residential colonies and societies in the peripheral range. Students' hostel areas, government office like HUDCO office and Audit Bhavan are also located in the 500m peripheral range of the corridor. Majority of the buildings are having height of four to five floors. Collector roads from neighbourhood areas intersect the corridor. These roads are lead to dense residential areas. The BRTS corridor terminates at L.D. Engineering College and is within walkable range of the metro corridor.

Map 17.8 Land use from Helmet Cross road to Commerce six roads

The map below shows the LAAP for this stretch.



Map 17.9 LAAP network around Helmet Cross Road and Commerce Six Roads metro stations

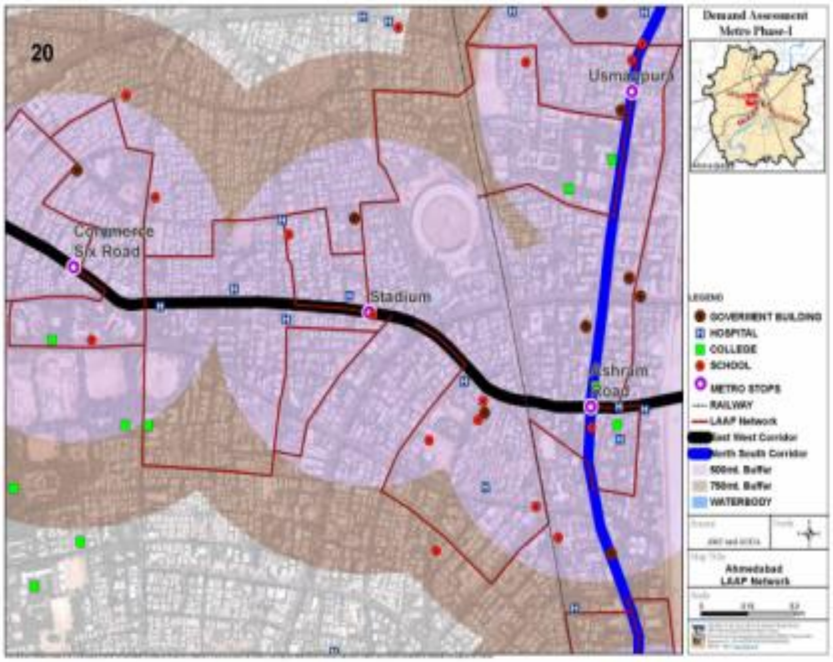
Commerce six roads to Stadium

The length between Commerce Six roads to stadium is 1 km with 18 to 24m right of way. The major land use along the corridor includes commercial, residential, recreational as well as institutional. This corridor and its peripheral area have balance of mixed land use. The corridor is surrounded with Gujarat Sport complex, health care facilities including Samved hospital, Nidhi multispecialty hospital, MRI centre, Vedant hospital, H.L. College of commerce, restaurants, main post office and dense residential area. Buildings on the corridor edge are five to six floor high while residential area is having tenements.

The corridor intersects with C.G. Road at Stadium Panch Rasta. C.G. Road being high commercial area, high passenger volume is expected to cater through this metro station. Swastik Char Rasta and Navrangpura AMTS bus stop are within walkable range of the corridor.

Map 17.10 Land use from Commerce six roads to Stadium

The map below shows the LAAP for this stretch.



Map 17.11 LAAP network around Stadium and Ashram road metro stations

Stadium to Ashram Road and Usmanpura on the northern side

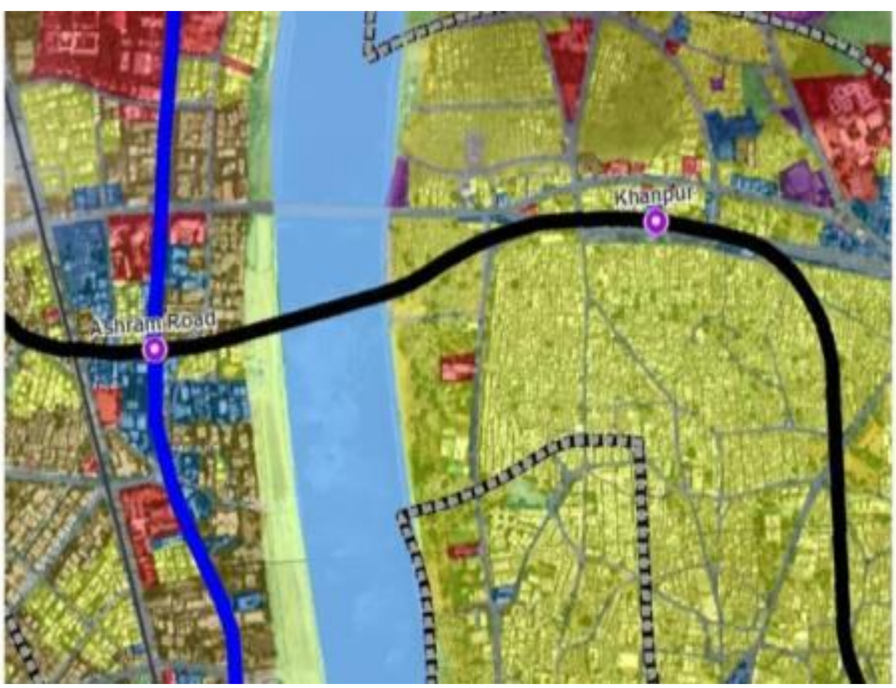
The stretch between Stadium to Ashram road is 0.75 km in length with 14m to 18m existing right of way. The major land use around this corridor is commercial with retail market and offices. The peripheral range of the corridor caters to Sardar Patel Stadium, Income tax office, Akash vani Kendra, vruddhashram, Dinesh hall along with old residential societies within. The corridor is further leading towards eastern side of the city by crossing Sabarmati river front and the river.

This part of the corridor is intersecting North South Metro corridor at Ashram road. Together this section of the corridor is creating important interchange station. Combining influence area of this includes all commercial activities along corridors e.g. Sardar Patel stadium, Gujarat Vidyapith, Usmanpura Municipal Corporation, Hotel Fortune Landmark, Darpan dance academy and Navrangpura Municipal ground. This area is also proposed to be developed as future CBD of Ahmedabad in the new Development Plan.

Map 12 Land use from Stadium to Ashram Road and Usmanpura on the northern side

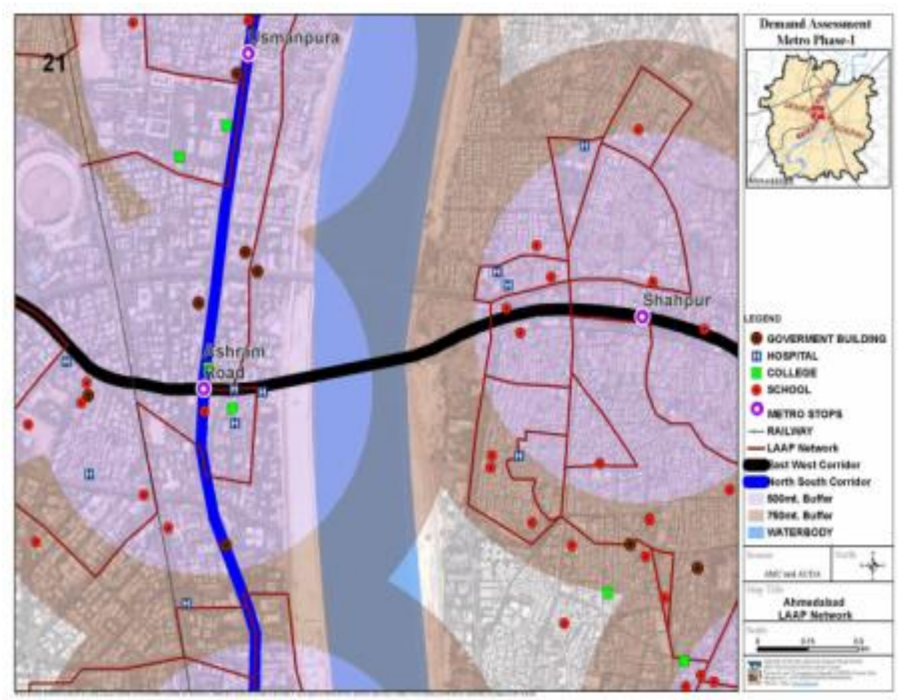
Ashram Road to Khanpur

This section is important since it connects eastern and western parts of the city. It also passes through Sabarmati River and goes underground in the eastern part of the city near Khanpur area. This part of the corridor can be accessed through underpasses from different stations. Area near this corridor includes municipal schools and wholesale markets near Shahpur as well as high density residential areas. This area is an access to walled city of Ahmedabad.



Map 17.13 Land use from Ashram Road to Khanpur

The map below shows the LAAP for this stretch.



Map 17.14 LAAP network around Shahpur metro station

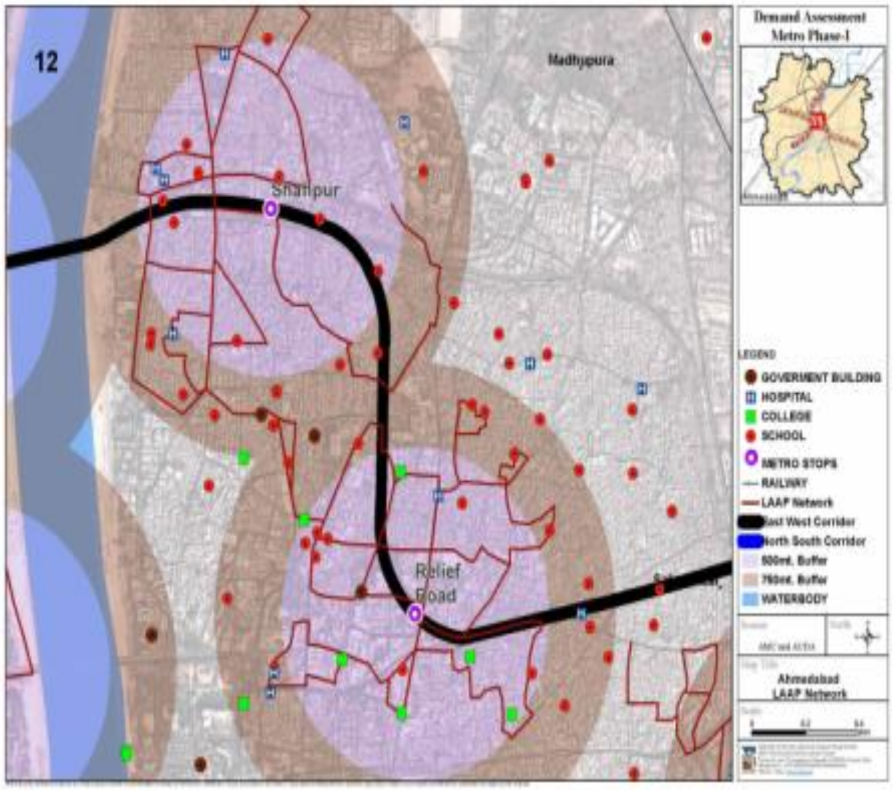
Khanpur to Relief road to Sakar bazaar (Walled city)

The length of this underground section till Sakar bazaar is 4km. This area is belongs to walled city of Ahmedabad. This densely populated area of walled city has commercial activities on road edges and equally high ratio of residential properties. The locality generally caters to mixed use with commercial, retail, residential and institutional uses within vicinity of metro corridor. Wholesale markets, retail markets, St. Xaviers School, district court, concert halls, Jama masjid, temples, Jilla Panchayat building are major uses around this corridor.

This area of walled city has many heritage monuments which are declared by the Archaeological survey of India.

Map 17.15 Landuse from Khanpur to Relief road to Sakar bazaar (Walled city)

The map below shows the LAAP for this stretch.



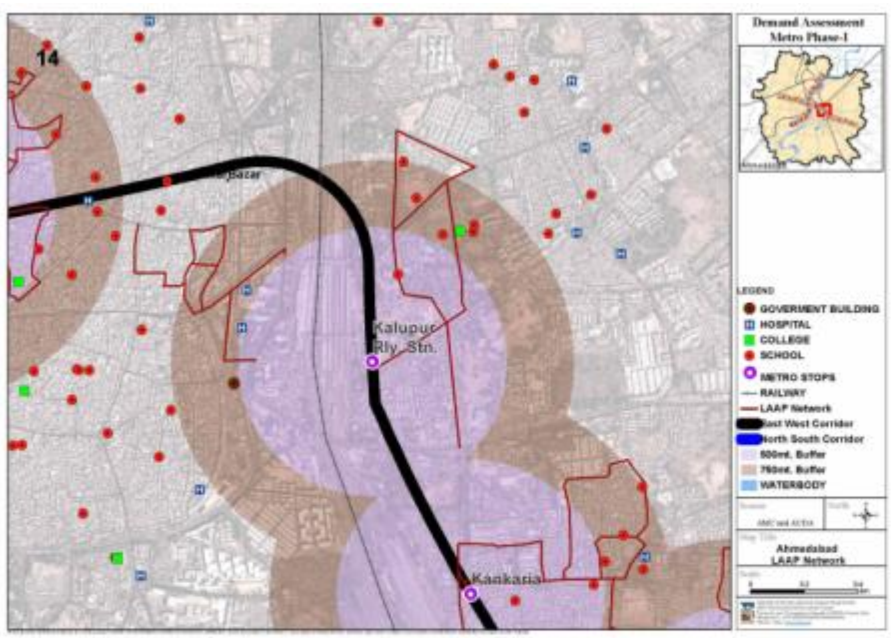
Map 17.16 LAAP network around Shahpur and Relief Road metro stations

Sakar Bazaar to Kalupur railway station

Sakar bazaar to Kalupur bazaar section majorly caters to railway station area near Kalupur and part of Relief road, Chokha bazaar, fruit market and Sakar bazaar having length of 0.9km. This section crosses Kalupur Railway station and has metro station on Saraspur side (eastern side of the railway station). Currently Part of Saraspur exit for Kalupur Railway station is not very active in terms of other commercial activities as well as availability of public or para transit service. The location of Kalupur metro station on the eastern side will support in decongesting Kalupur area on the western side of the station. The BRTS corridor is serving the western side of the station area already. There is also a proposal to shift AMTS services from Kalupur terminal to Saraspur. This will ensure even better integration with the metro. Overall, this station will be a primary interchange for the metro with regional and suburban rail.

Map 17.17 Landuse from Sakar bazaar to Kalupur railway station

The map below shows the LAAP for this stretch.



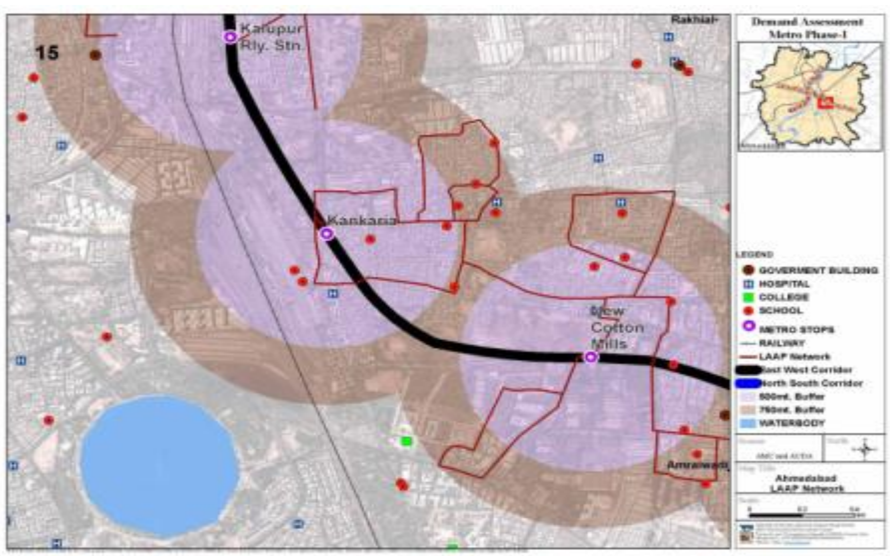
Map 17.18 LAAP network around Kalupur metro station

Kalupur railway station to New cotton mills

The section between Kalupur Railway Station and New Cotton Mills caters to industrial land use along the corridor. Major industries like Ashima Textiles and GIDC Apparel Park are located on southern part of the section whereas northern part of this section includes residential colonies near Gomtipur and Jantanagar. The BRTS corridor leading towards Soni ni Chali also crosses this section of the east west corridor near Gomtipur thus, Kalupur Railway station is being interchange station for all public transit modes available.

Map 17.19 Land use from Kalupur railway station to New cotton mills

The map below shows the LAAP for this stretch.



Map 17.20 LAAP network around Kankaria and New Cotton Mills metro stations

New cloth mills to Amraiwadi

The length of this section of the corridor is 1.2km. From this section onwards, the corridor will have elevated structure. The major land use along the corridor is again industrial with many small scale industries. The peripheral area in the northern part of the corridor includes dense residential societies including Jantanagar, Amraiwadi, Jay Bhavani nagar and Indira nagar. Schools managed by Municipal Corporation are also located within vicinity of this section.

This corridor intersects 132' ring road at Swastik char rasta. 132' eastern ring road leads towards Memco junction in the north direction and Narol junction in South, which is a major arterial and parallel to Narol Naroda National highway connectivity for catering local traffic.

Map 17.21 Land use from New cloth mills to Amraiwadi

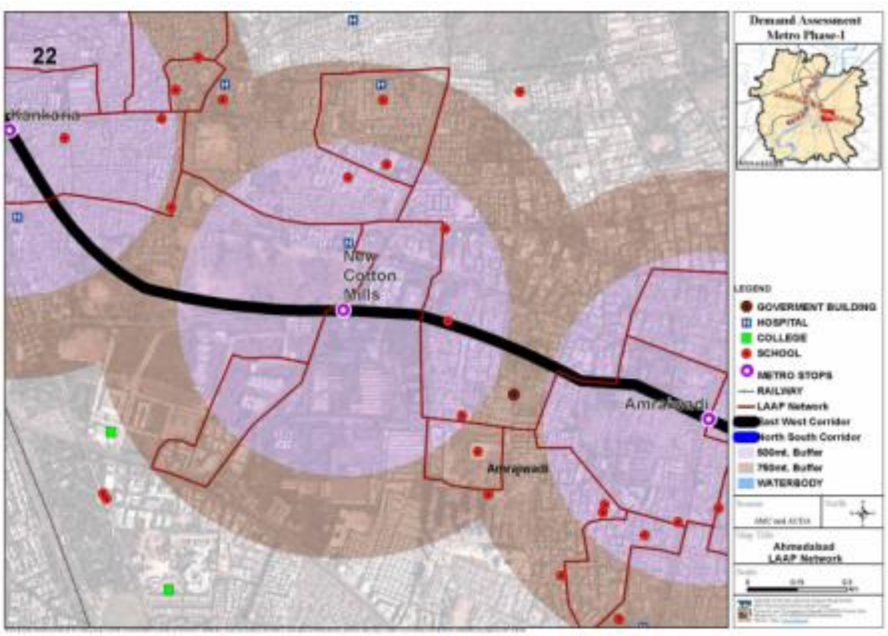
Amraiwadi to Rabari Colony

The length of this section from Amraiwadi to Rabari Colony is 1.3km. The major land use along the corridor is industrial with small scale industries and retail shops and dense residential within 500m vicinity on both side of the corridor. The major residential colonies include Rajiv nagar, Satyam nagar, Ambica nagar and Shivanand nagar. Municipal schools are also located within vicinity of this corridor.

This section is intersecting with Narol Naroda Highway at Rabari Colony junction. This arterial road is also serving as BRTS corridor. In future Rabari Colony will be interchange node for many commuters.

Map 17.22 Amraiwadi to Rabari Colony

The map below shows the LAAP for this stretch.



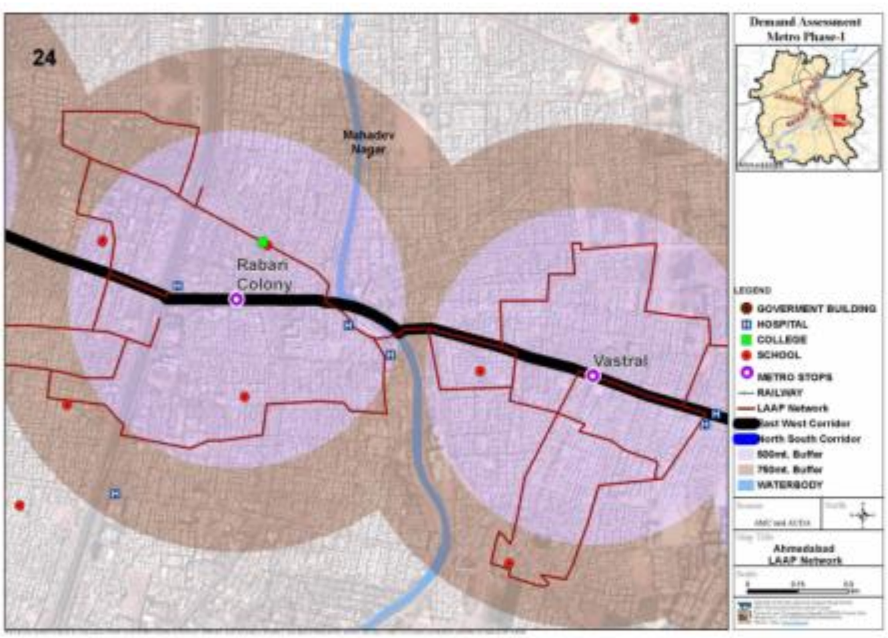
Map 17.23 LAAP network around New Cotton Mills metro station

Rabari Colony to Vastral

The length of this section is 1.5km with 18-26m right of way. The major land use along this corridor is residential. The walkable range within this part of the corridor small and large scale industries including Surelia estate and Khandelwal estate are also located. The dense residential societies include Ganjendra Park, Jhadeshwar Park, Parmeshwar Park, Maruti tenements, Shiv Park, Arbuda nagar, Hari Om society and Ram rajya nagar within vicinity of the corridor. Commercial activities along the road side also can be observed. A garden near canal has also developed and Bhavna higher secondary school is also located along the corridor. Many buildings are mainly residential having maximum of two floor height where Bhavna school and Shivalaya shopping complex being four to five floors high. Mainly collector roads from neighbourhood areas leading towards the corridor.

Map 17.24 Rabari Colony to Vastral

The map below shows the LAAP for this stretch.



Map 17.25 LAAP network around Vastral metro station

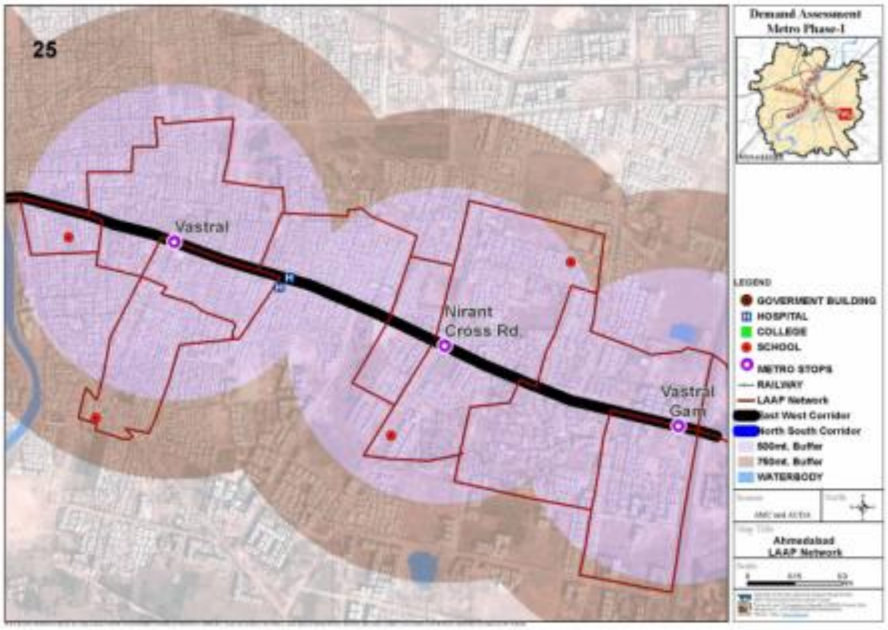
Vastral to Vastral gam via Nirant Cross road

The corridor from Vastral to Vastral gam is 1.7km in length with 24m right of way. The major land use along the corridor is residential including Tejendra park, Shiv Sukh nagar, Girivar home and Madhav nagar. The locality from Vastral to Vastral gamtal is under development and coming up with many residential townships.

The corridor is intersecting with S.P. ring road at Vastral Chokdi. S.P. Ring road is one of the major entry for the city. An interchange with regional transit services is also an opportunity to develop a transit node.

Map 17.26 Rabari Colony to Vastral to Vastral gam via Nirant Cross road

The map below shows the LAAP for this stretch.



Map 17.27 LAAP network around Nirant and Vastral gaam metro stations

17.5.4.2 North South Corridor: Motera Stadium to APMC (15.42 km)

The corridor measuring 15.42 km of length has road widths varying from 18.0m to 100 m. It holds many city level landmarks and is the most important arterial link along the river Sabarmati that facilitates connections for eastern walled city to western newer developments through river bridges. It is major institutional, commercial spine of the city offering connectivity to some of the important suburbs like Chandkheda, Tragad, Ramdevnagar, Wadaj, Vasna, Sarkhej, etc. and has now become integral part of the city.

The stretch from Usmanpura to Ellis Bridge is also identified as C.B.D. in proposed D.P. of Ahmedabad and has high end commercial and office spaces with social and educational institutions. The upcoming malls, presence of recreational spaces, institutes and the upcoming riverfront project has made this street a vibrant and active street in the city context.

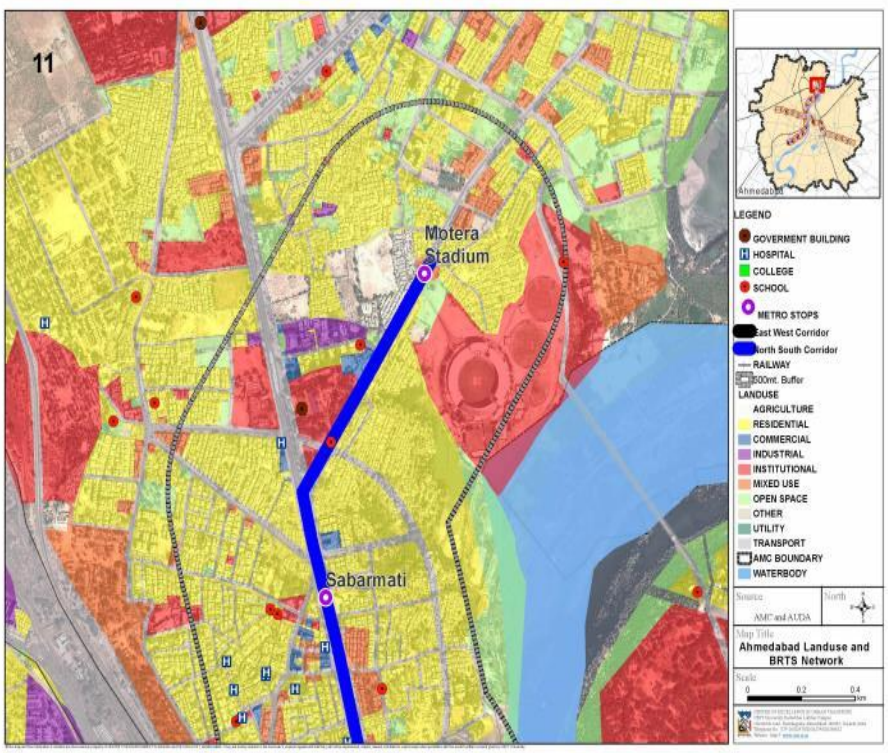
Ashram road being a continuous long stretch has given connectivity to many important places and destinations and is transforming rapidly. The stretch originating from Madalpur (V.S. Hospital) and terminating at APMC has a peculiar character. It passes through various suburbs such as Madalpur, Vasna, Sarkhej, etc. The residential character at the edges of this corridor is getting transformed to mix use, commercial and Institutional along the edges whereas the intact old residential fabric can be still observed in the inner areas. The alignment thus benefits the variety of users.

The stretch wise description is elaborated considering direction of movement from 'from node' to 'to node' referring as LHS and RHS for respective stretches to describe adjoining land uses, activities, major landmarks, etc.

Motera to Sabarmati

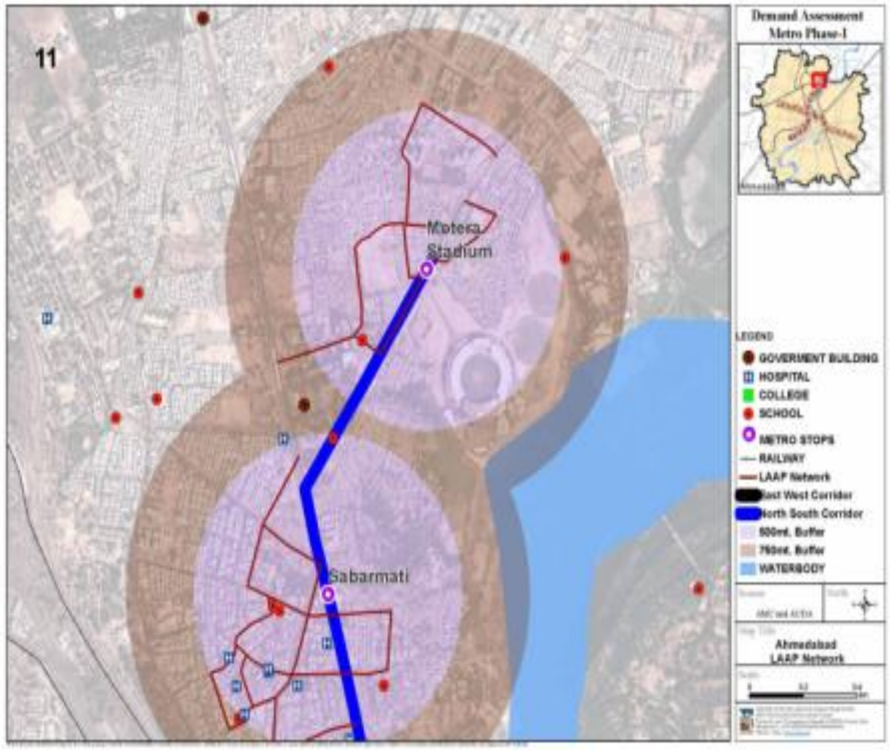
Motera Toll Naka to Ramdevnagar is a very active stretch that holds small scale commercial activities like Beronet mall along LHS and Ramdevnagar market along RHS is again a major activity generator. This serves as an important market place for local area. There are hospitals and other social institutes also that cater to the local neighbourhood.

The stretch from Ramdevnagar to Sabarmati shows majorly residential zone with small scale commercial development and workshop oriented activities along edges. The areas inside have dense residential fabric along with colonies for railway employees.



Map 28 Motera to Sabarmati

The map below shows the LAAP for this stretch.



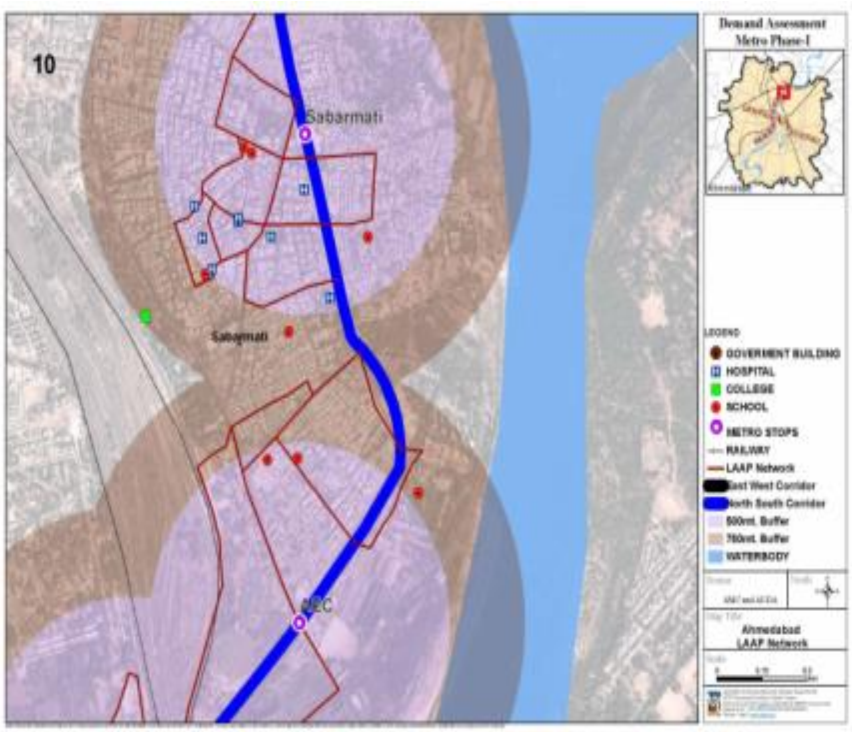
Map 17.29 LAAP network around Motera metro station

Sabarmati to AEC (Torrent Power Station)

The major landuse along the stretch from Sabarmati towards Chimanbhai Bridge is of residential use with presence of many important activities like Municipal swimming pool, Sabarmati railway station, Torrent power house, etc. next to the road. This stretch with 60 m right of way and 1.6 km length has campus developments along LHS whereas emergence of low rise apartments, commercial spaces, municipal offices, schools can be observed along RHS. This road towards eastern side is within the close vicinity of Sabarmati and gives access to river through Acher village. The access to crematorium at Acher is an important activity in this area. Torrent junction (AEC) is a very active node as it further towards its western side gives access to Sabarmati railway station. The rail over bridge connection called Chimanbhai Bridge is the only link from Sabarmati suburb to Ahmedabad city which starts from here. This node can function efficiently as interchange between Metro, BRTS, AMTS, IPT, etc to enhance the connectivity and facilitate more passengers.

Map 17.30 Sabarmati to AEC (Torrent Power Station)

The map below shows the LAAP for this stretch.



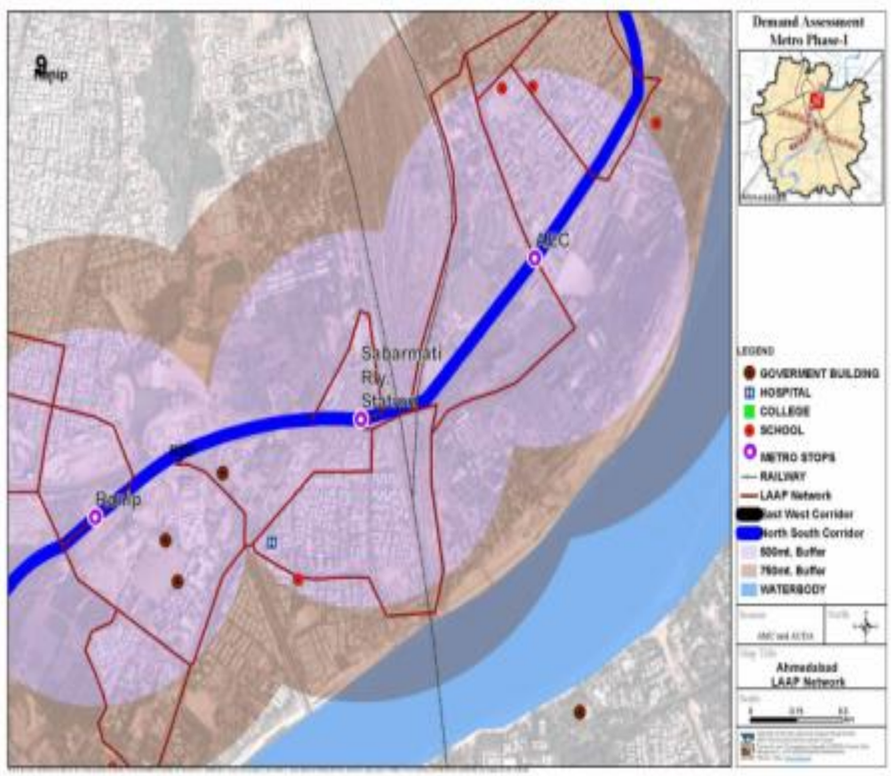
Map 17.31 LAAP network around Sabarmati railway station

AEC to Ranip

Chimanbhai Bridge, an important 2 lane rail over bridge link of 1.15 km of length, connects Torrent junction with RTO junction. RTO junction is a terminating point for 132 feet ring road from western side and Ashram road from eastern side and RTO to Chandkheda corridor from northern side. This junction gives way to many city scale important places in the precinct like Regional transport office, Jail staff training centre, exhibition ground at the junction and Central Jail, Ambedkar Bhavan towards north-west. It establishes connection through Subhash Bridge to eastern side that further connects Sabarmati riverfront, Shahibaug, historical walled city and road to Airport and Kalupur railway station for the residents across the river on western side. GSRTC stop, AMTS stop and BRTS station make this node as a potential interchange location for public transport systems that exist along with proposed metro alignment. Many other important destinations are located in the walkable range of the corridor. The stretch from RTO to Ranip of length approximately 1 km connects Ranip dense residential development towards north and Ramapir-no-Tekra slums near Wadaj.

Map 17.32 Land use from AEC to Ranip

The map below shows the LAAP for this stretch.



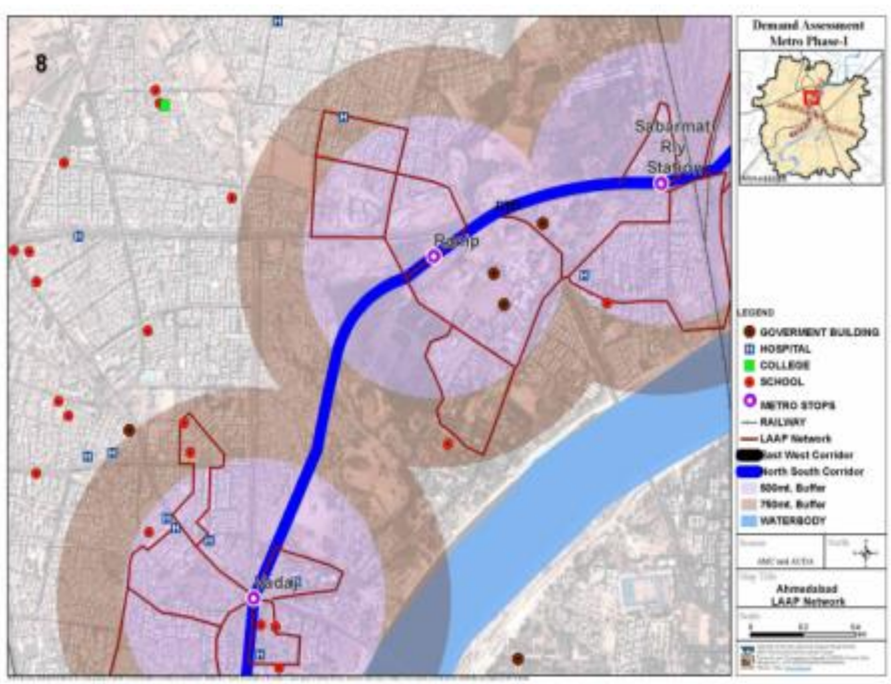
Map 17.33 LAAP network around Sabarmati and AEC metro stations

Ranip to Wadaj

The alignment passes through the settlement of Ramapir-no-tekra, majorly a residential use and green allocated pockets. The proximity to heritage and landmark site of Gandhi Ashram is a significant activity within the precinct. The stretch terminates at Wadaj junction which is a hub of activities. It acts as a transit node holding AMTS terminal, ESI hospital, auto stands at the junction while BRTS station towards north and new link as Dhudeshwar Bridge towards east. This bridge is a recently built river bridge that offers connectivity to eastern areas and is accessed by many people. The junction being at strategic location has potential to attract many passengers.

Map 17.34 Land use from Ranip to Wadaj

The map below shows the LAAP for this stretch.



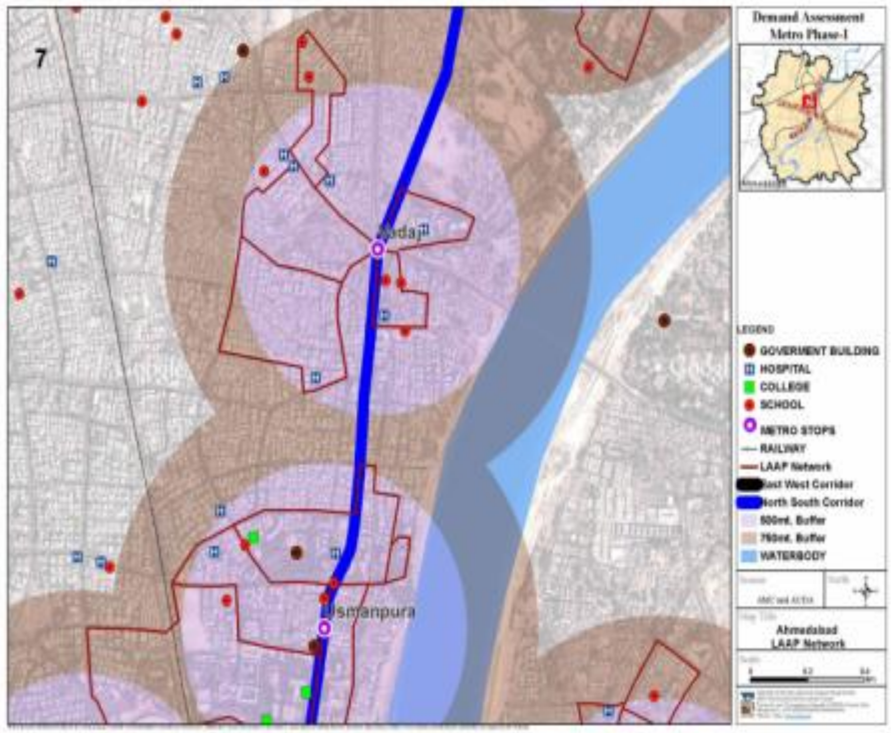
Map 17.35 LAAP network around Ranip metro station

Wadaj to Usmanpura

This stretch of Ashram road measures 1km length with road width varying from 36 m to 40 m. It is characterized by the presence of mix use at the edge and residential use at the inner areas. The prominent places include shop apartments such as Supath 2, Pruthvi apartment, Alaknanada society, Satyavadi society, etc. also housing major banks. Usmanpura junction intersects with a major link across that is an arterial road connecting University area, Navrangpura, Naranpura, etc. on western side. There are destinations like Usmanpura Dargah - a heritage site, AMC west zone office, Darpan dance academy, Navyug School which are in walking proximity from the stretch.

Map 17.36 Land use from Wadaj to Usmanpura

The map below shows the LAAP for this stretch.



Map 17.37 LAAP network around Usmanpura and Wadaj metro station

Usmanpura to Ashram road intersection

Description for this section can be referred in the corridor description for East west corridor.

Ashram road to Nava Gandhigram

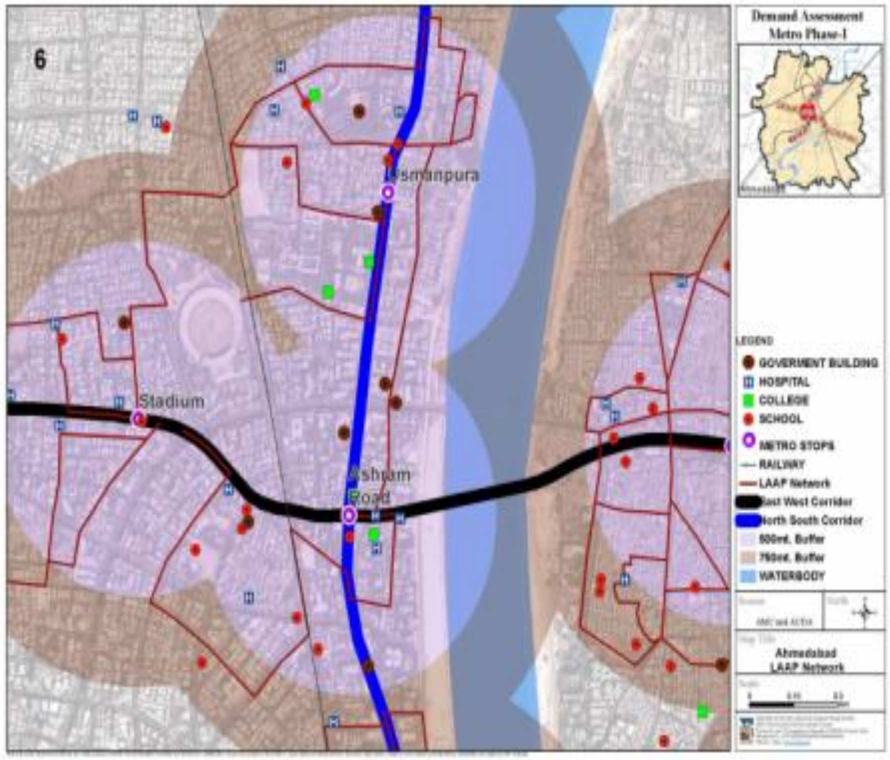
The institutional and commercial character of Ashram road continues along the stretch. It includes Mount Carmel school, school for deaf and dumb, office of Times of India, etc. The length of the stretch is 1.25 km having with road widths as 36m and 40 m. The five arm junction at Navrangpura railway crossing is intersected by a radial link further connecting western landmark places as C.G. road, University area, Navrangpura area terminating at Thaltej on S.G. highway.

The stretch from times of India junction to Vallabh Sadan has recreational, institutional and commercial as adjoining land uses. It includes landmark buildings like ATMA house, City gold multiplex, Shiv cinemax, Garvi Gurjari, Vallabh Sadan, etc. Here the extent of the stretch gets limited horizontally because of railways on western side and river bank on eastern side. Other than commercial and institutional use on the road edge inner areas have considerable residential development. Vallabh Sadan junction defines direct and main entry point to Sabarmati riverfront. Apart from several other activities, kite festival also becomes one of the activity generators attracting lot of people to this precinct and thus, can be termed as a potential node along the alignment.

The corridor from Vallabh Sadan to Nava Gandhigram has many institutional and commercial buildings such as C.P. building, Super market, Lilavati chambers, Handloom house, along western side (RHS) and Chinubhai centre, H.K. college and Sakar 7 along eastern side (LHS). Nava Gandhigram junction is an important junction that gives way to walled city via Nehru Bridge also holds Patang - the landmark revolving restaurant towards eastern side. It connects Gandhigram Railway station which is one of the important regional railway stations of the city. The alignment gives proximity to many important destinations or places situated in a walkable distance in the surrounding area that would facilitate more people.

Map 17.38 Ashram road to Nava Gandhigram

The map below shows the LAAP for this stretch.



Map 17.39 LAAP network around Ashram road metro station

Nava Gandhigram to Madalpur

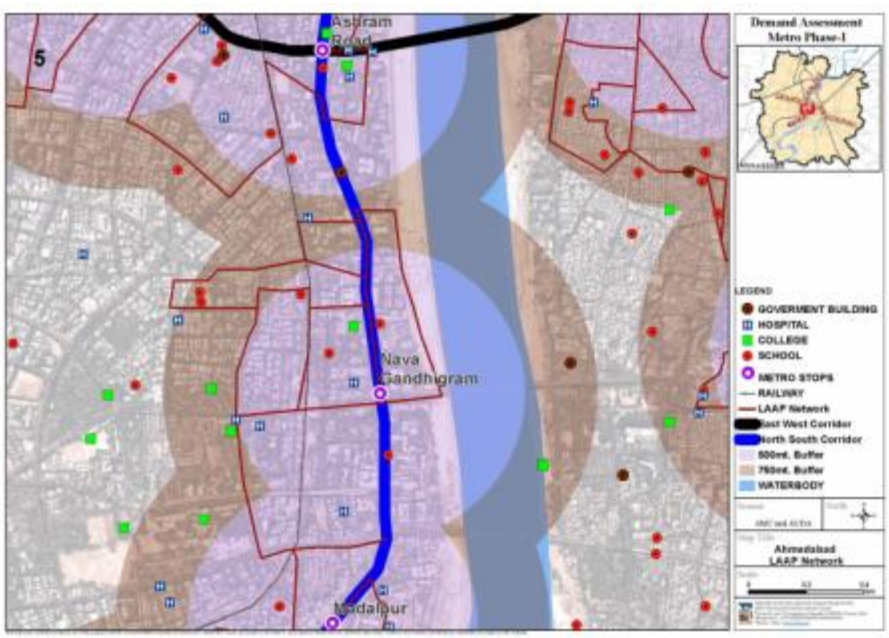
The corridor from Nava Gandhigram to Ellis bridge shows similar characteristics being a part of Ashram road and further down from Town hall junction to Madalpur, the street character changes gradually transforming in to mix use at edge and residential at inner areas.

This small stretch of 0.5 km with road width 40m from Nava Gandhigram to Town hall, has historical landmarks such as Ellis Bridge, Town hall, M.J. library and V.S. hospital at its edges around Town hall junction. A recently built flyover near M.J. library connects Ambavadi, a residential development on western side via Khadi Sarita, Gymkhana, Law garden, Panchvati, overlaps the town hall junction extent overhead descending at Khadi Sarita junction on western side and before Ellis Bridge on eastern side. Town hall junction through Ellis Bridge offers connectivity to walled city's important destinations like Sardar Baug, Sunday market, I.P. Mission church, Bhadra, Lal Darwaza, etc. which are within 1 to 1.5 km range. Town hall junction towards western side connects Madalpur Gaam and Gujarat college.

The V.S. hospital situated further down towards south west of the corridor is the major landmark and nucleus of activities giving rise to supporting activities such as hawking, small scale retail shops and other commercial developments. There have been major developments in terms of showrooms, malls, cafes that are coming up on this stretch as this gives access to city's important institute called NID towards southern side.

Map 17.40 Land use from Nava Gandhigram to Madalpur

The map below shows the LAAP for this stretch.



Map 29 LAAP network around Gandhigram metro station

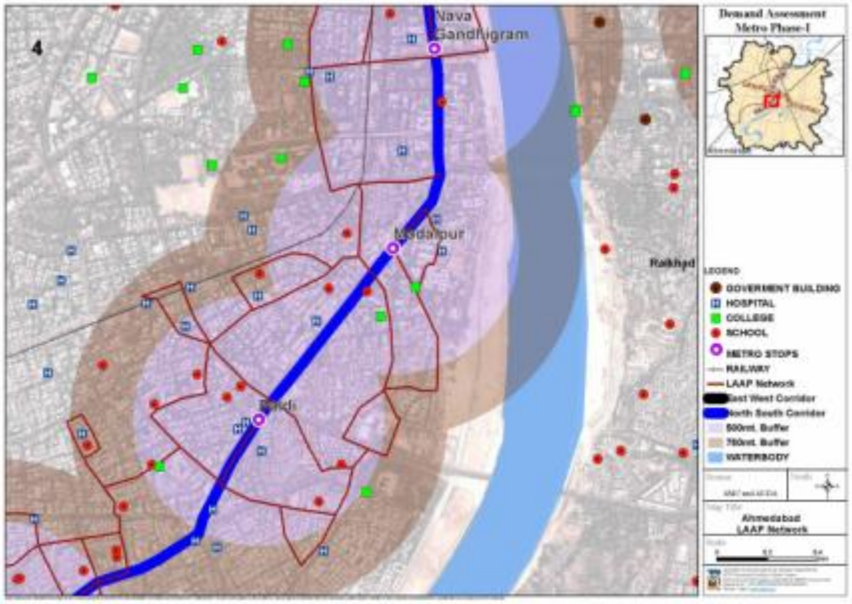
Madalpur to Paldi

The stretch from Madalpur to Paldi is 0.8 km long and 30 m wide. It has mix use along the edges with building heights moderately high towards Paldi junction and low rise residential development at inner areas. Some of the prominent buildings are Jai Shanti apartment, Bhikubhai chambers, Abhinav arcade, etc.

The majority of activities cater to transport oriented activities at Paldi junction as this junction is well located in the proximity to city and city outskirts. Paldi GSRTC terminal and private transport hub is the prime destinations of this area. Thus the prevailing land use is in tune with these activities. Across Paldi junction the road connects to Gymkhana, Law garden area towards north-west side whereas gives access to NID, Sanskar Kendra and Sardar Bridge towards south-east side. Sardar Bridge is an important link that further down connects whole sale and workshop oriented activities of old city areas.

Map 17.42 Land use from Madalpur to Paldi

The map below shows the LAAP for this stretch.



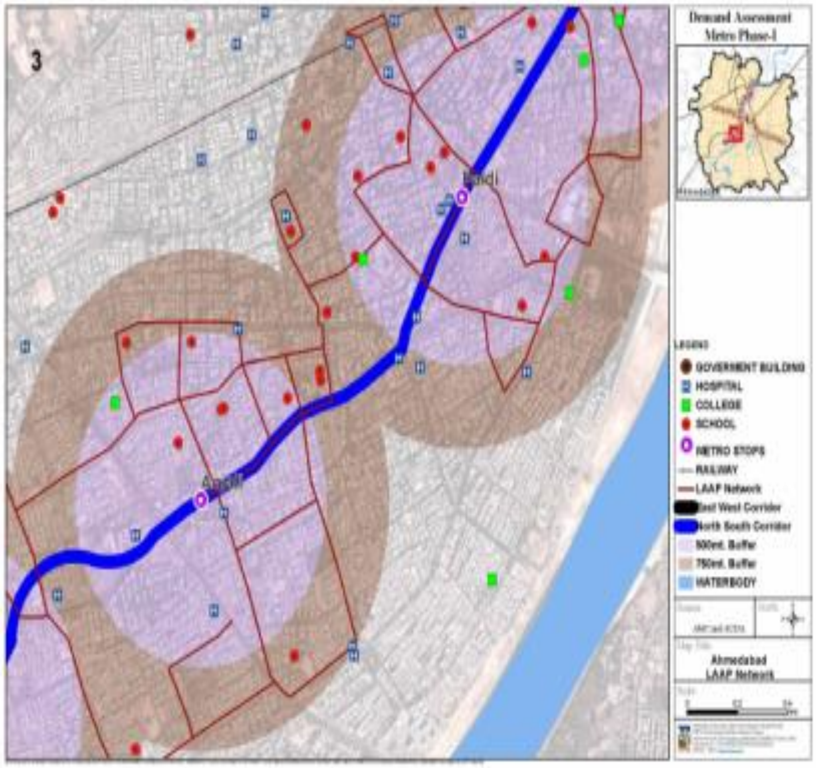
Map 17.43 LAAP network around Paldi and Madalpur metro stations

Paldi to Anjali

This stretch is 1.8 km long with varying road widths as 24m, 30m and 36m. The major land use along the corridor is residential and mix use dotted with commercial developments along major junctions. The corridor encompasses some major junctions and localities such as Mahalaxmi, Fatehpura, Bhattha which is known for eateries terminating at Anjali. At Anjali junction the road across connects Nehrunagar circle towards north-west and Pirana Bridge towards south east along BRT alignment. It also offers a significant connection across dense residential areas covering large expanse of passengers and arterial North – South connectivity and thus can act as a major node for the identified alignment.

Map 17.44 Land use from Paldi to Anjali

The map below shows the LAAP for this stretch.



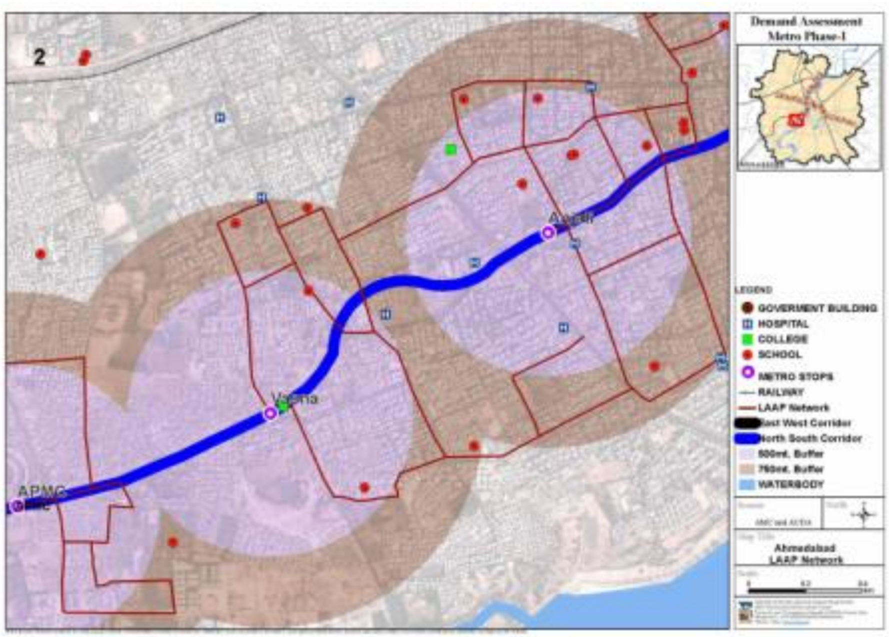
Map 17.45 LAAP network around Anjali and Paldi metro stations

Anjali to Vasna

The landuse along the stretch which is 0.8 km and 24m to 30m wide is majorly residential. A historic structure known as Vasna tomb situated at the edge of the street is a one of the ASI listed monuments is a destination hub for tourists. Vasna junction holds variety of activities like AMTS bus depot, Swaminarayan temple, and vegetable market and thus is a very populated place. The junction in recent years also shows commercial developments along the edges and towards the end of this stretch are institutions like Ahmedabad Art and Commerce College, RG Shah Science College in the vicinity. The corridor alignment would be beneficial for the residents of Vasna Gaam, visitors and tourists.

Map 17.46 Land use from Anjali to Vasna

The map below shows the LAAP for this stretch.



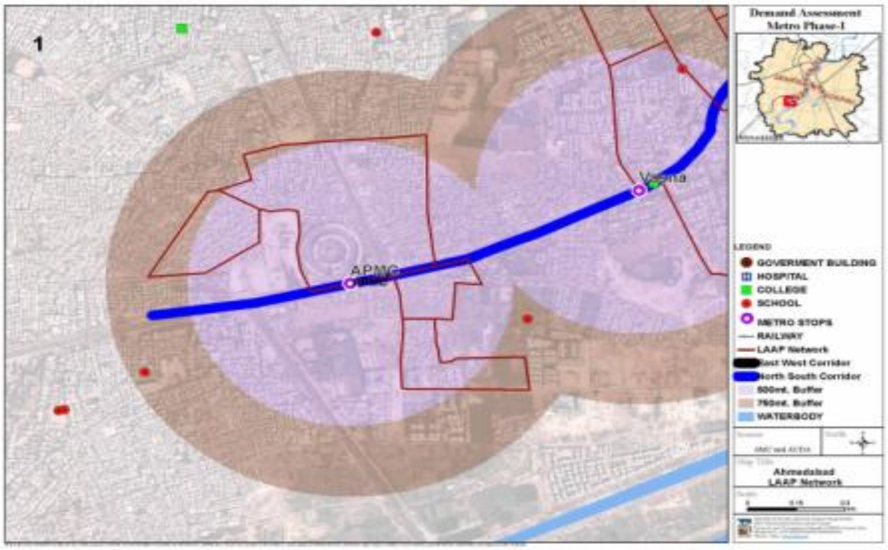
Map 17.47 LAAP network around Vasna and Anjali metro stations

Vasna to APMC market

The 1.2 km of stretch with road width 24m, 30m and 36m shows majorly residential use holding dense low rise residential fabric and predominantly housing low income group with commercial and mix development at the APMC junction. The continuous long alignment along Ashram road terminates at APMC junction. Agricultural Produce Market Committee's (APMC) Building is the dominant activity in the precinct and thus all other existing activities have come up as supporting activities. The loading, unloading spaces, parking areas for multi axle vehicles, auto stands, cycle stands, small scale retail shops, hawkers, repairing workshops, etc. are some of the activities that can be observed in the area. The junction towards north-west connects city's prime areas such as Jivraj park, Shyamal, Shivranjini, IIM, etc. through 132 feet ring road and further down towards south west side connects Sarkhej – Gandhinagar highway. The 132' ring road is also a future BRTS corridor. The junction thus, also gives opportunity to create interchange at this location with other modes. The next junction to APMC is Vishala which further offers connectivity to Narol – Sarkhej road and S.P. ring road.

Map 17.48 Vasna to APMC market

The map below shows the LAAP for this stretch.



Map 17.49 LAAP network around APMC and Vasna metro stations

17.5.5 Conceptual design

The lack of high quality pedestrian access and facility discourages the commuters to shift to public transport despite being offered excellent public transportation system. Besides that, cyclists are also sharing the carriage way for daily commuting and face high risk of accidents with fast moving traffic. Therefore, the first priority should be given to improve pedestrian access from various origins to Metro stations. In many areas, footpaths are not built due to fear of encroachments by street vendors. A better approach would be to integrate vendors in street design so that they have dedicated space.

Picture 17.1: Lack of adequate footpaths and dedicated cycle tracks

Picture 17.2: Provision of adequate footpaths and cycle tracks

The local government has to aim to make the footpaths clear from all types of encroachments. In residential areas, footpaths are constructed but have frequent interruptions of property entrances. An appropriate design solution should be adopted to manage the need of pedestrians and access management to private properties. Upgrading the footpath pavement quality is also an important factor.

Picture 17.3: Footpaths interrupted due to property access and other amenities

Picture 17.4: Designing continuous and uninterrupted footpaths taking care of its contextual needs.

Pedestrians are not willing to use footpaths because they are not properly cleaned. There are various roads where the foot path widths are less than 1 m. which becomes very difficult to walk on. Additionally, footpath width is also not adequate for pedestrians to walk in both directions. By placing appropriate street furniture and activity generators, footpath edge can become active edge and pedestrian will prefer to use footpath for walking. Additionally, landscaped areas can also be developed at regular intervals between benches to make footpaths inviting and visually appealing place to use it. It is recommended to plant trees to create comfortable walking environment

Picture 17.5: Pedestrians walking on road due to narrow footpaths

Picture 17.6: Designing wide footpaths pedestrian demand.

Picture 17.7: Roads without footpath

Picture 17.8: Adding footpaths where needed and planned.

There are various roads in Ahmedabad where there is no provision of footpaths. Especially roads adjacent to fly overs, internal roads, roads with lesser road width less than 12 m are observed to be lacking footpaths. Provision of footpath on such roads becomes very important for pedestrian safety as well as providing accessibility to the metro stations.

17.6 FEEDER SYSTEM

The present AMTS and BRTS transportation system both will act as feeder system for Metro. The feeder routes of proposed AMTS network will act as principal feeder system for Metro as well as BRT and AMTS. The proposed route structure of AMTS route consists of 21 feeders. BRT will feed to the Metro stations at selected interchange locations. The section below details out feeder systems for each metro station.

17.6.1 Thaltej Gaam to Helmet Cross Roads

Four metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Thaltej Gam

Thaltej Gam Metro stop is on East –West metro Line corridor and it is the last stop on west side of East – West line. There are two AMTS routes which feed to this metro stop. One is route no Feeder Loop (FL) 21 which connects science city road area on north side of metro stop and another is route no FL23 which connects to Judges bungalow road area which covers south side of metro stop.

B) Thaltej

There are two AMTS routes which feed to this metro stop. One is route no FL23 which connects to Judges bungalow area on south side of metro stop and another is route no Radial (R) 18 which connects Memnagar and Ujala circle via this metro stop.

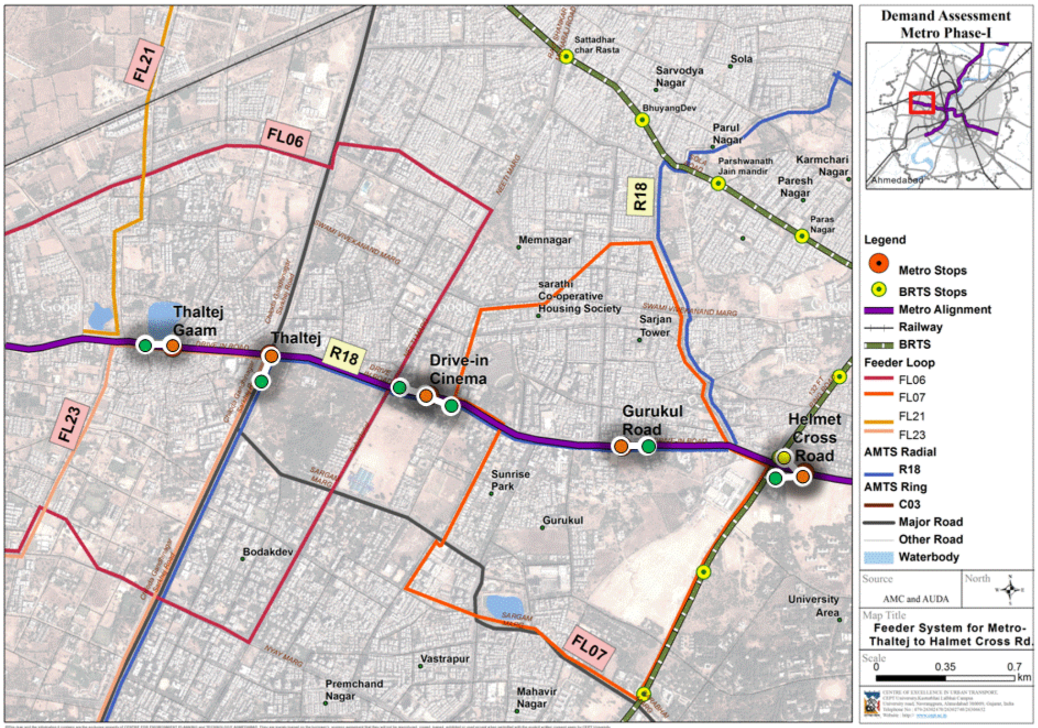
C) Drive-in Cinema

There are four AMTS routes which feed to this metro stop. Route no R18 connects Memnagar and Ujala circle via this metro stop. FL07 route connects Vastrapur Lake, Apha mall area. Route FL06 connects Bhaikakanagar, Thaltej lake area

D) Helmet Cross Road

There is one AMTS route and BRTS routes feeding to this metro stop. FL07 route is connecting Vastrapur lake, Alpha mall etc. Also BRTS routes are acting as feeder to this metro stop.

The map below shows the feeder routes for the four metro stations.



Map 17.50 Feeder services between Thaltej Gaam and Helmet Cross Roads

17.6.2 Commerce Six Roads to Ashram Road (Income Tax)

Three metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Commerce Six Roads

There are four AMTS routes which feed to this metro stop. Route no R18 which connects Memnagar and Ujala circle via this metro stop. FL07 route is connecting Vastrapur Lake, Alpha mall area. Circular (C) 03 is Naroda to Naroda circular route of AMTS via this stop.

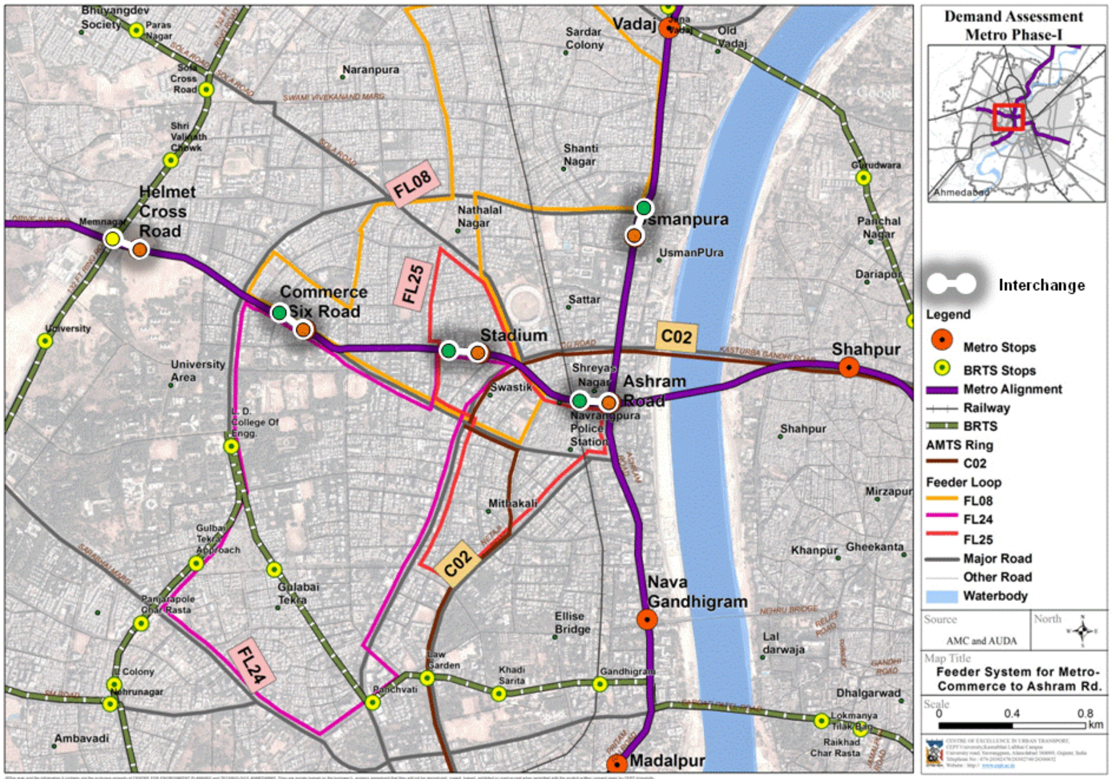
B) Stadium

There are three AMTS routes which feed to this metro stop. Route no FL08 which connects Naranpura area at north. Route no FL24 is connecting University area and Gulbai tekra. Route no C01 is Paldi to Paldi circular route of AMTS via this stop.

C) Ashram Road

There is one AMTS routes which feed to this metro stop. Route no FL25 which connects Sardar Patel Colony at north and CG Road at south of the stop.

The map below shows the feeder routes for these three metro stations.



Map 17.51 Feeder services between Helmet Cross Roads and Ashram road

17.6.3 Shahpur to Relief Road

Two metro stations are planned on this stretch. The proposed feeder services for each station are described below.

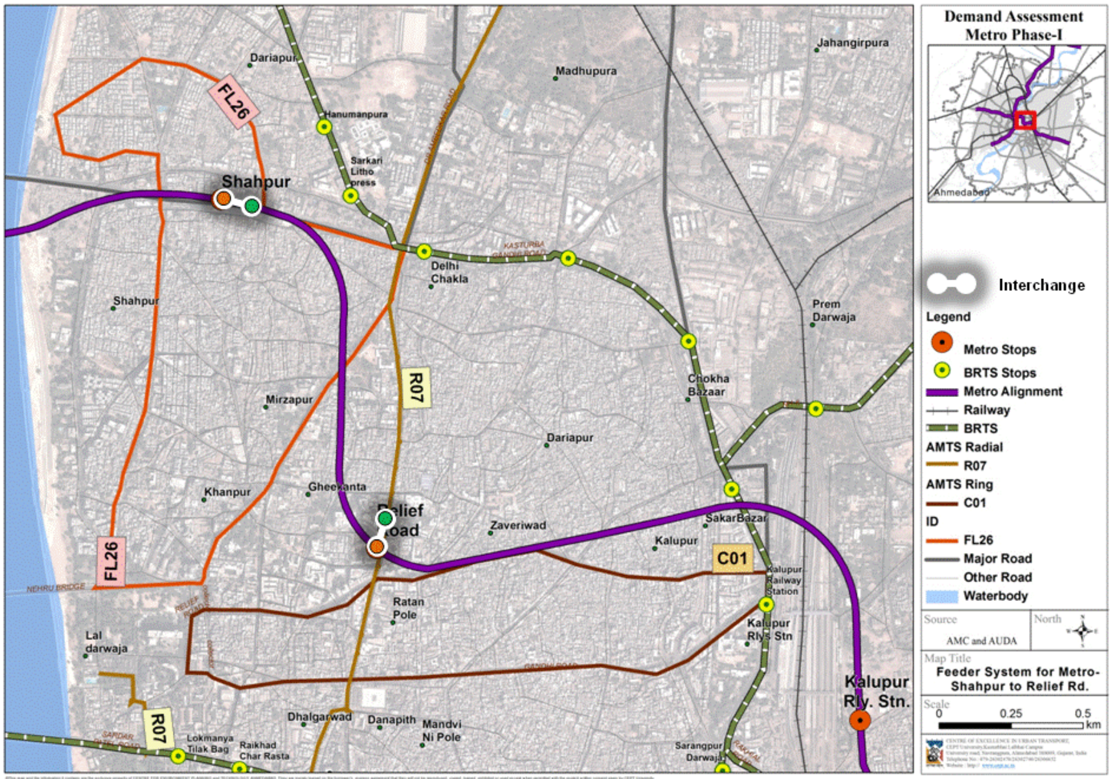
A) Shahpur

There is one AMTS route which feed to this metro stop. Route no FL26 is connecting Cama hotel road and Mirzapur Road to this stop.

B) Relief Road

There are two AMTS routes which feed to this metro stop. Route no R07 which is connecting Sarkhej and Meghaninagar via this stop and route no C01 is Lal Darwaza to Lal Darwaza circular route via this metro stop.

The map below shows the feeder routes for these metro stations.



Map 17.52 Feeder services between Shahpur and Relief Road

17.6.4 Kalupur to Amraiwadi

Four metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Kalupur Railway Station

There are four AMTS radial routes which feed to this metro stop. Route no R12 is connecting Vastral and Sarangpur via this stop, route no R14 is connecting Saraspur and Odhav GIDC, Route no R15 is connecting Saraspur and Kathvada and Route no R16 is connecting Saraspur and Nava-Naroda. This metro stop is also connecting regional railway station.

B) Kankaria

There is one AMTS radial route which feed to this metro stop. Route no R12 is connecting Vastral and Sarangpur via this metro stop.

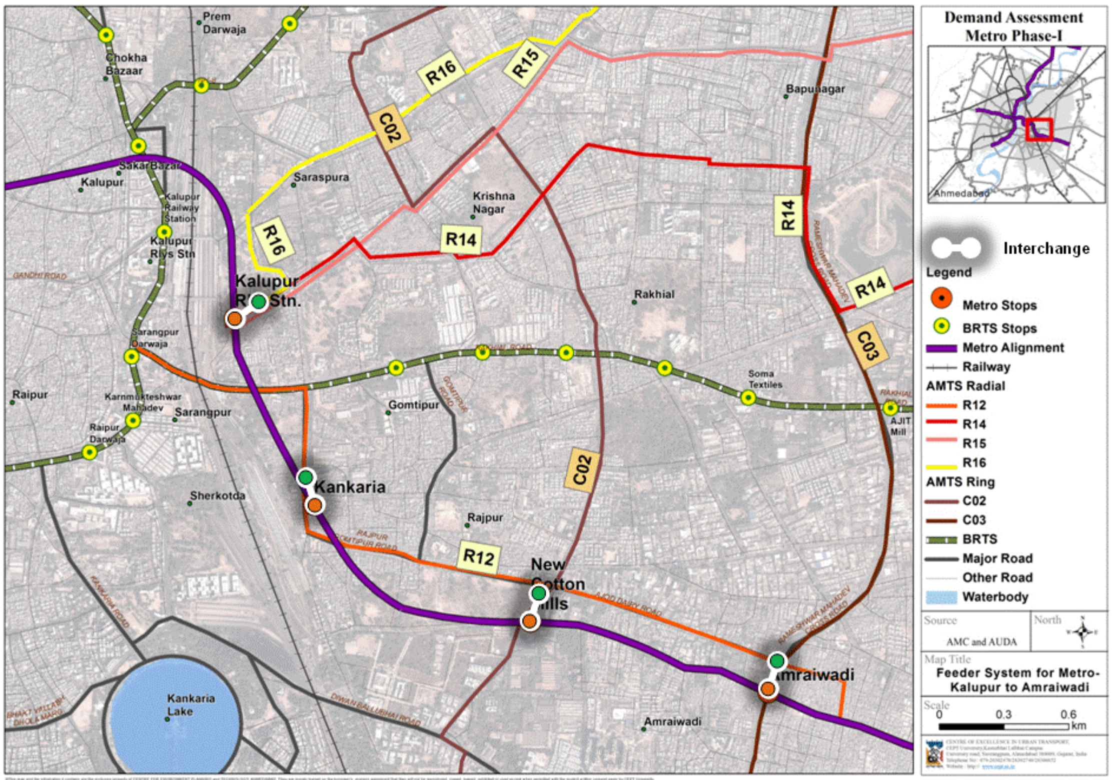
C) New Cotton Mills

There is one AMTS ring route which feed to this metro stop. Route no C02 is connecting Wadaj to Wadaj via this metro stop.

D) Amraiwadi

There is one AMTS ring route which feeds this metro stop. Route no C03 is connecting Naroda to Naroda via this metro stop.

The map below shows the feeder routes for these metro stations.



Map 17.53 Feeder services between Kalupur and Amraiwadi

17.6.5 Rabari Colony to Vastral Gam

Four metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Rabari Colony

There is one AMTS route which feeds this metro stop. Route no FL27 is connecting Mahadev nagar, Jagadish Industries etc area. It is also connected by BRTS routes.

B) Vastral

There are two AMTS routes which feed this metro stop. Route no FL27 is connecting Mahadev nagar, Jagadish Industries area. Route no FL17 is connecting CTM, Ramol road, Galaxy road etc.

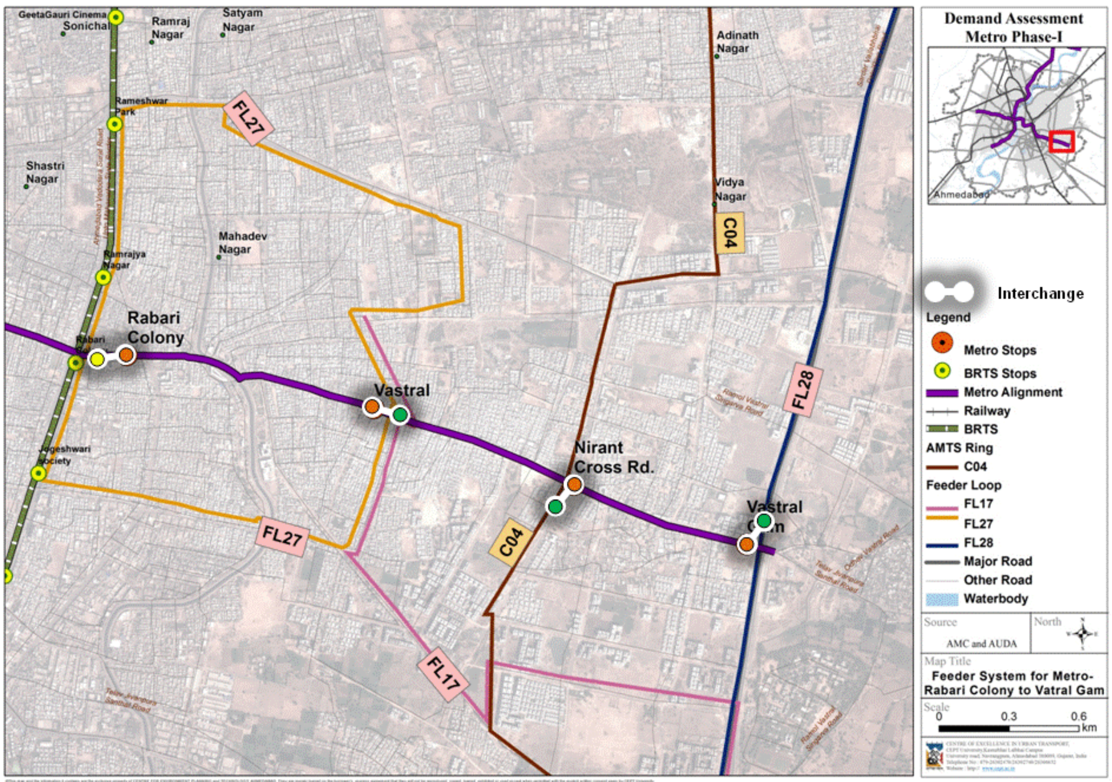
C) Nirant Cross Road

There is one AMTS route which feeds this metro stop. Route no C04 is Lal Darwaza to Lal Darwaza radial route via this metro stop

D) Vastral Gam

This is the last stop on east side of East – West line. There is one AMTS route which feed to this metro stop. Route no FL28 is connecting Gatrad, Chosmia and Odhav.

The map below shows the feeder routes for these metro stations.



Map 17.54 Feeder services between Rabari Colony and Vastraal

17.6.6 APMC to Anjali

Three metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) APMC

This is the last stop on south side of North – South line. There are four AMTS routes which feed to this metro stop. Route C03 is Naroda to Naroda ring route via APMC metro stop. Route no FL11 is connecting Juhapura, Vejalpur and Vasana area. Route no FL20 is connecting Sarkhej to this metro stop. Route no C04 is Lal Darwaza to Lal Darwaza Circular route via APMC metro stop. The proposed BRT from APMC to Shivranjini will also feed this metro station.

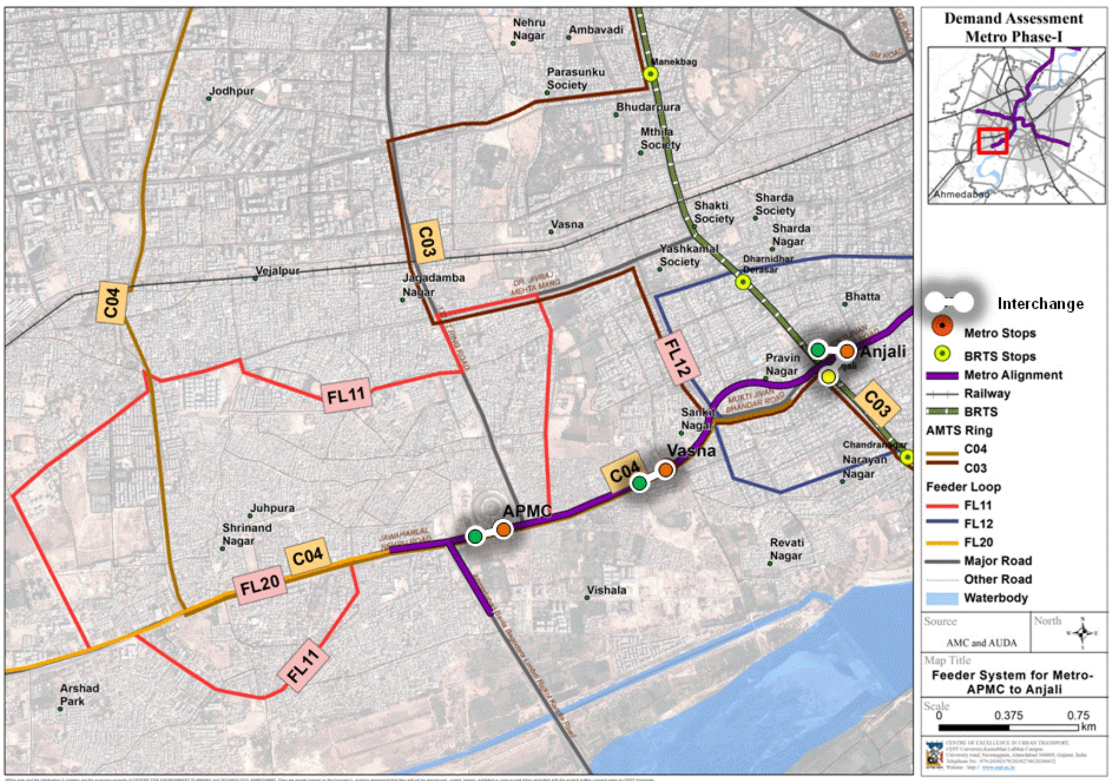
B) Vasna

There is one AMTS route which feed to this metro stop. Route FL12 is connects Vasana, Bhatta, Paldi.

C) Anjali

BRTS routes from RTO, Iscon towards Maninagar and Narol are feeder of this metro stops.

The map below shows the feeder routes for these metro stations.



Map 17.55 Feeder services between APMC and Anjali

17.6.7 Paldi to Nava Gandhigram

Three metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Paldi

There are two AMTS route which feed to this metro stop. Route C02 is Wadaj to Wadaj ring route originating from this stop. Route R06 is radial route connecting Paldi and Pralhadnagar.

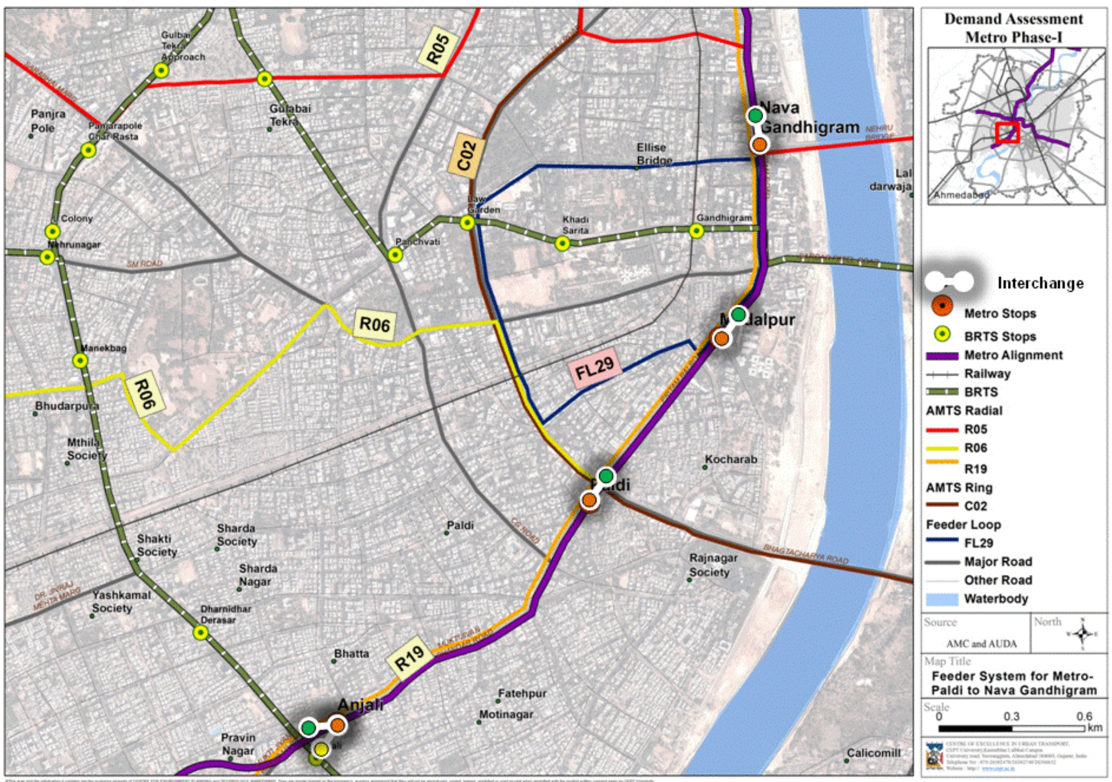
B) Maldalpur

There is one AMTS route which feeds this metro stop. Route FL29 is connects Ellisbridge and Netaji road.

C) Nava Gandhigram

There are two AMTS route which feed to this metro stop. Route R5 is radial route connecting Lal Darwaza and Sindhu bhavan via this metro stop and R19 is circular route connecting Lal Darwaza via this metro stop.

The map below shows the feeder routes for these metro stations.



Map 17.56 Feeder services between Paldi and Gandhigram

17.6.8 Usmanpura to Ranip

Three metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Usmanpura

There are two AMTS routes which feed to this metro stop. Route C02 is Wadaj to Wadaj ring route via this stop location. Route FL08 is connecting Naranpura, Usmanpura area.

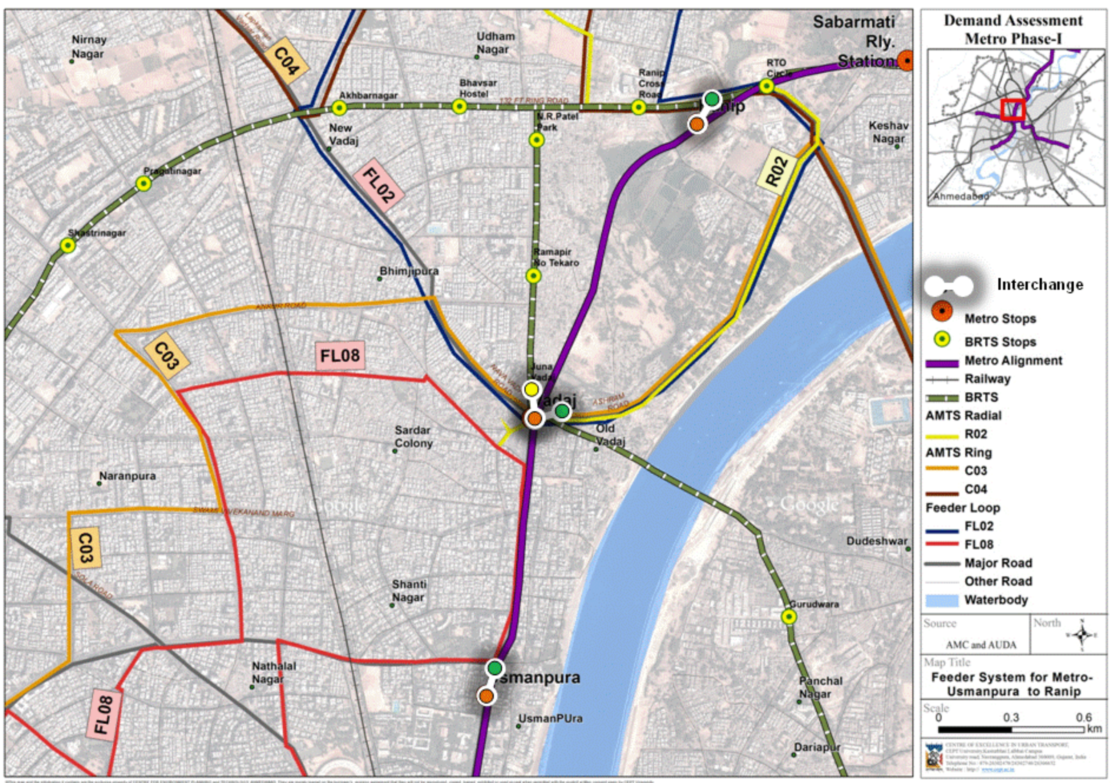
B) Wadaj

There are three AMTS routes which feed to this metro stop. Route C02 is Wadaj to Wadaj ring route originating from this stop location. Route FL02 is connecting Akhbarnagar, Ranip area. Route no R02 is radial route connects Wadaj and Nirma College. BRTS routes also feed this metro stop.

C) Ranip

There are three AMTS routes which feed this metro stop. Route C03 is Naroda to Naroda ring route via this stop. Route FL02 is connecting Akhbarnagar, Ranip area. Route no R02 is radial route connecting Wadaj and Nirma College.

The map below shows the feeder routes for these metro stations.



Map 17.57 Feeder services between Usmanpura and Ranip

17.6.9 Sabarmati Railway station to Motera Stadium

Four metro stations are planned on this stretch. The proposed feeder services for each station are described below.

A) Sabarmati Railway Station

There is one AMTS route which feeds this metro stop. Route R01 connects Wadaj and Koba via this metro stop.

B) AEC

AEC Metro Stops is on North – South metro Line corridor. There is one AMTS route which feeds this metro stop. Route R01 connects Wadaj and Koba via this metro stop.

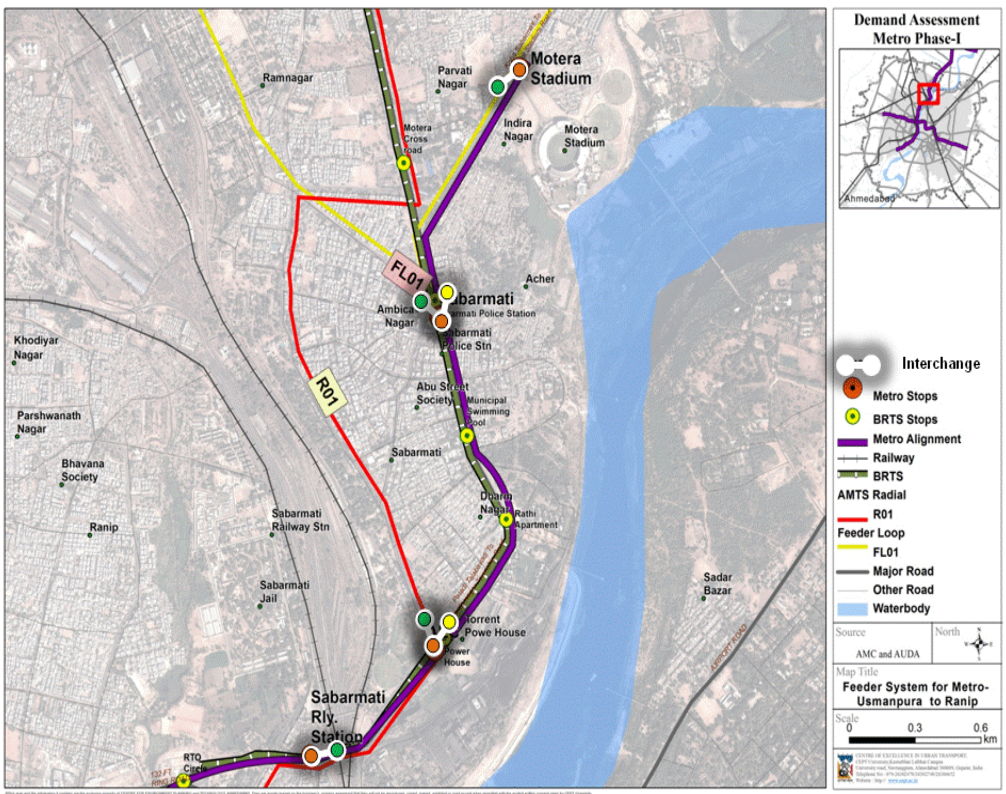
C) Sabarmati

There is one AMTS route which feeds this metro stop. Route FL01 connects Chandkheda and New CG Road to this stop

D) Motera Stadium

There is one AMTS route which feeds this metro stop. Route FL01 connects Chandkheda and New CG Road to this stop.

The map below shows the feeder routes for these metro stations.



Map 17.58 Feeder services between Sabarmati and Motera

17.6.10 Summary of feeder routes

The summary of feeder routes for each metro station is given in the table below. The details for the bus routes and BRT routes are attached in annexure.

Table 17.1 Summary of feeder routes

No	Metro Stations	Bus Route	BRT Route
1	Thaltej Gam	FL21, MF1	
	Thaltej	MF1, R18	
	Drive-in Cinema	R18,FL07,C03,FL06	
	Gurukul Road	R18	
	Helmet Cross Road	FL07	BRT10, BRT11, BRT20
2	Commerce Six Road	FL08, MF02	
	Stadium	MF02, FL08, C01	
	Ashram Road (income tax)	MF03	
3	Shahpur	MF04	
	Relief Road	R07, C04	
4	Kalupur Rly. Stn.	R12,R15,R16,R14	BRT18, BRT19
	Kankaria East	R14	
	New Cotton Mills	C01	
	Amraiwadi	C02	
5	Rabari Colony	MF05	BRT11, BRT12, BRT16
	Vastral	FL17, MF05	
	Nirant Cross Rd.	C03	
	Vastral Gam	MF06	
6	APMC	C03, FL11,FL20,C02	
	Vasna	FL12	
	Anjali		BRT10, BRT11
7	Paldi	C01, R20, R06	
	Madalpur	MF07	BRT14
	Nava Gandhigram	R05, R19	
8	Usmanpura	C02,Fl08	
	Vadaj	C02,FL02, R02	BRT17, BRT18
	Ranip	C03,FL02,R02	BRT10, BRT11, BRT18
9	Sabarmati Rail Stn		BRT10, BRT18
	AEC	G013, R03	
	Sabarmati	G13, FL01	
	Motera Stadium	FL01	

17.7 INTERCHANGE STATIONS

A transport interchange is a place where passengers and goods are exchanged between vehicles or between transport modes. Interchange can be either the physical action of transferring between services or modes as part of the passenger's journey or it can be the physical location that provides access to the Public Transport system. (IMP, Ahmedabad).

17.7.1 Type of Interchange

Interchanges permit riders from particular mode of transport to move and board same or different mode in order to reach their desired destination. Interchanges can be of several types, depending on available modes of transport. Transfer may happen between the same modes or among different available public transport. Interchanges bring public transport together. For example metro station can have interchanges with metro on particular corridor connecting metro station of different corridor or, Metro stations may have interchange with BRTS, AMTS and even rail. Interchange helps to integrate various means of transport system under a common node. Some of the identified types of interchanges along the Ahmedabad Gandhinagar metro corridor are as followed;

1. Metro - Metro Interchange; connecting particular metro station with another metro corridor
2. Metro- BRTS Interchange; connecting Metro Station with BRTS
3. Metro - AMTS Interchange; connecting Metro with AMTS
4. Metro – Rail Interchange; connecting Metro with Rail

Interchanges increases flexibility of movement and gives commuter option to avail multiple public transports at a common station. BRTS is the high capacity public transport system while metro and rail are considered to have even higher capacity than BRTS.

17.7.2 Level of Interchange

Interchanges can be of different levels, depending on the types of interchange. The four modes of transport mentioned above are under four different authorities. Metro is a Special Purpose Vehicle (SPV) under Metrolink Express for Gandhinagar and Ahmedabad (MEGA), BRTS is also an SPV under Ahmedabad Janmarg Limited (AJL), AMTS is under Ahmedabad Municipal Corporation (AMC) and Railways comes under Indian Railways. Design aspect of interchange needs prior planning for seamless mobility and transfer from one mode to other. The multiple authorities or institutions involved needs to take necessary decisions for efficient functioning.

Level 1

Level I interchange refers to the first type of interchange, which is metro to metro interchange. Under such category, single authority is responsible. It also involves transfer of people from Metro to Rail and Metro to Rail to BRT. Under such category multiple authorities are involved. Ahmedabad BRTS is considered to be the closed system, as mixed traffic is not allowed on the BRTS corridor. The same is the scenario with rail. Therefore level 1 interchange will involve integration Metro with Metro and Metro with closed system of BRTS and Railways.

Level 2

Level 2 interchange refers to integrating Metro with BRTS. Two SPV's AJL and MEGA will play role in such interchange. Another aspect to be taken care is integrating at-grade BRTS with elevated and underground Metro.

Level 3

Level 3 interchanges also involve integrating multiple authorities, MEGA and AMC, but the typology is different because metro has to be integrated with the open system of AMTS. In this level of interchange AMTS will function more as a feeder to the Metro corridor.

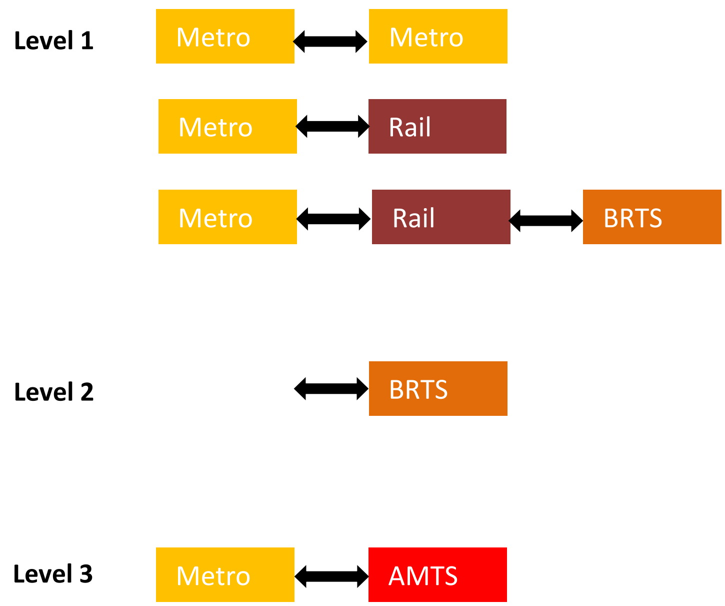


Figure 17.2 Different levels of interchanges in Ahmedabad

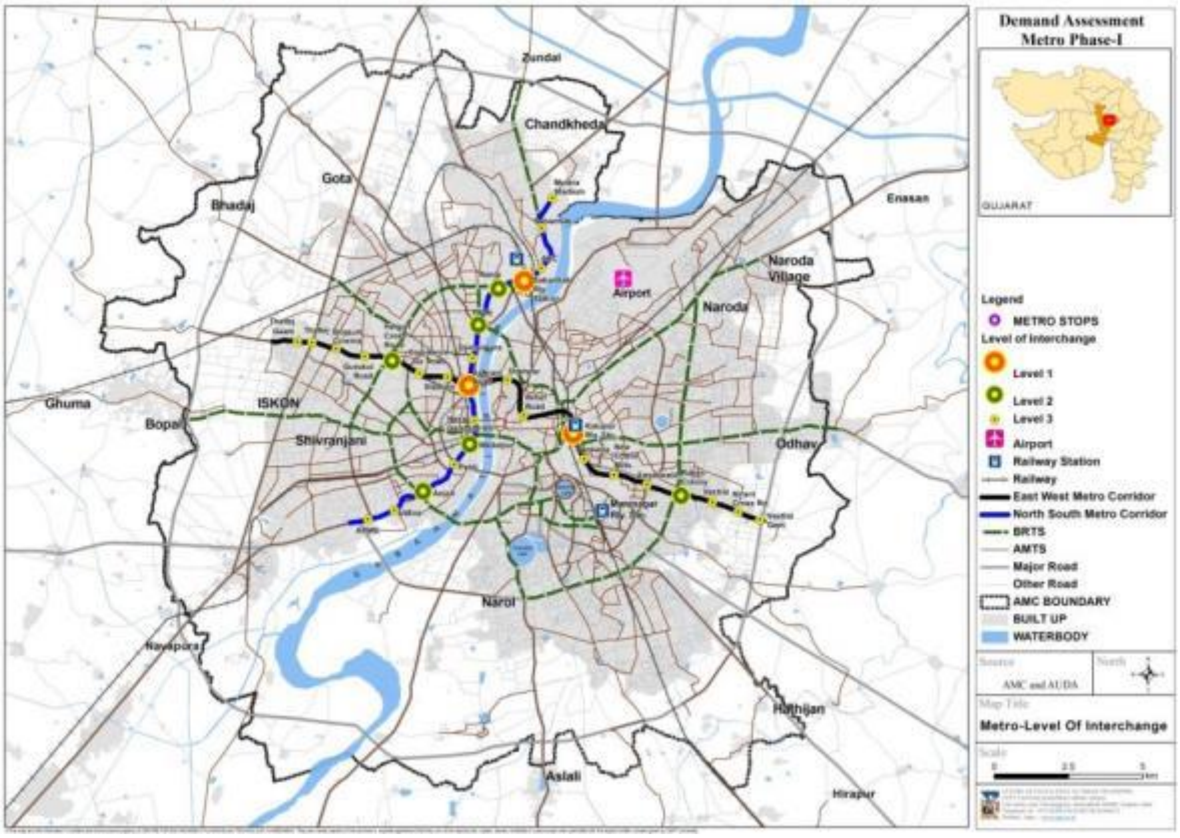
17.7.3 Ahmedabad Metro Interchange stations:

In order to develop an integrated public transport system, where one mode acts as a complimentary mode to another mode rather than its competitor, a trunk and feeder system of transportation network, which has been developed, would lead to incidences of transfers of passengers from one mode to the other. These interchange points are required to be seamless and barrier- free. Thus, this part of the study lays down principles for identification of interchanges within the city of Ahmedabad, determine the various typologies of interchanges, and thus identify the locations of various types of interchanges that needs to be developed all over the city of Ahmedabad for a seamless, barrier- free transportation experience.

The level of interchanges on each metro station is defined on the basis of the parameters described above. Details of interchange and map showing the level of interchanges on metro corridor are shown below.

Table 17.2 Levels of interchange for metro stations

No	Metro corridor	Metro Stations	AMTS	BRTS	Rail	Metro	Level
1	Thaltej- Vastral	Thaltej Gam	Yes	No	No	No	3
		Thaltej	Yes	No	No	No	3
		Drive-in Cinema	Yes	No	No	No	3
		Gurukul Road	Yes	No	No	No	3
		Helmet Cross Road	Yes	Yes	No	No	2
2		Commerce Six Road	Yes	No	No	No	3
		Stadium	Yes	No	No	No	3
		Ashram Road (income tax)	Yes	No	No	Yes	1
3		Shahpur	Yes	No	No	No	3
		Relief Road	Yes	No	No	No	3
4		Kalupur Rly. Stn.	Yes	Yes	Yes	No	1
		Kankaria East	Yes	No	No	No	3
		New Cotton Mills	Yes	No	No	No	3
		Amraiwadi	Yes	No	No	No	3
5		Rabari Colony	Yes	Yes	No	No	2
		Vastral	Yes	No	No	No	3
		Nirant Cross Rd.	Yes	No	No	No	3
		Vastral Gam	Yes	No	No	No	3
6	APMC - Motera	APMC	Yes	No	No	No	3
		Vasna	Yes	No	No	No	3
		Anjali	No	Yes	No	No	2
7		Paldi	Yes	No	No	No	3
		Madalpur	Yes	Yes	No	No	2
		Nava Gandhigram	Yes	No	No	No	3
8		Usmanpura	Yes	No	No	No	3
		Vadaj	Yes	Yes	No	No	2
		Ranip	Yes	Yes	No	No	2
9		Sabarmati Rail Stn	No	Yes	Yes	No	1
		AEC	Yes	No	No	No	3
		Sabarmati	Yes	No	No	No	3
		Motera Stadium	Yes	No	No	No	3



Map 17.59 Level of Interchange on Metro corridor

17.7.4 Principles for Developing an Interchange

AMTS is it will work as a feeder service of BRTS and upcoming METRO in Ahmedabad. Proper interchange will be provided to transfer passengers from feeder to trunk. The interchanges that need to be developed for Ahmedabad are based on certain principles, which are as follows:

- Every point where two or more public transport modes or routes of a public transport mode meet or coincide must be identified as an interchange.
- Interchanges must be pedestrian- friendly.
- Transfers within an interchange or within an interchange zone must be barrier- free
- Interchanges must be designed in a manner that when one attempts to transfer from one mode to the other, the transfer occurs between secured spaces, except in case of a transfer between AMTS and other modes.
- Every Metro and RRTS station must have a park and ride facility

17.7.5 Facilities for interchange

Facilities within an interchange may be categorized into four types, namely, transit support facility, transit- oriented passenger facility, additional facility and back office facility. Usually additional facilities and back office facilities are available in only the Type I and Type II interchanges. The facilities available for the various typologies of interchanges identified for the city of Ahmedabad are listed below. It is to be noted that provision of facilities in an interchange depends heavily on the contextual needs and the table below is to be referred as just guidelines.

Table 17.3 Facilities for levels of interchange

Facility	Level 1	Level 2	Level 3
Enquiry Counter	Green	Green	Green
Medical/ Pharmacy	Green		
Information Kiosk	Green	Green	
Wheelchair access	Green	Green	
Washroom	Green	Yellow	
Waiting Plaza	Green	Green	
Parking	Green	Green	Yellow
Ticket Vending Machine	Green	Green	
Security	Green	Green	Green
ATM	Green	Yellow	
Telephone Booth	Green	Yellow	
Food Court/ Coffee Shop	Yellow	Yellow	
Park and Ride	Green	Green	Yellow
Emergency	Green	Green	Yellow
First Aid	Green	Green	Green
Tourism Desk	Green		
Rest Room	Green		
Lost and Found Counter	Green	Yellow	
Internet Café	Yellow		
Computer/ Printing	Yellow		
Retail Shops	Yellow		
Rental Car Service	Yellow		
Kiss and Ride	Green	Yellow	
Bank	Yellow	Yellow	
Ticketing Centre	Green	Yellow	
Money Exchange	Yellow	Yellow	
Cloak Room	Green	Yellow	
Book Shops	Yellow		
Offices	Yellow		
Trip Planner	Yellow		
Restaurant	Yellow		
Customer Service Centre	Green	Yellow	
Super Market	Yellow		
Control Office	Green		
Staff Service & Facilities	Green	Yellow	
Goods Movement Facilities	Green		
Maintenance Facilities	Green	Yellow	
(Green)- Advisable , (Yellow) – To be provided in contextual need			

17.7.6 Conceptual design / typical design:

Conceptual designs for all the levels of metro station interchanges are discussed below.

17.7.6.1 Level 1 Interchange design: Kalupur Interchange.

Kalupur, which is the major railway station for the city of Ahmedabad has been proposed to be developed as a Type- I interchange. The railway station, located at 23° 1'47.48"N latitude and 23° 1'47.48"N longitude, lies in the eastern part of the city. Kalupur interchange is expected to be the biggest interchange in Ahmedabad.

At present, the railway station is connected by both the BRTS as well as the AMTS services, but in the future the railway station is supposed to be connected with the Gandhinagar-Ahmedabad Metro and a Regional Rapid Transit system. The introduction of these systems, would led to further increase in the footfalls in this station. Thus, this proposal aims to develop an interchange where pedestrians can make barrier- free movement and the public transportation modes are given priority.

The interchange integrates Railway station, Metro station and BRT as well as AMTS. The Metro station and BRT station are on the opposite sides of the Railway station. Metro and BRT station are proposed to be connected via underground concourse which will also connect to the two entry points of Kalupur railway station both on east and west side. An integrated AMTS bus stop is also proposed right next to the Kalupur Metro exit gate.

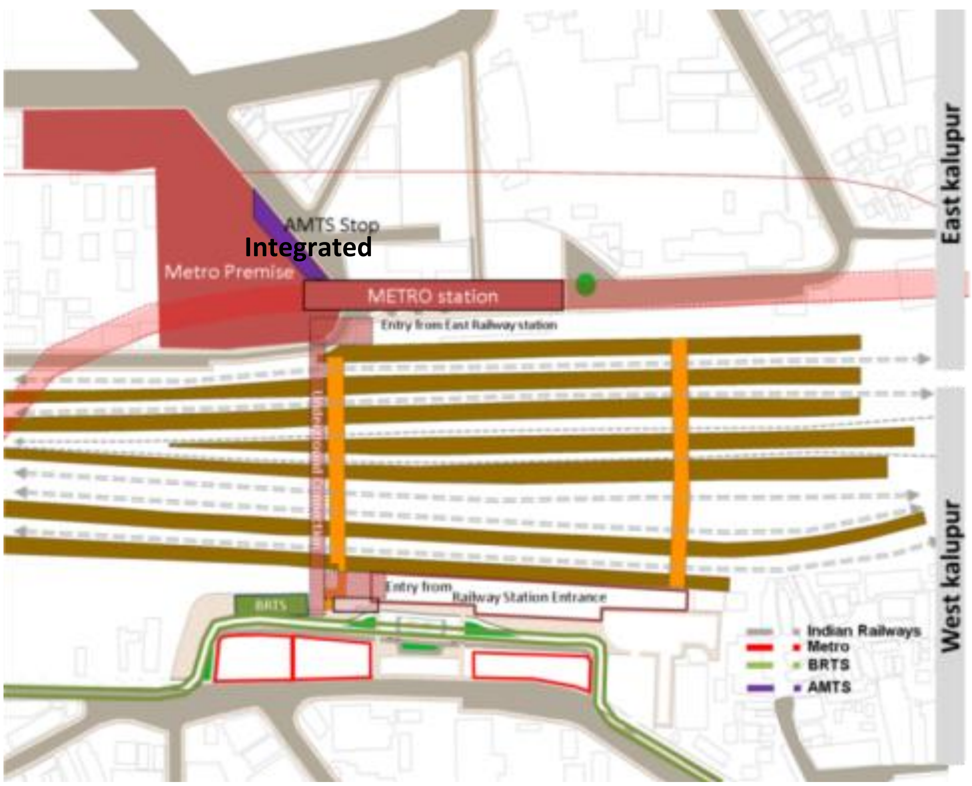


Figure 17.3 Conceptual Design Layout of Kalupur interchange.

17.7.6.2 Level 2 Interchange design – Typical Metro-BRT Interchange

Metro and BRT being closed systems a connection from the exit of metro station to the entry of BRT station should be designed. These close connections can either be elevated or underground as per contextual needs. While the exit of the metro station is proposed to be planned next to the AMTS stop. Thus the passengers do not need to search for the AMTS stop after egressing from metro station.

Figure 17.4 Conceptual Design Layout for Level 2 interchange.

17.7.6.3 Level 3 Interchange design: – Typical Metro-AMTS Interchange

The exit of the metro station is proposed to be planned next to the AMTS stop. Thus the passengers do not need to search for the AMTS stop after exiting from metro station.

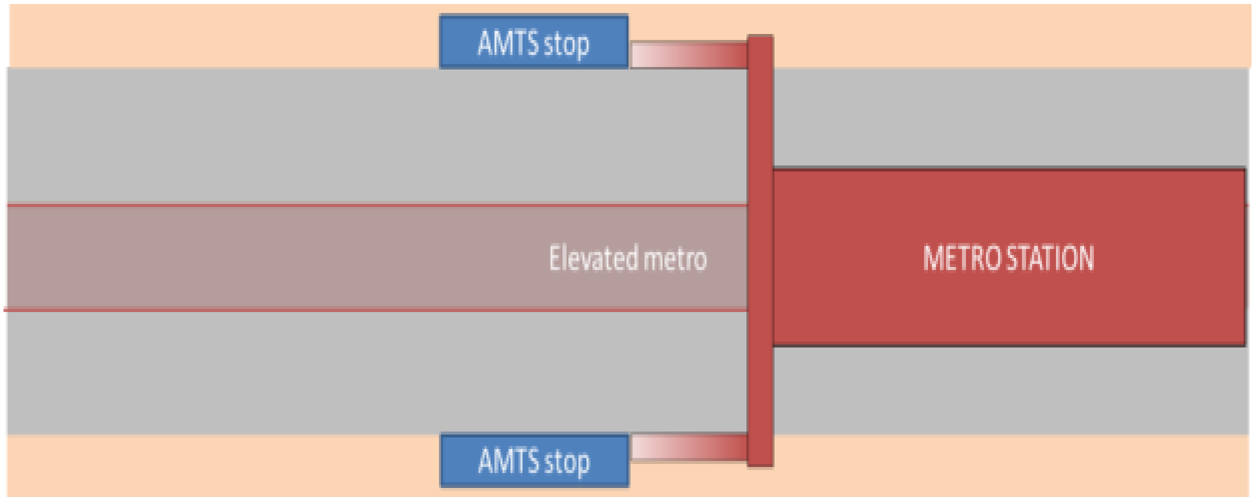


Figure 17.5 Conceptual design layout for level 3 interchange

17.7.7 Cost estimates for LAAP

The total length of proposed LAAP network for Metro is 150 mm. High quality pedestrian pathway, street furniture like benches, dustbins, bollards, street signages, pedestrian signages, cycle stands, railing, toilet blocks , landscape, tree guard, B.S. planters , street lights are proposed on the network. The cost for developing LAAP for Metro corridor is 525 cr INR.

The cost estimates for LAAP are described below.

Table 17.4 Cost estimates for LAAP

Road Development	Cost in cr	Total length for LAAP	Total cost in cr
Pathway	0.75		
Storm water drain	1.25		
Electrical	1		
Street furniture	0.5		
Total cost per Km	**3.5**	150	**525**

17.7.8 Cost estimates for Interchanges

The maximum development cost is estimated for level 1 interchange is estimated as below. These are block cost estimates only.

Table 17.2 Cost estimates for interchanges

Interchange costing	No of interchange	Block Cost in cr	Total
Level 1	3	250	750
Level 2	6	150	900
Total cost in cr			**1650**

17.8 ANNEXURE

Amts Radial			
ID	**From**	**To**	**Via**
R01	Wadaj	Koba Circle	Sabarmati
R02	Wadaj	Nirma College	Ranip, New Ranip
R03	Wadaj	Lapkaman	Pallav cross road, Ghatlodia, Gota
R04	Shilaj	Gatrad	Thaltej, Memnagar, Lal Darwaja, Hatkeshwer
R05	Lal Darwaja	Sindhu Bhavan	Pakwan, Vastrapur, Navarangpura
R06	Paldi	Prahaladnagar	Shyamal cross road, Jivraj Hospital
R07	Sarkhej	Meghaninagar	Vasana, Paldi, Lal Darwaja, Civil Hospital
R08	Jamalpur	Kamod	Baherampura, Khodiyar, Pipalaj
R09	Jamalpur	Ropada	Shah Alam, Isanpur, Vatva Villege
R10	Maninagar	Chosar approch	Ghodasar, Bibi Talav, Vatva Villege
R11	Maninagar	Vinobabhavenagar	Ghodasar village, Vatva GIDC, Vinzol
R12	Sarangpur	Vastral	Gomtipur, Amraiwadi
R13	Sarangpur	Adinathnagar	Ramrajnagar, Odhav GIDC (South)
R14	Saraspur	Odhav GIDC	Krisnanagar, Viratnagar, Odhav GIDC (North)
R15	Saraspur	Kathwada	Bapunagar, Nikol village
R16	Saraspur	Nava Naroda	Anil Startch road, Saijpur, Krishnagar
R17	Memnagar	Vaisnov Devi	Grukul road, S. G. Highway
R18	Memnagar	Ujala Circle	Thaltej, Iscon, Prahaldnagar
AMTS Ring			
ID	**From**	**To**	**Via**
C01	Paldi	Paldi	Navarangpura, Maninagar, Civil Hospital
C02	Wadaj	Wadaj	Meghaninagar, Bapunagar, Hatkeshwer,
C03	Naroda	Naroda	Akhabarnagar, APMC Vasana, Narol
C04	Lal Darwaja	Lal Darwaja	Relif road, Gandhiroad, Kalupur (Circular)
BRTS routes			
ID	**From**	**To**	**Via**
BRT10	Visat	Kankaria	RTO, Nehrunagar, Anjali, Dani limda
BRT11	RTO	Naroda	Nehrunagar, Dani limda
BRT12	Anjali	Naroda	Narol, Dani limda
BRT13	Odhav	Ajit mills	Soni ni chali
BRT14	Iscon	Maningr	Danilimbda, Anjali, Nehrunager, shivranjani
BRT16	Narol	Naroda	Soni ni chali
BRT17	AEC	DelhiDarw	Nehrunagar, University Kalupur
BRT18	Chandkheda	odhav	Wadaj,Delhi darwaja
BRT19	Naroda	APMC	Anjali, Lalupur, Townhall
BRT20	APMC	Gota	shivranjani, memnagar

Chapter - 18

Cost Estimates

Chapter - 18

COST ESTIMATES

18.1 INTRODUCTION

Project Cost estimates for the Ahemdabad metro rail network has been prepared covering civil, electrical, signalling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 750v dc traction at March 2014 price level, both for Capital and Operation & Maintenance costs.

While preparing cost estimates, various items have generally been grouped under three major heads on the basis of:-

(i) Route km. Length of alignment

(ii) No. of units of that item and

(iii) Item being an independent entity.

All items related with alignment, whether in underground or elevated or at-grade construction, permanent way OHE, signalling and telecommunication, have been estimated on rate per route km/km basis. Route km. cost for underground alignment construction, excludes station lengths. Station lengths (260m) have to be done by cut and cover in general and by tunneling under compelling exceptional circumstances. The rates adopted for underground stations include cost of civil structures and architectural finishes. Similarly, cost of elevated and at grade stations includes civil work for station structures, architectural finishes, platform roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc, have been worked out separately. These rates do not include cost of permanent way, O.H.E., power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, VAC, etc, costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-III. A suitable escalation factor has been applied to bring these costs to March 2014 price level. Taxes & Duties such as Customs Duty, Excise Duty, Sales Tax, Works Tax, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the Ahemdabad metro rail network at March 2014 price level works out to **Rs. 9327Crores** including applicable Taxes & Duties, as tabulated hereunder.

Table 18.1 – Corridor-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	East-West Corridor	5077	754	5831
2.	North-South corridor	3052	444	3496
	Total	**8129**	**1198**	**9327**

Details and methodology of arriving at these costs are discussed in paras hereinafter.

18.2 CIVIL ENGINEERING WORKS

18.2.1 Land

Land requirements have been kept to the barest minimum and worked out on area basis. Acquisition of private land has been minimised as far as possible. For underground and elevated alignment, no land is proposed to be acquired permanently, except small areas for locating entry/ exit structures, traffic integration etc. Elevated alignment is proposed to be located on the road verge and wherever, this is out side the road alignment, minimum land area about 20m wide is proposed for acquisition.

Cost of Govt. land is based on the rate provided by the MEGA Company Ltd. Gandhinagar.

Private land for MRTS project shall be acquired by MEGA and compensation shall be paid as per Land Acquisition Act 2013. The average rate of private land has been worked out to be Rs.18 Crore per hectare as provided by MEGA Company Ltd. Similarly average rate for govt. land has been taken 7.5 Crore per hectare to work out the cost of land.

Provision for cost of land required for resettlement and rehabilitation has been made in the cost estimates.

In addition to the lands required permanently, some areas of land (mainly Govt.) are proposed to be taken over temporarily for construction depots. Ground rent charges @ 5% per year for a period of 4 years have been provided for in project cost estimates.

Details of the lands with their costs have been shown in corridor cost estimate.

18.2.2 Formation and Alignment

(i) **Underground section:** In the underground section work is proposed to be done by Tunnel Boring Machines, or Cut and Cover method, depending upon the site conditions. Rates adopted for cut and cover section, as well as for work to be done by T.B.M. are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level. Cost of mid section ventilation shaft wherever needed, has also been included.

(ii) **Elevated section:** A good portion of alignment is proposed with elevated viaduct and the rates adopted are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level.

18.2.3 Stations

(i) **Underground Stations:** In the underground alignment, station lengths have to be done by cut and cover. Rate proposed for stations (length 260 m) includes Cost of station structures, platforms, architectural finishes, etc, and provisions for electrical and mechanical works, V.A.C., Lifts and Escalators etc., have been made separately. Provisions for O.H.E., P.way, Signaling and Telecommunication, Automatic fare collection installations, etc, have also been summed up in the cost estimates. Rates are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price, wherever required.

(ii) **Elevated Stations:** Rates adopted for elevated stations cover works of station structures, platforms, architectural finishes, covering, etc. Provisions for Electrical and Mechanical works have been made separately. Also provisions for Lifts and Escalators, Viaduct, Pway, O.H.E., Signalling & Telecommunication works, Automatic fare collection installations, etc, have been summed up in the cost estimates.

Mainly three type of stations are proposed for elevated alignment & rates are proposed accordingly.

Type A: Wayside station
Type B: Wayside with Signalling
Type C: Terminal Station

18.2.4 Permanent way

For underground and elevated alignment ballastless track and for depot, ballasted track is proposed. Rates adopted are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level.

18.3 DEPOT

Maintenance Depot have been planned as given hereunder:-

Table 18.2 - Maintenance Depot

S. No.	Corridor	Proposed Maintenance Depot
1.	East-West Corridor	New Cotton Mill
2.	North-South Corridor	Vasna

18.4 UTILITY DIVERSIONS, ENVIRONMENTAL PROTECTION, MISCELLANEOUS OTHER WORKS

Provisions have been made to cover the cost of utility diversions, miscellaneous road works involved, road diversions, road signages etc. and environmental protection works on route km basis, based on the experience gained from the works done in DMRC Phase-I and II.

18.5 REHABILITATION AND RESETTLEMENT

Provisions have been made on fair assessment basis, to cover cost of relocation of Jhuggies, shops, residential Houses on private land etc.

Provisions for barracks and security equipment for CISF and Staff Quarters for O&M Wing have been made in the cost estimates on the basis of average cost involved per km length based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level.

18.6 TRACTION AND POWER SUPPLY

Provisions have been made to cover the cost of 750 v dc, Auxiliary sub stations, Receiving substations, service connection charges, SCADA and miscellaneous items, on route km basis separately for underground alignment, elevated and at-grade section as the requirements are different and costs are more for underground section.

Provisions towards cost of lifts, escalators for underground, elevated and at-grade stations have been made in the cost estimates. Rates provided are based on the estimate recently prepared for calling tender for Kochi Metro. Provision for mid section shaft is made separately.

18.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level. These rates include escalation during manufacturing and supply of equipment and their installation at site. Cost of Platform Screen Doors (PSD) for few stations has also been added in the respective corridors.

18.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level.

18.9 ROLLING STOCK

Adopted rates are based on the DPR of DMRC Phase-IV, duly updated to March 2014 price level considering likely indigenization.

18.10 SECURITY

Adopted rates are as taken in phase IV DPR of DMRC suitably escalated to current price level.

18.11 MULTIMODAL TRAFFIC INTEGRATION

Adopted rates are as taken in phase IV DPR of DMRC suitably escalated to current price level. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

18.12 GENERAL CHARGES AND CONTINGENCES

Provision @ 5% has been made towards general charges on all items, except cost of land, which also includes the charges towards Detailed Design Charges (DDC), etc. Provision for contingencies @ 3 % has been made on all items including general charges.

18.13 CAPITAL COST ESTIMATES

18.13.1 Thaltej Gam to Vastral Gam (East- West Corridor)

The overall Capital Cost for this corridor estimated at March 2014 price level, based on the above considerations works out to **Rs. 5077Crores** without Taxes & Duties. Taxes & Duties such as Customs Duty (CD), Excise Duty (ED), Sales Tax (ST), Works Tax (WT), VAT, etc, have been worked out as **Rs. 754Crores.**

Table 18.3 – Thaltej Gam to Vastral Gam (East- West Corridor) Capital Cost Estimate

Total length = 20.536 km; Total UG (including C&C and half Ramp length) = 6.335 km; (UG by TBM: 5.631 km, UG by C&C: 0.704 km Including half ramp length)
Elevated (including half ramp length) = 14.201 km
Total Station = 18 nos, UG = 4, Elv = 14

March 2014 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	**7.50**	45.09	338.16
b	Private	ha	**18.00**	3.75	67.52
1.2	Temporary				
a	Government	ha	**1.50**	8.82	13.23
b	Private	ha	**3.60**	0.00	0.00
1.3	Property development				
a	Government	ha	**7.50**	0.00	0.00
b	Private	ha	**18.00**	0.00	0.00
	Subtotal (1)				**418.91**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (260m each)	R. Km.	112.27	4.85	544.64
2.2	Underground section by Cut & Cover excluding station length (260m each)	R. Km.	104.05	0.70	73.25
2.3	Elevated section including station length	R. Km.	30.86	14.20	438.26
2.4	Entry to depot	R. Km.	30.86	0.50	15.43
	Subtotal (2)				**1071.59**
3.0	**Station Buildings**				
3.1	Underground Station(260 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	115.92	4.00	463.68
b	Underground Station- EM works etc.	Each	60.93	4.00	243.73
3.1	Elevated stations(including finishes)	Each			

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
a	Type (A) way side- civil works	Each	24.32	9.00	218.84
b	Type (A) way side- EM works etc	Each	6.90	9.00	62.13
c	Type (B) Way side with signalling-civil works	Each	26.19	3.00	78.56
d	Type (B) Way side with signalling-EM works etc	Each	6.90	3.00	20.71
a	Type (C), Terminal station -civil works	Each	27.13	2.00	54.25
b	Type (c), Terminal station -EM works including lifts and escalators	Each	6.90	2.00	13.81
3.3	Metro Bhawan & OCC bldg.	LS			
a	civil works	LS			80.00
b	EM works etc	LS			20.00
3.4	Mid Shaft (cost of electrical works)	Each	6.75	2.00	13.51
	Subtotal (3)				**1269.22**
4.0	**Depot**	LS			
4.1					
a	Civil works	LS			63.73
b	EM works etc	LS			95.59
	Subtotal (4)				**159.31**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	**7.71**	21.04	162.20
5.2	Ballasted track for at grade alignment	R. Km.	**7.71**	5.00	38.55
	Subtotal (5)				**200.76**
6.0	**Traction & power supply incl. 750 v dc, ASS etc. Excl. lifts & Escalators**	R.Km.	11.50	21.04	241.91
	Subtotal (6)				**241.91**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.44	21.04	324.86
7.2	Automatic fare collection	Stn.			
	a) Underground stations	Each	5.31	4.00	21.24
	b) Elevated stations	Each	5.31	14.00	74.35
7.3	Providing **Platform Screen Doors** (PSD) at all stations	Each	3.19	36.00	114.71
	Subtotal (7)				**535.15**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
8.0	**R & R incl. Hutments etc.**	R. Km.	3.31	21.04	69.71
	Subtotal (8)				**69.71**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(3.75 cr/km)** + EM works (3.11 cr/km)	R. Km.	6.86	21.04	144.31
	Subtotal (9)				**144.31**
10.0	**Rolling Stock**	Each	10.41	51.00	530.83
	Subtotal (10)				**530.83**
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.25	20.54	5.13
b	EM works etc	R.Km.	0.06	20.54	1.22
	Subtotal (11)				**6.35**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.11	20.54	22.73
b	EM works etc	R.Km.	0.27	20.54	5.63
	Sub Total (12)				**28.35**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal traffic Integration	Each	2.12	18.00	38.24
	Sub Total (13)				**38.24**
14.0	**Total of all items except Land**				**4295.73**
15.0	**General Charges incl. Design charges @ 5 % on all items except land**				**214.79**
16.0	**Total of all items including G. Charges except land**				**4510.52**
17.0	**Contingencies @ 3 %**				**135.32**
18.0	**Gross Total**				**4645.83**
	Cost without land			**=**	**4646**
	Cost with land including contingencies on land			**=**	**5077**

Table 18.4 - Details of Taxes & Duties

Customs duty	=	22.8531	%		
Excise duty	=	12.36	%		
Sale tax	=	6.25	%	=	12.5%/2
Works tax	=	6.25	%	=	12.5%/2
VAT	=	12.5	%		

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties					Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	sale tax (Cr.)	works tax (Cr.)	VAT(Cr.)	
1	**Alignment & Formation**							
	Underground	617.89	42.36	37.42	10.63	10.63	21.26	**101.05**
	Elevated, at grade & entry to Depot	453.69		39.25	11.15	11.15	22.30	**61.56**
2	**Station Buildings**							
	a) Underground station-civil works	463.68	31.79	28.08	7.98	7.98	15.96	**75.83**
	b) Underground station-EM works	257.24	29.39	13.51	3.84	3.84	7.68	**50.58**
	Elevated station - civil works	351.65		30.42	8.64	8.64	17.29	**47.71**
	Elevated station-EM works	96.65	4.42	8.12	2.31	2.31	4.62	**17.16**
	e) OCC bldg-civil works	80.00		6.92	1.97	1.97	3.93	**10.85**
	f) OCC bldg-EM works	20.00	0.91	1.68	0.48	0.48	0.96	**3.55**
3	**Depot**							
	Civil works	63.73	4.37	3.86	1.10	1.10	2.19	**10.42**
	EM works	95.59	4.37	8.03	2.28	2.28	4.56	**16.97**
4	**P-Way**	200.76	36.70	4.22	1.20	1.20	2.40	**43.32**
5	**Traction & power supply**							
	Traction and power supply	241.91	22.11	15.25	4.33	4.33	8.66	**46.03**
6	**S and T Works**							
	S & T	324.86	59.39	8.03	2.28	2.28	4.56	**71.98**
	AFC	95.59	16.38	2.95	0.84	0.84	1.68	**21.02**
	PSD	114.71	20.97	2.84	0.81	0.81	1.61	**25.42**
7	**R & R hutments**	69.71				4.36	4.36	**4.36**
8	**Misc.**							
	Civil works	164.76		14.26	4.05	4.05	8.10	**22.35**
	EM works	52.48		5.51	1.57	1.57	3.13	**8.65**
9	**Rolling stock**	530.83	106.75	5.12	1.45	1.45	2.91	**114.78**
	Total	**4295.73**	**379.93**	**232.65**	**66.09**	**70.45**	**136.54**	**753.58**

18.13.2 APMC to Motera Stadium Corridor

The overall Capital Cost for this corridor estimated at March 2014 price level, based on the above considerations works out to **Rs. 3052Crores** without Taxes & Duties. Taxes & Duties such as Customs Duty (CD), Excise Duty (ED), Sales Tax (ST), Works Tax (WT), VAT, etc, have been worked out as **Rs. 444Crores**.

Table 18.5 - APMC to Motera Stadium (North-South Corridor) Capital Cost Estimate

Total Length = 15.420km
Elv = 15.420 km
Total Station =14 nos, UG = 0, Elv = 14

March 2014 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	**7.50**	31.76	238.19
b	Private	ha	**18.00**	2.16	38.81
1.2	Temporary				
a	Government	ha	**1.50**	6.62	9.93
b	Private	ha	**3.60**	0.00	0.00
1.3	Property development				
a	Government	ha	**7.50**	0.00	0.00
b	Private	ha	**18.00**	0.00	0.00
	Subtotal (1)				**286.93**
2.0	**Alignment and Formation**				
2.3	Elevated section including station length	R. Km.	30.86	15.42	475.88
2.4	Entry to depot	R. Km.	30.86	1.50	46.29
	Subtotal (2)				**522.17**
3.1	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	24.32	10.00	243.16
b	Type (A) way side- EM works etc	Each	6.90	10.00	69.04
c	Type (B) Way side with signalling-civil works	Each	26.19	2.00	52.37
d	Type (B) Way side with signalling-EM works etc	Each	6.90	2.00	13.81

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
a	Type (C), Terminal station -civil works	Each	27.13	2.00	54.25
b	Type (c), Terminal station -EM works including lifts and escalators	Each	6.90	2.00	13.81
3.3	OCC bldg.	LS			
a	civil works	LS			24.00
b	EM works etc	LS			6.00
	Subtotal (3)				**476.43**
4.0	**Depot**	LS			
4.1					
a	Civil works	LS			63.73
b	EM works etc	LS			95.59
	Subtotal (4)				**159.31**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	**7.71**	16.92	130.47
5.2	Ballasted track for at grade alignment	R. Km.	**7.71**	5.00	38.55
	Subtotal (5)				**169.02**
6.0	**Traction & power supply incl. 750v dc, ASS etc. Excl. lifts & Escalators**	R.Km.	11.50	16.92	194.58
	Subtotal (6)				**194.58**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	15.44	16.92	261.29
7.2	Automatic fare collection	Stn.			
	b) Elevated stations	Each	5.31	14.00	74.35
7.3	Providing **Platform Screen Doors** (PSD) at all stations	Each	3.19	28.00	89.22
	Subtotal (7)				**424.86**
8.0	**R & R incl. Hutments etc.**	R. Km.	3.31	16.92	56.07
	Subtotal (8)				**56.07**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works **(3.75 cr/km)** + EM works (3.11 cr/km)	R. Km.	6.86	16.92	116.07
	Subtotal (9)				**116.07**
10.0	**Rolling Stock**	Each	10.41	36.00	374.71
	Subtotal (10)				374.71

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
11.0	**Capital expenditure on security**				
a	Civil works	R.Km.	0.25	15.42	3.85
b	EM works etc	R.Km.	0.06	15.42	0.92
	Subtotal (11)				**4.77**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.11	15.42	17.07
b	EM works etc	R.Km.	0.27	15.42	4.23
	Sub Total (12)				**21.29**
13.0	**Capital expenditure on Multimodal Traffic Integration**				
a	Capital expenditure on Multimodal traffic Integration	Each	2.12	14.00	29.74
	Sub Total (13)				**29.74**
14.0	**Total of all items except Land**				**2549.02**
15.0	**General Charges incl. Design charges @ 5 % on all items except land**				**127.45**
16.0	**Total of all items including G. Charges except land**				**2676.47**
17.0	**Continegencies @ 3 %**				**80.29**
18.0	**Gross Total**				**2756.76**
	Cost without land			**=**	**2757**
	Cost with land including contingencies on land			**=**	**3052**

Table 18.6 - Details of Taxes & Duties

Customs duty	=	22.8531	%		
Excise duty	=	12.36	%		
Sale tax	=	6.25	%	=	12.5%/2
Works tax	=	6.25	%	=	12.5%/2
VAT	=	12.5	%		

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties					Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	sale tax (Cr.)	works tax (Cr.)	VAT(Cr.)	
1	**Alignment & Formation**							
	Underground	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated, at grade & entry to Depot	522.17		45.18	12.83	12.83	25.67	**70.85**
2	**Station Buildings**							
	a) Underground station-civil works	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	b) Underground station-EM works	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated station - civil works	349.78		30.26	8.60	8.60	17.19	**47.46**
	Elevated station-EM works	96.65	4.42	8.12	2.31	2.31	4.62	**17.16**
	e) OCC bldg-civil works	24.00		2.08	0.59	0.59	1.18	**3.26**
	f) OCC bldg-EM works	6.00	0.27	0.50	0.14	0.14	0.29	**1.07**
3	**Depot**							
	Civil works	63.73	4.37	3.86	1.10	1.10	2.19	**10.42**
	EM works	95.59	4.37	8.03	2.28	2.28	4.56	**16.97**
4	**P-Way**	169.02	30.90	3.55	1.01	1.01	2.02	**36.47**
5	**Traction & power supply**							
	Traction and power supply	194.58	17.79	12.27	3.48	3.48	6.97	**37.02**
6	**S and T Works**							
	S & T	261.29	47.77	6.46	1.83	1.83	3.67	**57.90**
	AFC	74.35	12.74	2.30	0.65	0.65	1.31	**16.35**
	PSD	89.22	16.31	2.21	0.63	0.63	1.25	**19.77**
7	**R & R hutments**	56.07				3.50	3.50	**3.50**
8	**Misc.**							
	Civil works	130.27		11.27	3.20	3.20	6.40	**17.67**
	EM works	41.59		4.37	1.24	1.24	2.48	**6.85**
9	**Rolling stock**	374.71	75.36	3.61	1.03	1.03	2.05	**81.02**
	Total	**2549.02**	**214.30**	**141.87**	**40.30**	**43.81**	**84.11**	**443.73**
	Total taxes & Duties					**SAY**		**444**

Chapter - 19

Financing Options, Fare Structure & Financial Viability

CHAPTER 19

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

19.1 INTRODUCTION

The Ahmadabad Metro Project is proposed to be constructed with an estimated cost of Rs 9102.00 Crore with central taxes and land cost. The length of the metro system and estimated cost at March-2014 price level without central taxes and with central taxes is placed in table 19.1 as under:

Table 19.1 Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)
1	E-W Corridor (Thaltej Gam to Vastral Gam)	20.536	5,077.00	5,692.00
2	N-S Corridor (APMC to Motera Stadium)	15.420	3,052.00	3,410.00
Total		**35.956**	**8129.00**	**9102.00**

The estimated cost at March-2014 price level includes an amount of Rs.11.12 Crore as one-time charges of security personal towards cost of weapons, barricades, and hand held and door detector machine etc. However, the recurring cost towards salary and allowances of security personal have not taken in to account in FIRR calculation. 2.12crore each station has been provide for Multi Modal Traffic Integration (first mile and last mile connectivity i.e., feeder bus services).

19.2 Costs

19.2.1 Investment Cost

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes has been calculated by taking escalation factor @7.5% per annum. It has been assumed that Gujarat State Government will exempt the local taxes or reimburse the same and provide the land worth Rs. 727.00 crore at March-2014 price level free of cost or it shall provide Interest Free Subordinate Debt.

It is assumed that the construction work will start on 01.07.2014 and is expected to be completed on 31.03.2018 with Revenue Opening Date (ROD) as 01.04.2018 for the both the corridors. The total completion costs duly escalated and cash flow of investments shown in the table 19.2 have been taken as the initial investment. The separately is placed in Table –19.2 below.

Table 19.2 Year –wise Investment (Completion Cost including cost of land)

Figures in Rs. Crore

Financial Year	Cost at March-2014 Price Level			Completion Cost		
	Corridor-I	Corridor-II	Total	Corridor-I	Corridor-II	Total
2014-15	407.00	255.00	662.00	407.00	255.00	662.00
2015-16	1459.00	878.00	2337.00	1558.00	936.00	2494.00
2016-17	1458.00	877.00	2335.00	1663.00	998.00	2661.00
2017-18	1578.00	934.00	2512.00	1960.00	1160.00	3120.00
2018-19	526.00	311.00	837.00	702.00	415.00	1117.00
2019-20	158.00	93.00	251.00	227.00	134.00	361.00
2020-21	106.00	62.00	168.00	164.00	96.00	260.00
Total	**5692.00**	**3410.00**	**9102.00**	**6681.00**	**3994.00**	**10675.00**

Although the construction is expected to get over by 31st March 2018, the cash flow spill over up to March 2021 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

The cost of Land of Rs. 727.00 crore at March-2014 price level included in the above completion cost will be provided free of cost by the Gujarat Government. However, Cost of 10 hectare land to be provided by Gujarat Government for property development has not been included in above.

19.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 19.3 as under: -

Table 19.3 Additional Investment towards Rolling Stock

(Rs/Crore)

Financial Year	No. of Cars		Amount	
	Corridor-I	Corridor-II	Corridor-I	Corridor-II
2021-22	15.00	15.00	281.00	295.00
2031-32	30.00	15.00	914.00	480.00
2043-44	-	30.00	-	1,723.00

19.2.3 Operation & Maintenance (O&M) Costs

The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs
(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables
(iii) Energy costs

The requirement of staff has been assumed @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The average rate of electricity being paid by Delhi Metro for its Phase-I and Phase-II operations in Delhi is Rs. 5.80 per unit whereas in Gujarat the applicable rate is Rs. 5.00 per unit which has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 7.50% per annum. The O&M costs have been tabulated in Table 19.4.1as below for the both corridors:

Table 19.4 Operation and Maintenance Costs (Combined)

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2018	-	2019	72.27	52.36	56.85	181.48
2019	-	2020	78.77	56.29	61.12	196.18
2020	-	2021	85.86	60.51	65.70	212.07
2021	-	2022	93.59	65.05	81.57	240.21
2022	-	2023	102.02	69.93	87.69	259.63
2023	-	2024	111.20	75.17	94.27	280.64
2024	-	2025	121.20	80.81	101.34	303.35
2025	-	2026	132.11	86.87	108.94	327.92
2026	-	2027	144.00	93.39	117.11	354.50
2027	-	2028	156.96	100.39	125.89	383.24
2028	-	2029	171.09	107.92	135.33	414.34
2029	-	2030	186.49	116.01	145.48	447.98
2030	-	2031	203.27	124.72	156.39	484.38
2031	-	2032	221.57	134.07	213.20	568.84
2032	-	2033	241.51	144.12	229.19	614.82
2033	-	2034	263.24	154.93	246.38	664.56
2034	-	2035	286.93	166.55	264.86	718.35
2035	-	2036	312.76	179.04	284.73	776.53
2036	-	2037	340.91	192.47	306.08	839.46
2037	-	2038	371.59	206.91	329.04	907.53
2038	-	2039	405.03	222.43	353.72	981.17
2039	-	2040	441.48	239.11	380.24	1060.84

YEAR			Staff	Maintenance Expenses	Energy	Total
2040	-	2041	481.22	257.04	408.76	1147.02
2041	-	2042	524.53	276.32	439.42	1240.27
2042	-	2043	571.73	297.04	472.38	1341.15
2043	-	2044	623.19	319.32	599.00	1541.51

19.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

19.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years.

19.3 Revenues

The Revenue of Ahmadabad Metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

19.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on trip distribution at different distance zones.

19.3.1 Traffic

19.3.1.1 a. The projected ridership figures years are as indicated in table 19.5 as below: -

Table 19.5 Projected Ridership

Financial Year	Trips per day (lakhs)		
	Corridor-I	Corridor-II	Total
2018-19	2.47	2.11	4.58
2021-22	3.62	3.00	6.62
2031-32	4.94	4.29	9.23
2043-44	6.19	6.24	12.43

b. The growth rate for traffic is assumed @12.50% Per Annum upto 2020-21, @3.00% Per Annum upto 2030-31 and thereafter @ 2.00% per annum.

19.3.1.2 Trip Distribution

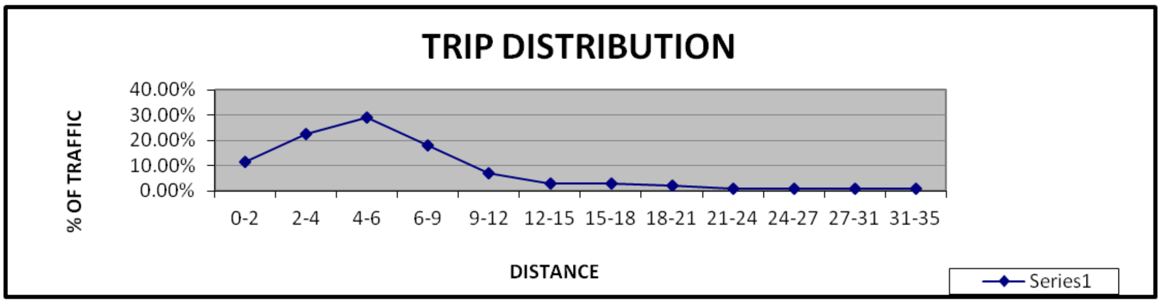
The trip distribution has been worked out by considering average lead of 6.71 KM and, which is placed in Table 19.6 below: -

Table 19.6 Trip Distribution

Distance in km	Percent distribution
0-2	11.50%
2-4	22.50%
4-6	29.00%
6-9	18.00%
9-12	7.00%
12-15	3.00%
15-18	3.00%
18-21	2.00%
21-24	1.00%
24-27	1.00%
27-31	1.00%
31-35	1.00%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-11.1.

Figure 19.1 –Trip Distribution



Fare Structure

The Delhi Metro Fares structures as fixed by a fare fixation committee in 2009 have been assumed with an escalation ed @15.00% for every two years, which is placed in table 19.7.

Table 19.7 Fare Structure in 2018-19

Distance in kms.	Fare (Rs)
0-2	15
2-4	19
4-6	23
6-9	28
9-12	30
12-15	34
15-18	36
18-21	39

Distance in kms.	Fare (Rs)
21-24	41
24-27	43
27-31	47
31-35	51

19.3.1.3 Other sources of revenues

Other revenues from Property business and advertisement have been assumed @ 10% of the fare box revenues during operations. Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises.

SPV/BOT operator will engage a developer/Concessionaire for generating rental income. It is assumed that about 10.00 Hectare. i.e., 40,00,000 square feet area will be available for property development with a FAR of 4. The developer will bring equity to the extent of Rs.220.00 crore and the balance amount towards construction shall be raised by SPV as 12% Market Debt. The estimated development cost will be Rs.883.00 crore. It is assumed that the rental revenue will accrue to the developer from the FY 2019-20 which has been escalated @5% every year. Out of the estimated rental income, apart from meeting maintenance expenditure, the developer will repay the loan and interest. After meeting these obligations and retaining 14% return on his equity with an escalation @5% every year, the residual rental earnings will accrue to SPV, which has been taken into account in the FIRR calculations. The details of PD income accrue to SPV is tabulated as under; -

Table 19.8 Estimated generation of Rental Income from PD

Rs. in Crore

Year			Construction cost	Rental Income	Maintenance Expenditure	Loan	IDC	Loan repayment	Bal Loan Amount	Interest on Loan @12%	Return @14% to the developer	Residual rental income to SPV
2014	-	2015	160			105	6		111		-55	
2015	-	2016	168			113	14		238		-55	
2016	-	2017	176			121	16		375		-55	
2017	-	2018	185			130	19		524		-55	
2018	-	2019	194			194	24		742		0	
2019	-	2020		61	6			74	668	89	31	-139
2020	-	2021		84	8			74	594	80	33	-111
2021	-	2022		118	12			74	520	71	35	-74
2022	-	2023		186	19			74	446	62	37	-6
2023	-	2024		313	31			74	372	54	39	115
2024	-	2025		328	33			74	298	45	41	135
2025	-	2026		345	34			74	224	36	43	158
2026	-	2027		362	36			74	150	27	45	180
2027	-	2028		380	38			74	76	18	47	203
2028	-	2029		399	40			76	0	9	49	225

Year			Construction cost	Rental Income	Maintenance Expenditure	Loan	IDC	Loan repayment	Bal Loan Amount	Interest on Loan @12%	Return @14% to the developer	Residual rental income to SPV
2029	-	2030		419	42						51	326
2030	-	2031		440	44						54	342
2031	-	2032		462	46						57	359
2032	-	2033		485	49						60	376
2033	-	2034		509	51						63	395
2034	-	2035		535	53						66	416
2035	-	2036		562	56						69	437
2036	-	2037		590	59						72	459
2037	-	2038		619	62						76	481
2038	-	2039		650	65						80	505
2039	-	2040		683	68						84	531
2040	-	2041		717	72						88	557
2041	-	2042		753	75						92	586
2042	-	2043		790	79						97	614
2043	-	2044		830	83						102	645
Total			**883**	**11621**	**1161**	**663**	**79**	**742**		**491**	**1291**	**7715**

19.4 Financial Internal Rate of Return (FIRR)

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

Corridor	FIRR
FIRR without PD	7.44%
FIRR with PD	8.54%

The FIRR with central taxes & duties is produced in Table 19.9.1 & Table 19.9.2

Table 19.9.1 –FIRR with Central Taxes (Without Property Development)

Figs in cr. (Rs.)

Year			Outflow					Inflow			Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2014	-	2015	662				662			0	-662
2015	-	2016	2494				2494			0	-2494
2016	-	2017	2661				2661			0	-2661
2017	-	2018	3120				3120			0	-3120
2018	-	2019	1117		181		1298	381	38	419	-879
2019	-	2020	361		196		557	429	43	472	-85
2020	-	2021	260		212		472	553	55	608	136
2021	-	2022	0	576	240		816	632	63	695	-121
2022	-	2023	0	0	260		260	748	75	823	563
2023	-	2024	0	0	281		281	770	77	847	566
2024	-	2025	0	0	303		303	919	92	1011	708
2025	-	2026	0	0	328		328	946	95	1041	713
2026	-	2027	0	0	355		355	1116	112	1228	873
2027	-	2028	0	0	383		383	1149	115	1264	881
2028	-	2029	0	0	414		414	1359	136	1495	1081
2029	-	2030	0	0	448		448	1400	140	1540	1092

Year	Outflow					Inflow			Cash Flow
	Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2030 - 2031	0	0	484		484	1659	166	1825	1341
2031 - 2032	0	1394	569		1963	1774	177	1951	-12
2032 - 2033	0	0	615		615	2088	209	2297	1682
2033 - 2034	0	0	665		665	2129	213	2342	1677
2034 - 2035	0	0	718		718	2498	250	2748	2030
2035 - 2036	0	0	777		777	2549	255	2804	2027
2036 - 2037	0	0	839		839	2998	300	3298	2459
2037 - 2038	0	0	908		908	3057	306	3363	2455
2038 - 2039	0	0	981		981	3585	359	3944	2963
2039 - 2040	0	0	1061	1537	2598	3657	366	4023	1425
2040 - 2041	0	0	1147	1614	2761	4291	429	4720	1959
2041 - 2042	0	0	1240	0	1240	4377	438	4815	3575
2042 - 2043	0	0	1341	0	1341	5143	514	5657	4316
2043 - 2044	0	1723	1542	0	3265	5573	557	6130	2865
Total	**10675**	**3693**	**16488**	**3151**	**34007**	**55780**	**5580**	**61360**	**7.44%**

Table 19.9.2 –FIRR with Central Taxes (With Property Development)

Figs in cr. (Rs.)

Year	Outflow					Cash Flow			
	Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2014 - 2015	662				662			0	-662
2015 - 2016	2494				2494			0	-2494
2016 - 2017	2661				2661			0	-2661
2017 - 2018	3120				3120			0	-3120
2018 - 2019	1117		181		1298	381	38	419	-879
2019 - 2020	361		196		557	429	-96	333	-224
2020 - 2021	260		212		472	553	-56	497	25
2021 - 2022	0	576	240		816	632	-11	621	-195
2022 - 2023	0	0	260		260	748	69	817	557
2023 - 2024	0	0	281		281	770	192	962	681
2024 - 2025	0	0	303		303	919	227	1146	843
2025 - 2026	0	0	328		328	946	253	1199	871
2026 - 2027	0	0	355		355	1116	292	1408	1053
2027 - 2028	0	0	383		383	1149	318	1467	1084
2028 - 2029	0	0	414		414	1359	361	1720	1306
2029 - 2030	0	0	448		448	1400	466	1866	1418
2030 - 2031	0	0	484		484	1659	508	2167	1683
2031 - 2032	0	1394	569		1963	1774	536	2310	347
2032 - 2033	0	0	615		615	2088	585	2673	2058
2033 - 2034	0	0	665		665	2129	608	2737	2072
2034 - 2035	0	0	718		718	2498	666	3164	2446
2035 - 2036	0	0	777		777	2549	692	3241	2464
2036 - 2037	0	0	839		839	2998	759	3757	2918
2037 - 2038	0	0	908		908	3057	787	3844	2936
2038 - 2039	0	0	981		981	3585	864	4449	3468
2039 - 2040	0	0	1061	1537	2598	3657	897	4554	1956
2040 - 2041	0	0	1147	1614	2761	4291	986	5277	2516
2041 - 2042	0	0	1240	0	1240	4377	1024	5401	4161
2042 - 2043	0	0	1341	0	1341	5143	1128	6271	4930
2043 - 2044	0	1723	1542	0	3265	5573	1202	6775	3510
Total	**10675**	**3693**	**16488**	**3151**	**34007**	**55780**	**13295**	**69075**	**8.54%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 19.10 below : -

Table 19.10 –FIRR (With PD)
Sensitivity

Capital Cost with Central Taxes but without land cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
7.91%	7.33%	9.27%	10.09%
REVENUE			
20% decrease in Fare Box revenue	**10% decrease in Fare Box revenue**	**10% increase in Fare Box revenue**	**20% increase in Fare Box revenue**
6.47%	7.56%	9.44%	10.26%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
8.27%		**8.81%**	

These sensitivities have been carried out independently for each factor.

19.5 Financing Options

Objectives of Funding: - The objective of funding metro systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
  - Low infrastructure maintenance costs
  - Longer life span
  - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai and Bengaluru metros are also funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

19.5.1 ALTERNATIVE MODELS OF FINANCING

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

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

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

SPV Model: - The corridor is a standalone one and therefore forming a separate SPV may be in the name of Ahmadabad Metro Rail Corporation may be desirable. The funding pattern under this model (SPV) is placed in table 19.11 as under: -

Table 19.11 Funding pattern under SPV model (with central taxes)

Particulars	With Taxes & Duties			
	Corridor-I	Corridor-II	Total	% of contribution
Equity By GOI	884.50	527.50	1412.00	13.23%
Equity By GOG	884.50	527.50	1412.00	13.23%
SD for CT by GOG (50%)	365.50	212.50	578.00	5.41%
SD for CT by GOI (50%)	365.50	212.50	578.00	5.41%
SD for Land by GOG (100%)	431.00	296.00	727.00	6.81%
1.40% JICA Loan /12% Market Borrowings	3750.00	2218.00	5968.00	55.91%
Total	**6681.00**	**3994.00**	**10675.00**	**100.00%**

In addition to the above, State Taxes of Rs.302.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in table 19.12.1 & 19.12.2 tabulated as under: -

Table 19.12.1 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost and without Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1990.00	20.00%
VGF by GOG	3855.00	38.75%
Equity by Concessionaire	1368.00	13.75%
Concessionaire's debt @12% PA	2735.00	27.50%
Total	**9948.00**	**100.00**
Land Free by GOG	727.00	
IDC	239.00	
Total	**10914.00**	

Table 19.12.2 Funding pattern under BOT –Combined (16% EIRR)
(With central taxes and without land cost and with Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	1990.00	20.00%
VGF by GOG	3315.00	33.32%
Equity by Concessionaire	1548.00	15.56%
Concessionaire's debt @12% PA	3095.00	31.12%
Total	**9948.00**	**100.00**
Land Free by GOG	727.00	
IDC	274.00	
Total	**10949.00**	

In addition to the above, State Taxes of Rs.302.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

19.6. Recommendations: - The combined FIRR of both the corridors with taxes is 8.54% with additional property development of 10 hectares. The pre-tax Equity IRR to the BOT operator is 16% with a total VGF of only Rs.6032.00 crore excluding the cost of 10 hectare Land required for PD if the additional PD income is considered. Since the Gujarat Government is providing huge land bank for PD, it is advisable to take up the job on DMRC model. Accordingly, the corridors are recommended for implementation.

The total fund contribution of GOI & GOG under various alternatives is tabulated in table 19.13.

Table 19.13

Rs. In crore

Particulars	SPV Model	BOT Model without PD	BOT Model with PD
GOI	1990.00	1990.00	1990.00
GOG	2717.00	4582.00	4042.00
Total	**4707.00**	**6572.00**	**6032.00**

In addition to the above, State Taxes of Rs.302.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Considering the difference, it is recommended to implement the project under SPV model as per the funding pattern given in Table 19.11.

The detailed cash flow statements under various alternatives are enclosed as per detail given below:-

Option	Table No.
SPV Model with JICA Loan without PD	19.14
SPV Model with Market Borrowings without PD	19.15
BOT Model without PD	19.16
SPV Model with JICA Loan with PD	19.17
SPV Model with Market Borrowings with PD	19.18
BOT Model with PD	19.19

The funding pattern assumed under SPV model & BOT model with PD is depicted in the pie chart i.e., Figure 19.2.1 & 19.2.2 as under: -

Figure 19.2.1
Funding pattern under SPV Model

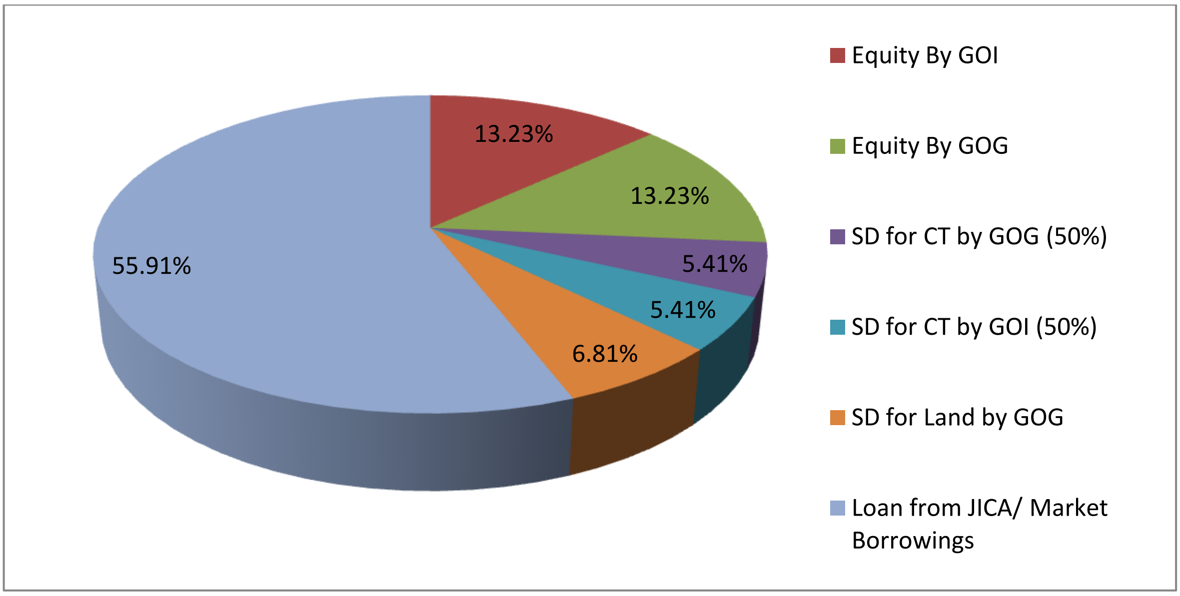


Figure 19.2.2
Funding pattern under BOT Model with PD

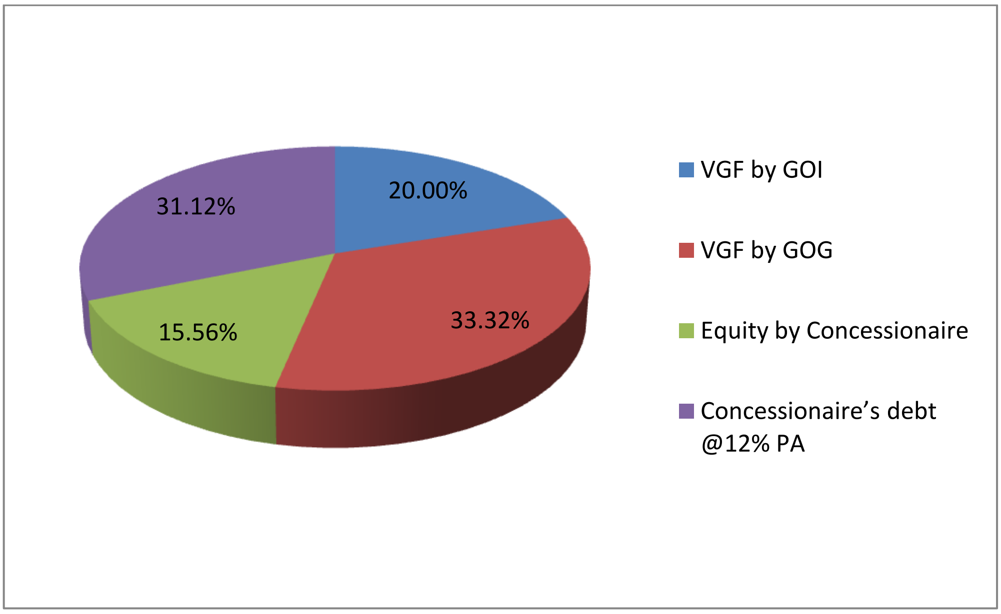


Table 19.14

Ahmedabad Metro Project

CAPITAL COST-FIXED		9102																				
CAPITAL COST - CURRENT		10675														JICA Loan		1.40%				
DOMESTIC FUNDING - BASE CASE																						
Year	**Completion Cost**	**Additional Capital**	**Running Expenses**	**Depreciation**	**Replacement Cost**	**Total Cost**	**Fare box Revenue**	**PD & Advertisement**	**Total Revenue**	**Net Cash Flow for IRR**	**Equity from GOI & GOG**	**Availability of cash**	**Cumulative cash**	**Cum. Loan**	**Loan**	**Repayment of Loan**	**IDC**	**Cumulative loan incl. IDC**	**Interest**	**Profit before Tax**	**Cash Balance**	**Cumulative Cash**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2014 - 2015	662					662			0	-662	543	-119	-119	119	119	0	1	120				
2015 - 2016	2494					2494			0	-2494	1187	-1307	-1426	1426	1307	0	11	1438				
2016 - 2017	2661					2661			0	-2661	1185	-1476	-2902	2902	1476	0	30	2944				
2017 - 2018	3120					3120			0	-3120	944	-2176	-5078	5078	2176	0	56	5176				
2018 - 2019	1117		181	323		1298	381	38	419	-879	848	-269	-5347	5347	269	0		5445	74	-159	164	164
2019 - 2020	361		196	323		557	429	43	472	-85		-361	-5708	5708	361	0		5806	79	-126	197	361
2020 - 2021	260		212	323		472	553	55	608	136		-260	-5968	5968	260	0		6066	83	-10	313	674
2021 - 2022	0	576	240	340		816	632	63	695	-121		0	0	0	0	0		6066	85	30	-206	468
2022 - 2023	0	0	260	340		260	748	75	823	563		0	0	0	0	0		6066	85	138	478	946
2023 - 2024	0	0	281	340		281	770	77	847	566		0	0	0	0	0		6066	85	141	481	1427
2024 - 2025	0	0	303	340		303	919	92	1011	708		0	0	0	0	303		5763	85	283	320	1747
2025 - 2026	0	0	328	340		328	946	95	1041	713		0	0	0	0	303		5459	81	292	329	2076
2026 - 2027	0	0	355	340		355	1116	112	1228	873		0	0	0	0	303		5156	76	457	493	2569
2027 - 2028	0	0	383	340		383	1149	115	1264	881		0	0	0	0	303		4853	72	469	506	3075
2028 - 2029	0	0	414	340		414	1359	136	1495	1081		0	0	0	0	303		4550	68	673	710	3784
2029 - 2030	0	0	448	340		448	1400	140	1540	1092		0	0	0	0	303		4246	64	688	725	4509
2030 - 2031	0	0	484	340		484	1659	166	1825	1341		0	0	0	0	303		3943	59	942	978	5488
2031 - 2032	0	1394	569	382		1963	1774	177	1951	-12		0	0	0	0	303		3640	55	945	-371	5117
2032 - 2033	0	0	615	382		615	2088	209	2297	1682		0	0	0	0	303		3336	51	1249	1328	6445
2033 - 2034	0	0	665	382		665	2129	213	2342	1677		0	0	0	0	303		3033	47	1248	1327	7772
2034 - 2035	0	0	718	382		718	2498	250	2748	2030		0	0	0	0	303		2730	42	1606	1684	9456
2035 - 2036	0	0	777	382		777	2549	255	2804	2027		0	0	0	0	303		2426	38	1607	1685	11142
2036 - 2037	0	0	839	382		839	2998	300	3298	2459		0	0	0	0	303		2123	34	2043	2122	13263
2037 - 2038	0	0	908	382		908	3057	306	3363	2455		0	0	0	0	303		1820	30	2043	2122	15385
2038 - 2039	0	0	981	382		981	3585	359	3944	2963		0	0	0	0	303		1517	25	2556	2634	18020
2039 - 2040	0	0	1061	428	1537	2598	3657	366	4023	1425		0	0	0	0	303		1213	21	2513	1100	19120
2040 - 2041	0	0	1147	476	1614	2761	4291	429	4720	1959		0	0	0	0	303		910	17	3080	1639	20759
2041 - 2042	0	0	1240	476	0	1240	4377	438	4815	3575		0	0	0	0	303		607	13	3086	3259	24018
2042 - 2043	0	0	1341	476	0	1341	5143	514	5657	4316		0	0	0	0	303		303	8	3832	4004	28022
2043 - 2044	0	1723	1542	528	0	3265	5573	557	6130	2865		0	0	0	0	303		0	4	4056	2557	30579
	10675	**3693**	**16488**	**9809**	**3151**	**34007**	**55780**	**5580**	**61360**	**7.44%**	**4707**				**5968**	**6066**	**98**		**1383**	**33680**	**30579**	
										27353												

Table 19.15

Ahmedabad Metro Project

CAPITAL COST-FIXED 9102

CAPITAL COST - CURRENT 10675 Market Borrowings 12.00%

DOMESTIC FUNDING - BASE CASE

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertiseme nt	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOG	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2014 - 2015	662					662			0	-662	543	-119	-119	119	119	0	7	126				
2015 - 2016	2494					2494			0	-2494	1187	-1307	-1426	1426	1307	0	93	1526				
2016 - 2017	2661					2661			0	-2661	1185	-1476	-2902	2902	1476	0	260	3262				
2017 - 2018	3120					3120			0	-3120	944	-2176	-5078	5078	2176	0	479	5917				
2018 - 2019	1117		181	345		1298	381	38	419	-879	848	-269	-5347	5347	269	0		6186	726	-833	-488	-488
2019 - 2020	361		196	345		557	429	43	472	-85		-361	-5708	5708	361	0		6547	764	-833	-488	-976
2020 - 2021	260		212	345		472	553	55	608	136		-260	-5968	5968	260	0		6807	801	-750	-405	-1381
2021 - 2022	0	576	240	362		816	632	63	695	-121		0	0	0	0	681		6126	817	-724	-1619	-3000
2022 - 2023	0	0	260	362		260	748	75	823	563		0	0	0	0	681		5446	735	-534	-853	-3853
2023 - 2024	0	0	281	362		281	770	77	847	566		0	0	0	0	681		4765	653	-449	-768	-4621
2024 - 2025	0	0	303	362		303	919	92	1011	708		0	0	0	0	681		4084	572	-226	-544	-5165
2025 - 2026	0	0	328	362		328	946	95	1041	713		0	0	0	0	681		3404	490	-139	-458	-5623
2026 - 2027	0	0	355	362		355	1116	112	1228	873		0	0	0	0	681		2723	408	103	-216	-5839
2027 - 2028	0	0	383	362		383	1149	115	1264	881		0	0	0	0	681		2042	327	192	-126	-5966
2028 - 2029	0	0	414	362		414	1359	136	1495	1081		0	0	0	0	681		1361	245	474	155	-5811
2029 - 2030	0	0	448	362		448	1400	140	1540	1092		0	0	0	0	681		681	163	567	248	-5563
2030 - 2031	0	0	484	362		484	1659	166	1825	1341		0	0	0	0	681		0	82	897	579	-4984
2031 - 2032	0	1394	569	404		1963	1774	177	1951	-12		0	0	0	0	0		0	0	978	-12	-4996
2032 - 2033	0	0	615	404		615	2088	209	2297	1682		0	0	0	0	0		0	0	1278	1682	-3314
2033 - 2034	0	0	665	404		665	2129	213	2342	1677		0	0	0	0	0		0	0	1273	1677	-1637
2034 - 2035	0	0	718	404		718	2498	250	2748	2030		0	0	0	0	0		0	0	1626	2030	393
2035 - 2036	0	0	777	404		777	2549	255	2804	2027		0	0	0	0	0		0	0	1623	2027	2420
2036 - 2037	0	0	839	404		839	2998	300	3298	2459		0	0	0	0	0		0	0	2055	2459	4879
2037 - 2038	0	0	908	404		908	3057	306	3363	2455		0	0	0	0	0		0	0	2051	2455	7334
2038 - 2039	0	0	981	404		981	3585	359	3944	2963		0	0	0	0	0		0	0	2559	2963	10297
2039 - 2040	0	0	1061	450	1537	2598	3657	366	4023	1425		0	0	0	0	0		0	0	2512	1425	11722
2040 - 2041	0	0	1147	498	1614	2761	4291	429	4720	1959		0	0	0	0	0		0	0	3075	1959	13681
2041 - 2042	0	0	1240	498	0	1240	4377	438	4815	3575		0	0	0	0	0		0	0	3077	3575	17256
2042 - 2043	0	0	1341	498	0	1341	5143	514	5657	4316		0	0	0	0	0		0	0	3818	4316	21572
2043 - 2044	0	1723	1542	550	0	3265	5573	557	6130	2865		0	0	0	0	0		0	0	4038	2865	24437
	10675	**3693**	**16488**	**10381**	**3151**	**34007**	**55780**	**5580**	**61360**	7.44%	**4707**				**5968**	**6807**	**839**		**6784**	**27707**	**24437**	
										27353												

Table 19.16

Ahmedabad Metro Project

CAPITAL COST-FIXED 9102

CAPITAL COST - CURRENT 4103

Market Borrowings (BOT) 12.00%

DOMESTIC FUNDING - BASE CASE

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2014 - 2015	-31					-31			0	31	342	373	373	0	0	0	0	0					-342
2015 - 2016	851					851			0	-851	342	-509	-136	136	136	0	8	144					-342
2016 - 2017	970					970			0	-970	342	-628	-764	764	628	0	54	826					-342
2017 - 2018	1770					1770			0	-1770	342	-1428	-2192	2192	1428	0	177	2431					-342
2018 - 2019	267		181	123		448	381	38	419	-29		-267	-2459	2459	267	0		2698	292	-177	-54	-54	-54
2019 - 2020	16		196	123		212	429	43	472	260		-16	-2475	2475	16	0		2714	324	-171	-48	-101	-48
2020 - 2021	260		212	123		472	553	55	608	136		-260	-2735	2735	260	0		2974	326	-53	70	-31	70
2021 - 2022		576	240	140		816	632	63	695	-121		0	0	0	0	0		2974	357	-42	-478	-509	-478
2022 - 2023	0	0	260	140		260	748	75	823	563		0	0	0	0	0		2974	357	66	206	-303	206
2023 - 2024	0	0	281	140		281	770	77	847	566		0	0	0	0	0		2974	357	69	209	-94	209
2024 - 2025	0	0	303	140		303	919	92	1011	708		0	0	0	0	297		2677	357	211	54	-40	54
2025 - 2026	0	0	328	140		328	946	95	1041	713		0	0	0	0	297		2379	321	252	94	54	94
2026 - 2027	0	0	355	140		355	1116	112	1228	873		0	0	0	0	297		2082	286	447	290	344	290
2027 - 2028	0	0	383	140		383	1149	115	1264	881		0	0	0	0	297		1784	250	491	334	678	334
2028 - 2029	0	0	414	140		414	1359	136	1495	1081		0	0	0	0	297		1487	214	727	569	1248	569
2029 - 2030	0	0	448	140		448	1400	140	1540	1092		0	0	0	0	297		1190	178	774	616	1864	616
2030 - 2031	0	0	484	140		484	1659	166	1825	1341		0	0	0	0	297		892	143	1058	901	2765	901
2031 - 2032	0	1394	569	182		1963	1774	177	1951	-12		0	0	0	0	297		595	107	1093	-416	2348	-416
2032 - 2033	0	0	615	182		615	2088	209	2297	1682		0	0	0	0	297		297	71	1429	1313	3661	1313
2033 - 2034	0	0	665	182		665	2129	213	2342	1677		0	0	0	0	297		0	36	1459	1344	5005	1344
2034 - 2035	0	0	718	182		718	2498	250	2748	2030		0	0	0	0	0		0	0	1848	2030	7035	2030
2035 - 2036	0	0	777	182		777	2549	255	2804	2027		0	0	0	0	0		0	0	1845	2027	9062	2027
2036 - 2037	0	0	839	182		839	2998	300	3298	2459		0	0	0	0	0		0	0	2277	2459	11521	2459
2037 - 2038	0	0	908	182		908	3057	306	3363	2455		0	0	0	0	0		0	0	2273	2455	13976	2455
2038 - 2039	0	0	981	182		981	3585	359	3944	2963		0	0	0	0	0		0	0	2781	2963	16939	2963
2039 - 2040	0	0	1061	228	1537	2598	3657	366	4023	1425		0	0	0	0	0		0	0	2734	1425	18364	1425
2040 - 2041	0	0	1147	276	1614	2761	4291	429	4720	1959		0	0	0	0	0		0	0	3297	1959	20323	1959
2041 - 2042	0	0	1240	276	0	1240	4377	438	4815	3575		0	0	0	0	0		0	0	3299	3575	23898	3575
2042 - 2043	0	0	1341	276	0	1341	5143	514	5657	4316		0	0	0	0	0		0	0	4040	4316	28214	4316
2043 - 2044	0	1723	1542	328	0	3265	5573	557	6130	2865		0	0	0	0	0		0	0	4260	2865	31079	2865
	4103	**3693**	**16488**	**4609**	**3151**	**27435**	**55780**	**5580**	**61360**	**15.14%**	**1368**				**2735**	**2974**	**239**		**3975**	**36288**	**31079**		**16.01%**
										33925													

Ahmedabad Metro Project **Table 19.17**

CAPITAL COST-FIXED 9102

CAPITAL COST - CURRENT 10675 JICA Loan 1.40%

DOMESTIC FUNDING - BASE CASE

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOG	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2014 - 2015	662					662			0	-662	543	-119	-119	119	119	0	1	120				
2015 - 2016	2494					2494			0	-2494	1187	-1307	-1426	1426	1307	0	11	1438				
2016 - 2017	2661					2661			0	-2661	1185	-1476	-2902	2902	1476	0	30	2944				
2017 - 2018	3120					3120			0	-3120	944	-2176	-5078	5078	2176	0	56	5176				
2018 - 2019	1117		181	323		1298	381	38	419	-879	848	-269	-5347	5347	269	0		5445	74	-159	164	164
2019 - 2020	361		196	323		557	429	-96	333	-224		-361	-5708	5708	361	0		5806	79	-265	58	222
2020 - 2021	260		212	323		472	553	-56	497	25		-260	-5968	5968	260	0		6066	83	-121	202	424
2021 - 2022	0	576	240	340		816	632	-11	621	-195		0	0	0	0	0		6066	85	-44	-280	144
2022 - 2023	0	0	260	340		260	748	69	817	557		0	0	0	0	0		6066	85	132	472	616
2023 - 2024	0	0	281	340		281	770	192	962	681		0	0	0	0	0		6066	85	256	596	1212
2024 - 2025	0	0	303	340		303	919	227	1146	843		0	0	0	0	303		5763	85	418	455	1667
2025 - 2026	0	0	328	340		328	946	253	1199	871		0	0	0	0	303		5459	81	450	487	2154
2026 - 2027	0	0	355	340		355	1116	292	1408	1053		0	0	0	0	303		5156	76	637	673	2827
2027 - 2028	0	0	383	340		383	1149	318	1467	1084		0	0	0	0	303		4853	72	672	709	3536
2028 - 2029	0	0	414	340		414	1359	361	1720	1306		0	0	0	0	303		4550	68	898	935	4470
2029 - 2030	0	0	448	340		448	1400	466	1866	1418		0	0	0	0	303		4246	64	1014	1051	5521
2030 - 2031	0	0	484	340		484	1659	508	2167	1683		0	0	0	0	303		3943	59	1284	1320	6842
2031 - 2032	0	1394	569	382		1963	1774	536	2310	347		0	0	0	0	303		3640	55	1304	-12	6830
2032 - 2033	0	0	615	382		615	2088	585	2673	2058		0	0	0	0	303		3336	51	1625	1704	8534
2033 - 2034	0	0	665	382		665	2129	608	2737	2072		0	0	0	0	303		3033	47	1643	1722	10256
2034 - 2035	0	0	718	382		718	2498	666	3164	2446		0	0	0	0	303		2730	42	2022	2100	12356
2035 - 2036	0	0	777	382		777	2549	692	3241	2464		0	0	0	0	303		2426	38	2044	2122	14479
2036 - 2037	0	0	839	382		839	2998	759	3757	2918		0	0	0	0	303		2123	34	2502	2581	17059
2037 - 2038	0	0	908	382		908	3057	787	3844	2936		0	0	0	0	303		1820	30	2524	2603	19662
2038 - 2039	0	0	981	382		981	3585	864	4449	3468		0	0	0	0	303		1517	25	3061	3139	22802
2039 - 2040	0	0	1061	428	1537	2598	3657	897	4554	1956		0	0	0	0	303		1213	21	3044	1631	24433
2040 - 2041	0	0	1147	476	1614	2761	4291	986	5277	2516		0	0	0	0	303		910	17	3637	2196	26629
2041 - 2042	0	0	1240	476	0	1240	4377	1024	5401	4161		0	0	0	0	303		607	13	3672	3845	30474
2042 - 2043	0	0	1341	476	0	1341	5143	1128	6271	4930		0	0	0	0	303		303	8	4446	4618	35092
2043 - 2044	0	1723	1542	528	0	3265	5573	1202	6775	3510		0	0	0	0	303		0	4	4701	3202	38294
	10675	**3693**	**16488**	**9809**	**3151**	**34007**	**55780**	**13295**	**69075**	**8.54%**	**4707**				**5968**	**6066**	**98**		**1383**	**41395**	**38294**	
										35068												

Ahmedabad Metro Project **Table 19.18**

CAPITAL COST-FIXED 9102

CAPITAL COST - CURRENT 10675 Market Borrowings 12.00%

DOMESTIC FUNDING - BASE CASE

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOG	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2014 - 2015	662					662			0	-662	543	-119	-119	119	119	0	7	126				
2015 - 2016	2494					2494			0	-2494	1187	-1307	-1426	1426	1307	0	93	1526				
2016 - 2017	2661					2661			0	-2661	1185	-1476	-2902	2902	1476	0	260	3262				
2017 - 2018	3120					3120			0	-3120	944	-2176	-5078	5078	2176	0	479	5917				
2018 - 2019	1117		181	345		1298	381	38	419	-879	848	-269	-5347	5347	269	0		6186	726	-833	-488	-488
2019 - 2020	361		196	345		557	429	-96	333	-224		-361	-5708	5708	361	0		6547	764	-972	-627	-1115
2020 - 2021	260		212	345		472	553	-56	497	25		-260	-5968	5968	260	0		6807	801	-861	-516	-1631
2021 - 2022	0	576	240	362		816	632	-11	621	-195		0	0	0	0	681		6126	817	-798	-1693	-3324
2022 - 2023	0	0	260	362		260	748	69	817	557		0	0	0	0	681		5446	735	-540	-859	-4183
2023 - 2024	0	0	281	362		281	770	192	962	681		0	0	0	0	681		4765	653	-334	-653	-4836
2024 - 2025	0	0	303	362		303	919	227	1146	843		0	0	0	0	681		4084	572	-91	-409	-5245
2025 - 2026	0	0	328	362		328	946	253	1199	871		0	0	0	0	681		3404	490	19	-300	-5545
2026 - 2027	0	0	355	362		355	1116	292	1408	1053		0	0	0	0	681		2723	408	283	-36	-5581
2027 - 2028	0	0	383	362		383	1149	318	1467	1084		0	0	0	0	681		2042	327	395	77	-5505
2028 - 2029	0	0	414	362		414	1359	361	1720	1306		0	0	0	0	681		1361	245	699	380	-5125
2029 - 2030	0	0	448	362		448	1400	466	1866	1418		0	0	0	0	681		681	163	893	574	-4551
2030 - 2031	0	0	484	362		484	1659	508	2167	1683		0	0	0	0	681		0	82	1239	921	-3630
2031 - 2032	0	1394	569	404		1963	1774	536	2310	347		0	0	0	0	0		0	0	1337	347	-3283
2032 - 2033	0	0	615	404		615	2088	585	2673	2058		0	0	0	0	0		0	0	1654	2058	-1225
2033 - 2034	0	0	665	404		665	2129	608	2737	2072		0	0	0	0	0		0	0	1668	2072	847
2034 - 2035	0	0	718	404		718	2498	666	3164	2446		0	0	0	0	0		0	0	2042	2446	3293
2035 - 2036	0	0	777	404		777	2549	692	3241	2464		0	0	0	0	0		0	0	2060	2464	5757
2036 - 2037	0	0	839	404		839	2998	759	3757	2918		0	0	0	0	0		0	0	2514	2918	8675
2037 - 2038	0	0	908	404		908	3057	787	3844	2936		0	0	0	0	0		0	0	2532	2936	11611
2038 - 2039	0	0	981	404		981	3585	864	4449	3468		0	0	0	0	0		0	0	3064	3468	15079
2039 - 2040	0	0	1061	450	1537	2598	3657	897	4554	1956		0	0	0	0	0		0	0	3043	1956	17035
2040 - 2041	0	0	1147	498	1614	2761	4291	986	5277	2516		0	0	0	0	0		0	0	3632	2516	19551
2041 - 2042	0	0	1240	498	0	1240	4377	1024	5401	4161		0	0	0	0	0		0	0	3663	4161	23712
2042 - 2043	0	0	1341	498	0	1341	5143	1128	6271	4930		0	0	0	0	0		0	0	4432	4930	28642
2043 - 2044	0	1723	1542	550	0	3265	5573	1202	6775	3510		0	0	0	0	0		0	0	4683	3510	32152
	10675	**3693**	**16488**	**10381**	**3151**	**34007**	**55780**	**13295**	**69075**	**8.54%**	**4707**				**5968**	**6807**	**839**		**6784**	**35422**	**32152**	
										35068												

Table 19.19

Ahmedabad Metro Project

CAPITAL COST-FIXED 9102

CAPITAL COST - CURRENT 4643

DOMESTIC FUNDING - BASE CASE

Market Borrowings (BOT) 12.00%

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2014 - 2015	-31					-31			0	31	387	418	418	0	0	0	0	0					-387
2015 - 2016	1001					1001			0	-1001	387	-614	-196	196	196	0	12	208					-387
2016 - 2017	1070					1070			0	-1070	387	-683	-879	879	683	0	65	956					-387
2017 - 2018	1920					1920			0	-1920	387	-1533	-2412	2412	1533	0	197	2686					-387
2018 - 2019	267		181	139		448	381	38	419	-29		-267	-2679	2679	267	0		2953	322	-223	-84	-84	-84
2019 - 2020	156		196	139		352	429	-96	333	-19		-156	-2835	2835	156	0		3109	354	-356	-217	-302	-217
2020 - 2021	260		212	139		472	553	-56	497	25		-260	-3095	3095	260	0		3369	373	-227	-88	-390	-88
2021 - 2022	0	576	240	156		816	632	-11	621	-195		0	0	0	0	0		3369	404	-179	-599	-989	-599
2022 - 2023	0	0	260	156		260	748	69	817	557		0	0	0	0	0		3369	404	-3	153	-836	153
2023 - 2024	0	0	281	156		281	770	192	962	681		0	0	0	0	0		3369	404	121	277	-560	277
2024 - 2025	0	0	303	156		303	919	227	1146	843		0	0	0	0	337		3032	404	283	102	-458	102
2025 - 2026	0	0	328	156		328	946	253	1199	871		0	0	0	0	337		2695	364	351	170	-288	170
2026 - 2027	0	0	355	156		355	1116	292	1408	1053		0	0	0	0	337		2358	323	574	393	105	393
2027 - 2028	0	0	383	156		383	1149	318	1467	1084		0	0	0	0	337		2021	283	645	464	569	464
2028 - 2029	0	0	414	156		414	1359	361	1720	1306		0	0	0	0	337		1685	243	907	727	1296	727
2029 - 2030	0	0	448	156		448	1400	466	1866	1418		0	0	0	0	337		1348	202	1060	879	2175	879
2030 - 2031	0	0	484	156		484	1659	508	2167	1683		0	0	0	0	337		1011	162	1365	1184	3359	1184
2031 - 2032	0	1394	569	198		1963	1774	536	2310	347		0	0	0	0	337		674	121	1422	-111	3248	-111
2032 - 2033	0	0	615	198		615	2088	585	2673	2058		0	0	0	0	337		337	81	1779	1640	4888	1640
2033 - 2034	0	0	665	198		665	2129	608	2737	2072		0	0	0	0	337		0	40	1834	1695	6583	1695
2034 - 2035	0	0	718	198		718	2498	666	3164	2446		0	0	0	0	0		0	0	2248	2446	9029	2446
2035 - 2036	0	0	777	198		777	2549	692	3241	2464		0	0	0	0	0		0	0	2266	2464	11493	2464
2036 - 2037	0	0	839	198		839	2998	759	3757	2918		0	0	0	0	0		0	0	2720	2918	14411	2918
2037 - 2038	0	0	908	198		908	3057	787	3844	2936		0	0	0	0	0		0	0	2738	2936	17347	2936
2038 - 2039	0	0	981	198		981	3585	864	4449	3468		0	0	0	0	0		0	0	3270	3468	20815	3468
2039 - 2040	0	0	1061	244	1537	2598	3657	897	4554	1956		0	0	0	0	0		0	0	3249	1956	22771	1956
2040 - 2041	0	0	1147	292	1614	2761	4291	986	5277	2516		0	0	0	0	0		0	0	3838	2516	25287	2516
2041 - 2042	0	0	1240	292	0	1240	4377	1024	5401	4161		0	0	0	0	0		0	0	3869	4161	29448	4161
2042 - 2043	0	0	1341	292	0	1341	5143	1128	6271	4930		0	0	0	0	0		0	0	4638	4930	34378	4930
2043 - 2044	0	1723	1542	344	0	3265	5573	1202	6775	3510		0	0	0	0	0		0	0	4889	3510	37888	3510
	4643	**3693**	**16488**	**5025**	**3151**	**27975**	**55780**	**13295**	**69075**	**15.17%**	**1548**				**3095**	**3369**	**274**		**4486**	**43076**	**37888**		**16.00%**
										41100													

Chapter - 20

Economic Appraisal

Chapter - 20

ECONOMIC APPRAISAL

20.1 INTRODUCTION

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

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

In highway construction projects, 'without' is taken as "base case" and 'with' implies 'alternative case'. In 'alternative case' a portion of traffic on the road is diverted to a new road which is estimated first. Then the difference between maintenance & construction cost for 'base case' and for 'alternative case' which is known as relative road agency cost (RAC) is derived. Difference between road user cost for 'base case' and of 'alternative case' is also derived which is known as relative road user cost (RUC). Difference between RAC and RUC calculated for each year generates net benefit stream. Economic indicators (EIRR, BC Ratio, NPV) are the obtained.

In metro projects, same principal is followed but procedure is slightly different. Here, diverted traffic is nothing but the passengers shifted from road based modes to metro. Travel time saving is the difference between time which would be taking on metro and road based transports for same distance. Fuel cost saving is the difference between the cost of the fuel burnt on road based modes by the shifted passengers and the energy cost of running the metro rail which is a part of the maintenance cost. Thus benefits are directly obtained by correlating with them with the passenger km (ridership and average trip length is multiplied to get passenger km). As is done in highway projects, net benefit is obtained by subtracting the cost of the project (incurred for construction (capital) and maintenance (recurring) costs for the metro line) from the benefits derived from pass km savings in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first four benefit components given in **Table 20.1** are direct benefits due to shifting of trips to metro, but other benefit components are due to decongestion effect on the road. Benefit components were first estimated applying market values then were converted into respective Economic values by using separate economic factors which are also given in table 20.1. Depending upon methodology of estimation, economic factors are assumed. Overall economic value of benefit components is 90% of the market value. Similarly economic value of the cost components are 80% of the market cost.

Table 20.1 - Cost/Benefit Components due to Metro

	Cost/Benefit Components	Economic Factors
1	Construction Cost	80%
2	Maintenance Cost	80%
3	Annual Time Cost Saved by Metro Passengers	90%
4	Annual Fuel Cost Saved by Metro Passengers	90%
5	Annual Vehicle Operating Cost Saved saved by Metro Passengers	90%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	80%

20.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in table 20.2.

Table 20.2 - Values adopted for some important variables

	Values	Important variables
1	Rs. 1.7/min (2014)	Travel Time Cost derived from passenger's travel time against travel cost incurred.
2	Market Rate (2014)	Fuel Cost (value of Petrol, Diesel and CNG).
3	Table 20.3	Vehicle Operating Cost (Derived from Life Cycle Cost of different passenger vehicles per km)
4	Table 20.4 (CPCB)	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton).

	Values	Important variables
5	Table 20.5 (Accident Rate & Cost)	Accident Rate (No of fatal and all accidents per one Cr.KM). Accident costs are derived from published papers at current rate.
6	66.52%	Passenger km – Vehicle km conversion factor and mode share percent values (derived from House Hold Survey and Modal Split within study area)
7	Road User Cost Study Model (CRRI-2010)	Fuel Consumption of vehicles at a given speed is derived
8	Rs. 0.5/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km
9	11.38 min	Average Journey Time Saved for average trip length (km) journey after Shifting (Derived)
10	24.33 kmph	Average Journey Speed

Table 20.3 - Vehicle Operating Cost in Rs.(2014)

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	4.61	3.77	2.14	0.59	0.74	2.39	2.98
Capital Cost	4.21	4.27	1.60	0.18	0.16	1.20	2.57
Total VOC	**9.70**	**8.84**	**4.12**	**0.85**	**0.99**	**3.95**	**6.11**

Table 20.4 - Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

VEHICLE	CO	HC	NOX	PM	CO	CO2
BUS	3.72	0.16	6.53	0.24	3.72	787.72
2W-2 STROKE	1.4	1.32	0.08	0.05	1.4	24.99
2W-4 STROKE	1.4	0.7	0.3	0.05	1.4	28.58
MINI BUS	2.48	0.83	8.26	0.58	2.48	358.98
4W-SMALL	1.39	0.15	0.12	0.02	1.39	139.51
4W-LARGE	0.58	0.05	0.45	0.05	0.58	156.55
TATA MAGIC	1.24	0.17	0.58	0.17	1.24	160
3W	2.45	0.75	0.12	0.08	2.45	77.89
Cost	**RS. 100000 PER TON**					**500**

Table 20.5 - Accident Rate and Cost in Rs

Accident Rate in the year 2014	Cr. Vehicle KM	Average Cost in Rs
All Types.	1.5	588911
Fatal Accident.	0.2	1692648

Traffic parameter values used for economic analysis are given in table 20.6

Table 20.6 - Summary of the Ridership on the Phase I Metro Ahmadabad

Particulars	2018	2021	2026	2031	2036	2043
Trips/day	457664	661606	792231	922855	1084254	1245653
Line Length (km)	35.95	35.95	35.95	35.95	35.95	35.95
Average Trip length (km)	6.680	6.700	6.760	6.820	6.830	6.840
Passenger km	3057196	4432760	5355478	6293871	7405455	8520267
Passenger km/km	85040	123303	148970	175073	205993	237003

20.3 ECONOMIC BENEFIT STREAM

For deriving the values of economic indicators (EIRR, NPV, BCR), cost and benefit stream table is constructed in terms of money value. Socio-Economic Benefits are are first quantified and converted in to money cost.

While cost component is estimated for each year, benefits are obtained directly from the projected passenger km saved for the horizon years (2018,2021, 2026, 2031 and 2043) and the values for other years are interpolated and extrapolated on the basis of projected traffic.

Market values are used for calculating costs and then appropriate economic factors (see table 20.1) are applied. For each year values of each benefit components are obtained and thus benefit stream is estimated. Benefit Components Stream for proposed Phase 1 line is shown in table 20.7.

Table 20.7 - Component wise Stream of Economic Benefit Value

From	To	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Operating Cost Saved saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost	Total Benefits without Discount
2018	2019	1117.00	181.00	1298.00	824.90	470.79	233.40	176.55	45.61	8.77
2019	2020	361.00	196.00	557.00	316.06	564.54	266.46	210.03	55.29	10.65
2020	2021	260.00	212.00	472.00	239.13	676.95	304.30	249.85	56.05	12.95
2021	2022	576.00	240.00	816.00	369.12	744.24	318.96	272.73	50.13	14.44
2022	2023	0.00	260.00	260.00	105.01	818.23	334.43	297.70	55.76	16.10
2023	2024	0.00	281.00	281.00	101.33	899.57	350.76	324.96	62.02	17.95
2024	2025	0.00	303.00	303.00	97.56	989.00	367.99	354.71	68.99	20.02
2025	2026	0.00	328.00	328.00	94.29	1087.32	386.16	387.19	76.74	22.32
2026	2027	0.00	355.00	355.00	91.12	1188.85	403.11	420.31	84.90	24.76
2027	2028	0.00	383.00	383.00	87.77	1299.85	420.91	456.26	93.91	27.46
2028	2029	0.00	414.00	414.00	84.71	1421.22	439.61	495.29	103.89	30.45
2029	2030	0.00	448.00	448.00	81.85	1553.91	459.25	537.66	114.92	33.77
2030	2031	0.00	484.00	484.00	78.95	1699.00	529.12	643.54	140.17	37.44
2031	2032	1394.00	569.00	1963.00	285.90	1860.82	553.60	699.32	155.23	41.54
2032	2033	0.00	615.00	615.00	79.97	2038.05	579.34	759.93	171.89	46.07
2033	2034	0.00	665.00	665.00	77.21	2276.06	621.47	848.04	190.70	52.17
2034	2035	0.00	718.00	718.00	74.43	2541.87	666.67	946.36	211.57	59.07
2035	2036	0.00	777.00	777.00	71.92	2838.71	715.16	1056.08	234.72	66.89
2036	2037	0.00	839.00	839.00	69.34	3170.23	767.17	1178.52	260.41	75.74
2037	2038	0.00	908.00	908.00	67.00	3540.46	822.97	1315.15	288.90	85.76
2038	2039	0.00	981.00	981.00	64.63	3953.93	882.83	1467.63	320.51	97.11
2039	2040	1537.00	1061.00	2598.00	152.82	4415.68	947.03	1637.78	355.59	109.96
2040	2041	1614.00	1147.00	2761.00	145.01	4931.36	1015.91	1827.67	394.49	124.51
2041	2042	0.00	1240.00	1240.00	58.15	5507.26	1089.80	2039.56	437.66	140.99
2042	2043	0.00	1341.00	1341.00	56.15	6150.41	1169.06	2276.03	485.55	159.64
2043	2044	1723.00	1542.00	3265.00	122.06	6868.68	1254.09	2539.91	538.69	180.77

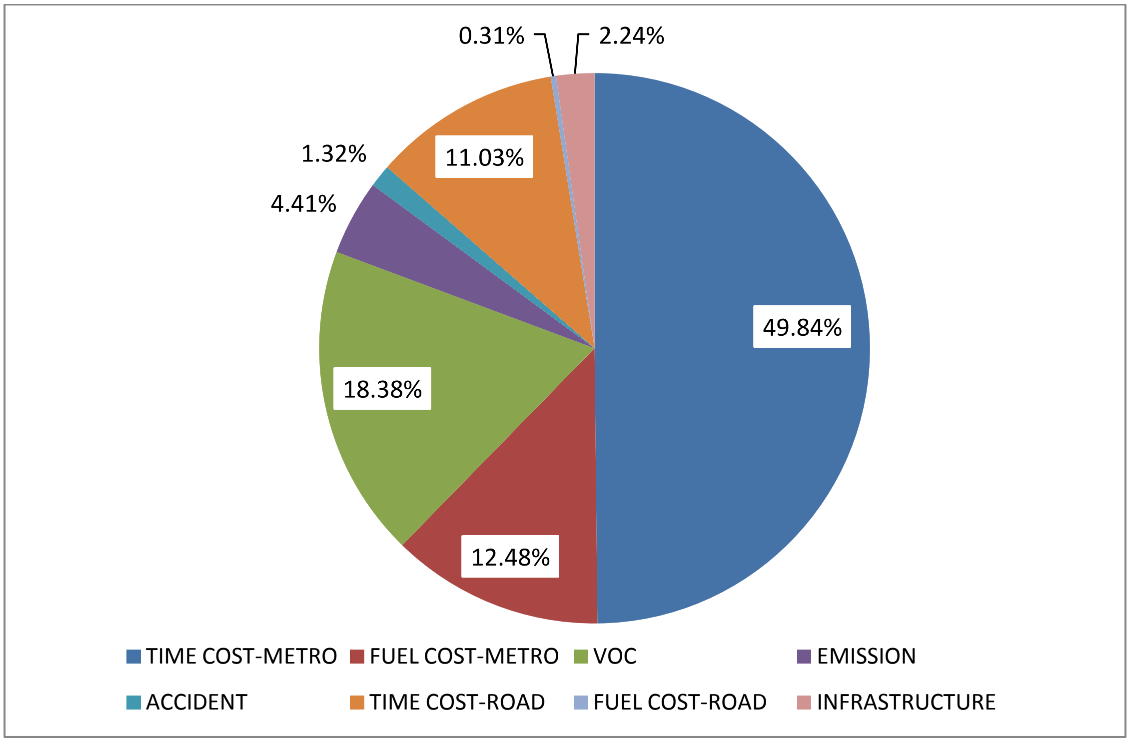


Figure 20.1 - Percent of Benefits

All Benefit component values (economic) accrued between the years 2018-2043 are shown in figure 20.1 which shows that benefits are mainly coming from saving of travel time by metro and road passengers (60.86%), Fuel Cost (12.79%) and VOC cost (18.38%). Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 7.97%.

In this area, personalised modes (car, three and two wheelers) are dominant which have made vehicle by passenger ratio very high (66.52%). Average motorised passenger trip modal split shows that 68.83% trips are by personal modes, 21.31% vehicular trips are by IPT modes and 9.86% are by public transport as may be seen in table 20.8 More smaller size vehicles on road indicates more congestion.

Table 20.8 - Average modal split in study area

MODE	PASSENGER	VEHICLE
BUS	9.18%	0.36%
CAR	17.02%	11.63%
CHARTERED BUS	0.67%	0.03%
2 WH	51.81%	74.17%
AUTO	21.31%	13.81%

20.4 METRO CONSTRUCTION COST

Total cost of metro construction (CAPITAL COST) is derived after considering cost of all major component such as Relocation and Rehabilitation(RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. RUCURRING COST includes energy cost, maintenance cost, and operation cost. Economic analysis period is taken from 2014-15 to 2043-44 out of which 8 years (2014-2022) are marked as construction period. Additional capital expenditure may be incurred in the years 2021-23 (purchase of more rolling stock). During the years 2041-43 major repairing and replacement cost is envisaged. Operation is expected to start in 2018-19 (4TH Year). This cost stream is generated with Central taxes. Detail is shown in **Table 20.9.**

Table 20.9 - Estimated Capital and Recurring Cost including Central Tax

Year Start	Year Ending	Capital Cost Cr. Rs.	Recurring Cost Cr. Rs
2014	2015	662	0
2015	2016	2494	0
2016	2017	2661	0
2017	2018	3120	0
2018	2019	1117	181
2019	2020	361	196
2020	2021	260	212
2021	2022	576	240
2022	2023	0	260
2023	2024	0	281
2024	2025	0	303
2025	2026	0	328
2026	2027	0	355
2027	2028	0	383

Year Start	Year Ending	Capital Cost Cr. Rs.	Recurring Cost Cr. Rs
2028	2029	0	414
2029	2030	0	448
2030	2031	0	484
2031	2032	1394	569
2032	2033	0	615
2033	2034	0	665
2034	2035	0	718
2035	2036	0	777
2036	2037	0	839
2037	2038	0	908
2038	2039	0	981
2039	2040	1537	1061
2040	2041	1614	1147
2041	2042	0	1240
2042	2043	0	1341
2043	2044	1723	1542

20.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are presented in **table 20.10**. Project period is 2014-2043, EIRR (without tax) is found to be **17.09%** and B/C ratio as 4.22 and with 12 % discount, EIRR is **4.54%** and B/C ratio is 1.54. NPV without discount is Rs **87484** Cr. and with 12% discount rate, NPV is Rs. **4822** Cr. which shows that the project is economically viable.

Table 20.10 - Economic Indicator Values (2042-43)

AHMDABAD PAHSE 1	WITHOUT DISCOUNT	WITH DISCOUNT[1] (12%)
Total cumulative cost	27206	8902
Total cumulative benefit	114690	13724
Benefit Cost Ratio	**4.22**	**1.54**
NPV	**87484**	**4822**

[1] Discount Rate is the rate of depreciation of future values of both cost and benefit. Values obtained after applying depreciation are present values of future cost and benefits. Discount rate is a weighted combination of market rate interest of money and inflation rate. In a strong economy this value ranges from 3%-5% and in weak market this value ranges from 12%-15%. We have tried to show that even if we depreciate the money value of the benefits and remove the inflation effect, the project is economically viable as it produces positive values of the economic parameters shown in table 20.10.

20.6 SENSITIVITY ANALYSIS

Sensitivity of EIRR and B/C ratios both with and without discount was carried out and the output is given in the **table 20.11**. 2042-43 is taken for the year of comparison.

Table 20.11 - Sensitivity of EIRR

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	17.09%	4.22	27206	4.54%	1.54	8902
-10%	0%	16.47%	4.01	27206	3.99%	1.47	8902
-20%	0%	15.83%	3.80	27206	3.42%	1.39	8902
0%	10%	15.91%	3.83	29926	3.49%	1.40	9792
0%	20%	14.86%	3.51	32647	2.56%	1.28	10682
-10%	10%	15.31%	3.64	29926	2.95%	1.33	9792
-20%	20%	13.67%	3.16	32647	1.49%	1.16	10682

Sensitivity analysis shows that economic indicator values namely EIRR is within the limit of acceptance as also the B/C ratios. If cost is increased by more than 20% or traffic is decreased by 20%, economic return reduces to 13.67%.

20.7 QUANTIFIED BENEFITS.

Benefits which are shown in previous tables are money value of the benefits. These benefits are estimated first and the converted into money value. For brevity, only 5 year estimates are shown in table 20.8 (Reduction of Vehicle gas Emission) and in table 20.12 (Reduction of Fuel, Time of Travel, Vehicle on Road etc).

Table 20.12 - Environmental Benefits Quantified

Tons/Year	2019	2020	2021	2022	2023
CO	2227.37	2523.56	2323.20	1858.08	1931.62
HC	1265.92	1434.26	1326.04	1067.79	1110.05
NOX	199.68	226.24	255.53	264.83	275.31
PM	51.84	58.73	64.81	65.58	68.17
SO2	4.10	4.64	4.82	4.55	4.73
CO2	46944	53187	60258	62643	65122
Total Emission Saved	**50693**	**57434**	**64232**	**65904**	**68512**

From Table 20.13, it may be seen that in 2020, Time saving will be 2.31 Crore (10 million) hour, fuel saving 7.30 thousand tons. Amount of travel in terms of passenger km reduced due to shifting to Mono Rail is equivalent to reduction of 6069 vehicle from the road. More than 2 fatal accidents and 19 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the area.

Table 20.13 - Travel Benefits Quantified

Quantified Benefits in Horizon Years	**2019**	**2020**	**2021**	**2022**	**2023**
Annual Time Saved by Metro Passengers in Cr. Hr.	3.62	4.13	4.72	4.94	5.17
Annual Fuel Saved by Metro Passengers in thousand Tons.	36.52	41.75	47.76	50.13	52.64
Daily vehicles reduced (off the road)	56959	64534	73114	76007	79016
CO_2 reduced in thousand tons	46.94	53.19	60.26	62.64	65.12
Other gases reduced in thousand tons	3.75	4.25	3.97	3.26	3.39
Reduced No of Fatal Accidents in Year	18.55	21.07	23.93	24.94	25.99
Reduced No of Other Accidents in year	120.57	136.94	155.53	162.09	168.93
Annual Vehicle km Reduced in Thousand Km.	**25.346**	**28.717**	**32.534**	**33.822**	**35.161**

Chapter - 21

Implementation Plan

Chapter - 21

IMPLEMENTATION PLAN

21.1 WAY FORWARD FOR IMPLEMENTING AHMEDABAD METRO PROJECT

On receipt of the Detailed Project Report, following action will be required for implementing the Ahmedabad Metro:

- Approval to the Detailed Project Report to be taken from Gujarat State Government (Cabinet approval).
- The DPR to be forwarded to the Ministry of Urban Development(GOI), Planning Commission and Finance Ministry with the request for approving the Metro project and for financial participation through equity contribution in the MEGA.
- Signing of an MOU between Gujarat 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, operational subsidy, if any, etc.
- MEGA Ltd, the Special Purpose Vehicle (SPV) already set up for implementing the project and for its subsequent Operation & Maintenance.
- The Metro Railways (Amendment) Act-2009 can readily be made use of for implementation of Ahmedabad Metro by declaring Ahmedabad City as Metropolitan Area in terms of clause c of section 243 P of Constitution.
- Request to GOI for a notification for making the Metro Railways (Amendment) Act 2009 applicable to Ahmedabad Metro.
- The State Government should formulate the funding plan for executing this project and get the same approved by the Government of India. The loan portion of the funding will have to be tied up by State Government in consultation with the Government of India.
- The Government should freeze all developments along the corridors suggested. For any constructions within 50 m. of the proposed alignment a system of No Objection Certificate should be introduced so that infructuous expenditure at a later stage is avoided.

- The Metro Railways (Amendment) Act-2009 can readily be made use of for implementation of Ahmedabad Metro by declaring Ahmedabad City as Metropolitan Area.

21.2 Implementation on Delhi Metro/Chennai Metro Model

MEGA has to take action for appointment of General Consultants for project management including preparation of tender documents. Till the General Consultants are in position, MEGA should appoint an interim Consultant for all preliminary and enabling jobs such as land acquisition, detailed design of civil structures, utility diversions, etc.

The proposed date of commissioning of the both corridor with suggested dates of important milestones is given in Table 21.1

Table 21.1 - Implementation Schedule through DMRC model Phase I

S. No.	Item of Work	Completion Period
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D + 0.5momth
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D + 1month
4	Appoint interim Consultant for preliminary works	D + 3months
5	Approval of Project by Empowered Committee	D +3months
6	Sanction of Project by EGOM.	D +6months
7	Appoint General Consultant	D +9months
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	D +57months
9	Testing and Commissioning	D +60moths
10	Revenue Operation	D +60months

21.3 ORGANISATIONAL SET-UP OF MEGA

The MEGA organization, as stated earlier, should be very lean but effective. It will consist of a non-executive Chairman, a Managing Director with full Executive Powers (in Schedule 'A') and three Functional Directors (in Schedule 'B') including Director (Finance). All the three Functional Directors will be full members of the Management Board. The Directors will be assisted by Heads of Departments in each of the major disciplines and they in turn will have Deputy Heads of Departments. The organization should be basically officer-oriented with only Personal Assistants and Technical Assistants attached to senior officers by eliminating unproductive layers of staff such as Peons, Clerks, etc. We strongly recommend that the total organizational strength is limited to 70 to 80 eliminating too many tiers to enable faster decision-making.

It is necessary for the MEGA officers to get exposed to the Metro technology and Metro culture through study tours of some of the selected foreign Metros and Delhi/Calcutta Metros.

Implementing a metro project in a congested metropolis is indeed a challenge. In sheer size, magnitude and technical complexity there are no parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without dislocating city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems some of these technologies used in these systems are totally new to the country each one of which is a major project by itself. Interfacing various system contracts is a difficult and highly skilled exercise. Side by side, timely and adequate funds have to be assured for implementation and lands, without encumbrances, have to be taken possession of in time. Clearances from the local authorities have to be taken which includes permission to cut trees, diversion of utilities, management of road traffic, etc., all of which will call for an efficient and competent project implementing agency.

Metro projects cannot be executed the way Government agencies execute projects in this country. Timely completion is very important to safeguard the financial viability. Competent and skilled technical personal to man such an organization are difficult to mobilize. In fact such experienced persons are not readily available in the country. Being a rail based project, for most of the systems such as rolling stock, signaling, telecommunication, traction power supply, etc., persons with railway background would be necessary. As systems & construction technology used in metro are much more advanced and sophisticated than the one used in Railways as these have to suit dense urban areas, Metro experience will enable faster & smoother execution and thus is desirable & therefore should be preferred.

Since MEGA will not have the required expertise and experienced manpower to check and monitor the General Consultants it may be necessary to engage Prime Consultants from the very start of GC's assignment who will do this job on behalf of MEGA.

Delhi Metro Rail Corporation can also be considered straightaway for being appointed as General Consultant to MEGA which will reduce the construction time by 4 to 6 months.

21.4 CONTRACTS

21.4.1 Civil Works

It is proposed to carry out the civil works through following construction contracts-

(a) Viaduct Construction-It is suggested that each contract can be limited to about 5 to 6 kms in length.

(b) Station Contracts- It is proposed that each station contract comprises of 3 to 6 stations.

Corridor wise number of contracts is expected to be as follows:

Table 21.2 - Construction Strategy (Elevated Portion)

Corridor	Length of Elevated Section (km)	Elevated Stations (Nos.)	Proposed Contracts	
			Viaduct	Station
Thaltejgam to Vastralgam	14.201	14	3 Nos	4 Nos.
APMC to Motera Stadium	15.420	14	3 No.	4 No.

(c) Underground Section: Following contracts are suggested for underground section including stations:-

Table 21.3 - Construction Strategy (Underground Portion)

Corridor	Underground Section		Proposed Contracts
	Length (km)	Station (Nos.)	Underground section including stations
Thaltejgam to Vastralgam	6.335	4	2 Nos

Architectural finishes, fire fighting arrangements and general electrification, will form part of civil contracts.

21.4.2 System Contracts

- Design, construct and installation for Traction and Power Supply.
- Design, construct and installation of Signal and Telecommunication works.
- Design, construct and installation of lifts.
- Design, construct and installation of escalators.
- Design, construct and commissioning of Automatic Fare Collection System.
- Design and supply of rolling stock.
- Installation of track in Depot and on main line.

- Design and installation of Signages.

21.4.3 Depot Contracts

The contracts are required for Civil and E&M works at Vasana Depot and New Cotton Mill Depot. Each depot will have one package for civil works.

The number of contracts for supply of Depot Equipment may be decided as and when the work is in progress.

21.5 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, Gujarat should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project. Commissioner of Ahmedabad Urban Development Authority and Chief Executive Officer of Ahmedabad Nagar Nigam should also be the member of this committee. This Committee should meet once a month and sort out all problems brought before it by MEGA. For Delhi Metro also such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro rail project.

21.6 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 Urban Development, Ministry of Surface Transport, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi Government 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 should be enlarged to include Ahmedabad Metro project also and the Chief Secretary, Gujarat should be inducted as a member of this Committee.

21.7 EMPOWERED GROUP OF MINISTERS (EGOM)

Union Cabinet had set up a Empowered Group of Ministers (EGoM) to take decisions on behalf of the Cabinet on policy matters concerning Delhi Metro project. The Group of Ministers is chaired by the Home Minister. Other members of the GOM are Minister of Urban Development and Poverty Alleviation, Minister of Railways, Minister of Finance and

Company Affairs and Deputy Chairman Planning Commission. Chief Minister, Delhi and Lt. Governor, Delhi, are permanent invitees to all meetings of the GOM. The GOM meets whenever any problem requiring decision on behalf of the Union Cabinet is to be taken. It is suggested that the role of this GOM should be enlarged to include Ahmedabad Metro. The Chief Minister, Gujarat should be inducted as a member and should attend the meetings of GOM whenever any issue concerning Ahmedabad Metro is to be deliberated upon.

21.8 LEGAL COVER FOR AHMEDABAD METRO

Construction of Ahmedabad Metro should commence soon. Thus there is immediate need to have a legislation to provide legal cover to the construction stage of Ahmedabad Metro.

Implementation of proposed Ahmedabad Metro can now be done under "The Metro Railways (Amendment) Act 2009". The copies of the Gazette notification and the amendment are put up enclosure to this chapter.

21.9 CONCESSIONS FROM GOVERNMENT

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return. With reasonable fare level, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level.

As in the case of Delhi Metro, the State Government should exempt/reimburse the Gujarat Value Added Tax (VAT) to Ahmedabad Metro. It should also exempt the following: -

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Gujarat State Government may pursue the Central government to extend the same benefit to Ahmedabad Metro.

21.10 NEED FOR DEDICATED FUND FOR METRO PROJECTS

We also strongly recommend that the State Government start building up funds for the project through dedicated levies as has been done by other State Governments notably Karnataka.

To enable the State Governments to provide their share of equity in the Special Purpose Vehicles set up for such projects, it would be necessary to constitute a Special Metro Fund at the State Government level. The State Government should resort to imposition of dedicated levies for raising resources for these Funds. Areas where such dedicated levies are possible are given below:

- A 50% cess on the tax levies for registration of road vehicles.
- A Green Surcharge on fuel (petrol, diesel).

  The above two levies would also assist to discourage the use of personalized motorized vehicles and encourage the use of public transport, which would not only reduce the pollution level in the city but also reduce traffic congestion on the road.
- A onetime Green Tax (Rs. 5000 to Rs. 10000 for four wheelers and Rs. 2000 for two wheelers) on existing vehicles registered in the City.
- All receipts from traffic challans to be channeled to this Fund.
- A 1 % turnover Tax on all shops, restaurants and hotels on a monthly basis.
- A 20 % surcharge on Property Tax within the Corporation limits.
- Metro Tax @ 2% on pay rolls of all establishments having more than 100 employees. Such cess is in existence in a number of Western countries for raising resources for metro rail. The employers' benefit a good deal by good Metro System.
- Surcharge @ 10% on luxury tax on the earning of all Star Hotels. At present level, the luxury tax is 10%. The surcharge will raise the level to only 11%. Chinese cities have adopted this scheme.
- Densification ofCorridor by way of selling of Floor Area Ratio (FAR) along the proposed metro corridors.

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रजिस्ट्री सं॰ डी॰ एल॰-33004/99

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भारत का राजपत्र
The Gazette of India

असाधारण

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PART II—Section 3—Sub-section (ii)

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शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

विमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under. Secy.

3269 GI/2009

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भारत का राजपत्र
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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/*Bhadra* 5, 1931 *(Saka)*

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[26*th August*, 2009.]

An Act further to amend the Metro Railways (Construction of Works) Act, 1978 and to amend the Delhi Metro Railway (Operation and Maintenance) Act, 2002.

BE it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009. Short title and commencement

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (*3*), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area".

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

'(*ka*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (*2*), after clause (*b*), the following clauses shall be inserted, namely:— Amendment of section 6.

"(*ba*) develop any metro railway land for commercial use;

(*bb*) provide for carriage of passengers by integrated transport services or any other mode of transport;".

9. Section 7 of the Delhi Metro Railway Act shall be renumbered as sub-section (*1*) thereof and after sub-section (*1*) as so renumbered, the following sub-section shall be inserted, namely:— Amendment of section 7.

"(*2*) The Commissioner shall function under the administrative control of the Chief Commissioner of Railway Safety appointed under section 5 of the Railways Act, 1989.". 24 of 1989.

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:— Substitution of new section for section 12.

"12. The Chief Commissioner of Railway Safety shall, for each financial year, prepare in such form, and within such time, as may be prescribed, an annual report giving a full account of the activities of the Commissioners during the financial year immediately preceding the financial year in which such report is prepared and forward copies thereof to the Central Government.". Annual report.

11. In section 13 of the Delhi Metro Railway Act, for the word "Commissioner", the words "Chief Commissioner of Railway Safety" shall be substituted. Amendment of section 13.

12. In section 23 of the Delhi Metro Railway Act, in sub-section (*1*), for the words "Hindi and English", the words "Hindi, English and official language of the State in which such station is located" shall be substituted. Amendment of section 23.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted. Amendment of section 26.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:— Amendment of section 34.

"(4) The Central Government and the State Government shall nominate one member each to the Fare Fixation Committee:

Provided that a person who is or has been an Additional Secretary to the Government of India or holds or has held an equivalent post in the Central Government or the State Government shall be qualified to be nominated as a member.".

Amendment of section 38.

15. In section 38 of the Delhi Metro Railway Act, in sub-section (2), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted.

Amendment of section 85.

16. In section 85 of the Delhi Metro Railway Act,—

(i) in sub-section (1), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted;

(ii) in sub-section (2), for the words "Government of the National Capital Territory of Delhi in the Delhi Gazette", the words "State Government" shall be substituted.

T.K. VISWANATHAN,
Secretary to the Govt. of India.

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Chapter - 22

Conclusions

Chapter – 22

CONCLUSIONS AND RECOMMENDATIONS

22.1 Ahmadabad has witnessed enormous growth during the last 10 years. The growth is mainly the result of immigration as the city provided better employment opportunities. Ahmadabad is the principal administrative, commercial and distribution center of the State. Ahmadabad is fast developing as educational hub of Gujarat. Rapid urbanization in the recent past has put the city's travel infrastructure to stress. Being thickly populated area, Ahmadabad's traffic needs cannot be met by only road-based system.

Road-based, has already come under stress leading to longer travel time, increased air pollution and rise in number of road accidents. However BRTS has offered some respite in this context and limited to the out skirt of the city, but it may not be sustainable and cater travel demand in longer horizon. With projected increase in the population of the city, strengthening and augmenting of transport infrastructure has assumed urgency. For this purpose provision of rail-based Metro system in the city has been considered.

Studies have brought out that a Light Capacity Metro with carrying capacity of about 15,000 to 25,000 phpdt will be adequate to meet not only the traffic needs for the present but for the future 30 to 40 years also. A Light Metro System consisting of two Corridors namely (i) Thaltej Gam to Vastral Gam Corridor (20.536km) and (ii) APMC to Motera Stadium (15.420km) at an estimated completion cost of **Rs. 6681Crores and Rs. 3994Crores** respectively(with Central taxes & duties) to be made operational as recommended in implementation chapter.

22.2 A detailed Environmental Impact Assessment Study has been carried out for the project. As a part of this Study, comprehensive environmental baseline data was collected, and both positive and negative impacts of the project were assessed in detail. The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc, with a few negative impacts (especially during implementation phase of the project) for which Environmental Management Plan has been suggested.

22.3 After examining the various options for execution of Ahmadabad Metro Project**,** it has been recommended that the project should be got executed through a SPV on DMRC funding pattern

22.4 The fare structure has been estimated based on Delhi Metro fares decided by Fare Fixation Committee in 2009. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 15% every two years.

22.5 As in the case of Delhi Metro, the State Government should exempt/ reimburse the Gujarat Value Added Tax (VAT) to Ahmadabad Metro. It should also exempt the following:

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

22.6 As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Gujarat State Government may pursue the Central Government to extend the same benefit to Ahmadabad Metro.

22.7 While the Financial Internal Rate of Return (FIRR) for the project has been assessed as 8.54**%** with central taxes with property development and the Economic Internal Rate of Return (EIRR) works out 17.09**%.**

22.8 To avoid delays in processing the clearance for the Project, Government of Gujarat should approve project immediately on receipt of the DPR and forward the DPR to the Secretary, Ministry of Urban Development, Government of India, advising the GOI of the State Government's intention to take up the Project on DMRC pattern requesting for the *latter's "in principle" clearance to go ahead with the Project.*

22.9 Meanwhile the State Government should freeze all future developments along the proposed route of Ahmadabad Metro to avoid in-fructuous expenditure.

22.10 The combined FIRR of both the corridors with taxes is 8.54% with additional property development of 10 hectares land and EIRR is 17.09 %. The pre-tax Equity FIRR to the BOT operator is 16% with a total VGF of only Rs.6032.00 crore excluding the cost of 10 hectare Land required for PD if the additional PD income is considered. Since the Gujarat Government is providing requisite land for PD and being social sector project, it is advisable to take up the job on DMRC model. Accordingly, the corridors are recommended for implementation.